TOPIC

7 Ecology

Water birds, along with a variety of other plants and animals, rely on the presence of wetlands for their survival. How might the loss of wetland areas affect these aquatic species? Learning about organisms and how they interact with one another, with other species, and with their environment, is what the study of ecology is all about.

VOCABULARY

ecology	abiotic
population	habitat
food chain	niche
producer	photosynthesis
autotroph	biosphere
consumer	cellular respiration
heterotroph	energy pyramid
herbivore	carrying capacity
carnivore	limiting factor
omnivore	competition
decomposer	predation
food web	parasitism
ecosytem	biodiversity
biotic	succession

Roles in Ecology

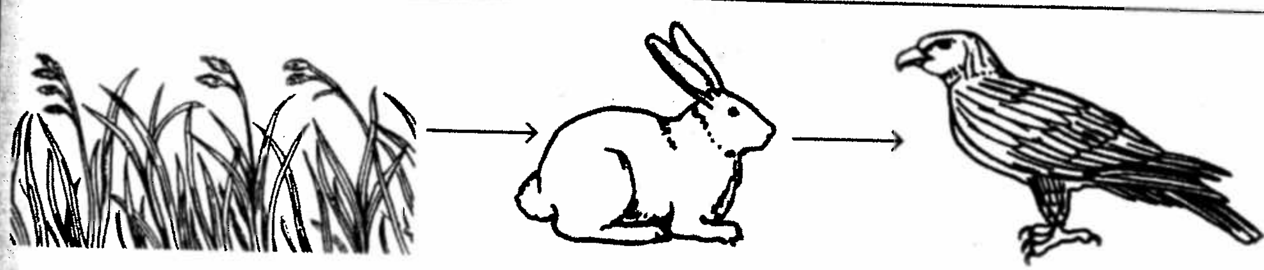
Main Idea: Populations can be categorized by the function they serve. Food webs identify the relationships among producers, consumers, and decomposers carrying out either autotrophic or heterotrophic nutrition.

Ecology is the study of the interactions among living things and between living things and their surroundings. Ecologists study nature on different levels, from a local to a global scale. An organism is one individual living thing, while a **population** is a group of the same species that lives in one area. A community is a group of different species that live together in one area.

Interactions among communities of species can be thought of as making a food chain or food web, which are models of the flow of energy in an environment. A **food chain,** such as the one shown in Figure 7.1, shows the feeding relationships for a single chain of producers and consumers. A **producer** is an organism that makes its own food. Plants and other photosynthesizing organisms are producers. Producers are also called **autotrophs.** Every ecosystem must have organisms that carry out autotrophic nutrition. Most producers on Earth use sunlight as their energy source.

Some consumers eat producers. A **consumer** is an organism that gets its energy by eating other organisms, including plants and animals. Consumers are also called **heterotrophs.** Different types of consumers have different food sources.

Figure 7.1 Food chains show a sequence of feeding relationships.



Grasses are producers. They get energy through photosynthesis.

Rabbits are consumers. They eat producers, such as grasses.

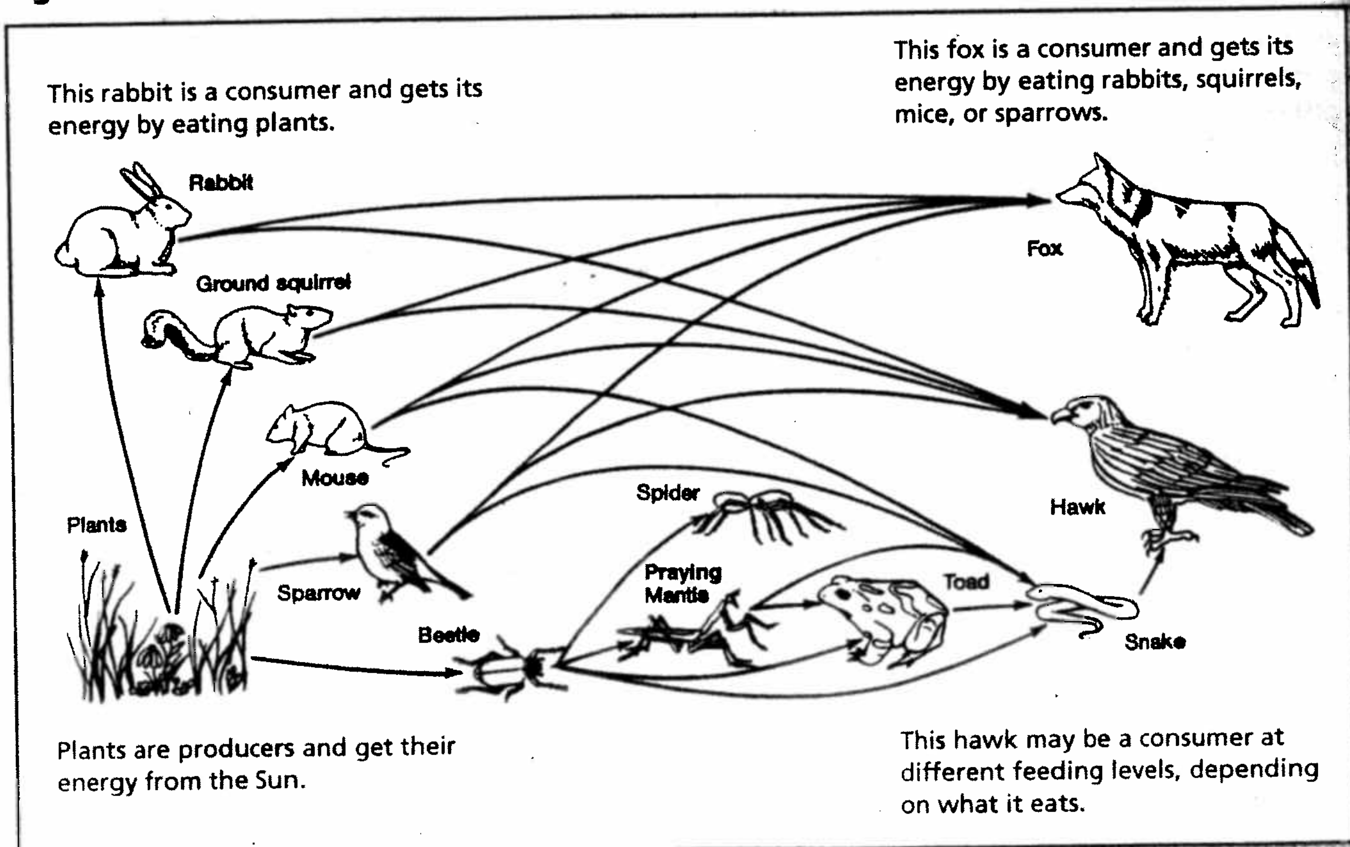
Hawks are also consumers. They eat other consumers, such as rabbits.

- An **herbivore** is an organism that eats only plants.
- A **carnivore** is an organism that eats only animals.
- An **omnivore** is an organism that eats both plants and animals.
- A **decomposer** breaks down plant and animal matter into simpler organisms. Fungi and bacteria are decomposers.

You can think of each link in a food chain as a level of feeding. Energy flows through the food chain from the lowest link to the highest. Plants are at the first link. The next link is made of the herbivores that eat the plants. The following link is made of carnivores that eat herbivores. Continuing through the food chain are carnivores that eat other carnivores. Omnivores, such as most humans, can be listed at different links in different food chains. Someone who is eating a salad is at a different link of the food chain than someone who is eating beef or chicken.

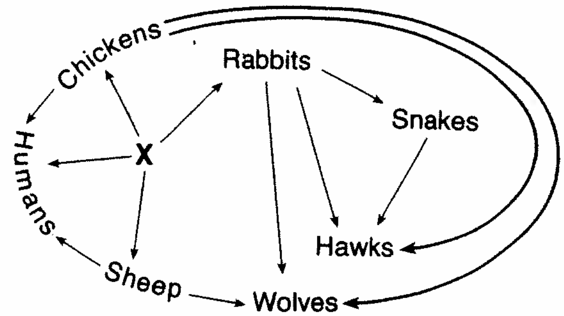
A food chain shows a simple sequence of feeding relationships. But most feeding relationships are not very simple. For example, a grey wolf may be part of several food chains that involve elk, deer, mice, and other organisms. This complex network of feeding relationships and the related flow of energy can be represented by a **food web,** as shown in Figure 7.2. Food webs show alternative pathways for an organism to get nutrition. If there are changes to an environment, organisms that are part of a food web have more stability than organisms that eat only one or two specific organisms.

Figure 7.2 A food web shows a complex network of feeding relationships.



NYS Regents Questions

1 A partial food web is represented in the diagram below.



Letter X most likely represents

(1) autotrophs
(2) carnivores
(3) decomposers
(4) parasites

Figure 7.3. A habitat includes all of the living and nonliving parts of the environment in which an organism lives.

Ecosystems

Main Idea: An ecosystem is shaped by the nonliving environment as well as by its interacting species. The world contains a wide diversity of physical conditions, which creates a variety of environments.

An **ecosystem** includes all of the organisms as well as the climate, soil, water, rocks, and other nonliving things in an area. An entire ecosystem may live within a single decaying log. But the log is also part of a larger ecosystem, such as a forest.

All ecosystems are made up of living and nonliving components. These parts are called biotic and abiotic factors. **Biotic** factors are living things, such as plants, animals, fungi, and bacteria. **Abiotic** factors are nonliving things, such as temperature, moisture, wind, rocks, and sunlight. In an ecosystem, biotic and abiotic factors work together to create different habitats. A **habitat** can be described as all of the living and nonliving factors in an area where an organism lives. These factors include all aspects of the environment.

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

You can think of a habitat, such as the one shown in Figure 7.3, 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 nonliving 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.

Main Idea: Ecosystems, like many other complex systems, tend to show cyclic changes around a state of approximate equilibrium.

An ecosystem may look similar from one year to the next, with similar numbers of animals and plants. However, an ecosystem is always undergoing some changes. For example, a long period of increased precipitation might allow one plant species to grow better than others. As the plant continues to grow, it may crowd out other plant species, changing the community's composition. Though the total number of plants in the community may remain the same, the species have changed. As these cyclic changes occur, an ecosystem falls into a balance, which is known as approximate equilibrium.

NYS Regents Questions

2 Two closely related species of birds live in the same tree. Species A feeds on ants and termites, while species B feeds on caterpillars. The two species coexist successfully because

(1) each occupies a different niche
(2) they interbreed
(3) they use different methods of reproduction
(4) birds compete for food

3 Which ecological term includes everything represented in the illustration below?

(1) ecosystem
(2) community
(3) population
(4) species

Energy in Ecosystems

Main Idea: Energy flows through ecosystems in one direction, typically from the Sun, through photosynthetic organisms including green plants and algae, to herbivores to carnivores and decomposers.

An important part of an ecosystem is its flow of energy. All organisms need a source of energy in order to survive. **Photosynthesis** is the process by which plants and green algae use energy from the Sun to make sugars. These producers provide the basis for an ecosystem's energy. For example, in an ocean ecosystem, tiny free-floating organisms called plankton live in the water. Plankton includes both animals and algae. Zooplankton is another term for animal plankton. Phytoplankton, on the other hand, are photosynthetic. Phytoplankton are critical to life on the planet. These organisms carry out the bulk of photosynthesis on Earth, and therefore provide most of the oxygen. According to many estimates, 70 percent or more of the oxygen in every breath you take can be traced back to marine phytoplankton.

In addition to their role in oxygen production, phytoplankton also form the base of the oceanic food web. For instance, zooplankton and herbivorous small fish eat phytoplankton. In turn, zooplankton are eaten by omnivorous and carnivorous fish. These fish may be eaten by bigger carnivorous fish or by squid—which then may be eaten by sharks. When any of these organisms die, decomposers such as bacteria and fungi that live in the ocean will recycle the organic nutrients from their decaying bodies back to the ecosystem.

Main Idea: The atoms and molecules on the Earth cycle among the living and nonliving components of the biosphere. Continual input of energy from sunlight keeps the process going. This concept may be illustrated with an energy pyramid.

The **biosphere** is the part of Earth where life exists. All of Earth's ecosystems, taken together, form the biosphere. Atoms and molecules, such as carbon dioxide and water molecules, cycle throughout both the biotic and abiotic parts of the biosphere. For example, plants absorb energy from sunlight and use this energy to build sugars. After plants use energy from sunlight to make food, herbivores eat the plants to get energy. Some of the energy is used by the animals to grow and some is used for cellular respiration. During **cellular respiration**, mitochondria within plant and animal cells release chemical energy to make ATP.

In photosynthesis, carbon dioxide molecules (CO_2) are used to make sugars, and water molecules (H_2O) are used to produce oxygen. In cellular respiration, sugars ($C_6H_{12}O_6$) are used to make carbon dioxide, and oxygen is used to make water.

Photosynthesis

$$6CO_2 + 6H_2O \longrightarrow \longrightarrow \longrightarrow C_6H_{12}O_6 + 6O_2$$

Cellular Respiration

$$C_6H_{12}O_6 + 6O_2 \longrightarrow \longrightarrow \longrightarrow 6CO_2 + 6H_2O$$

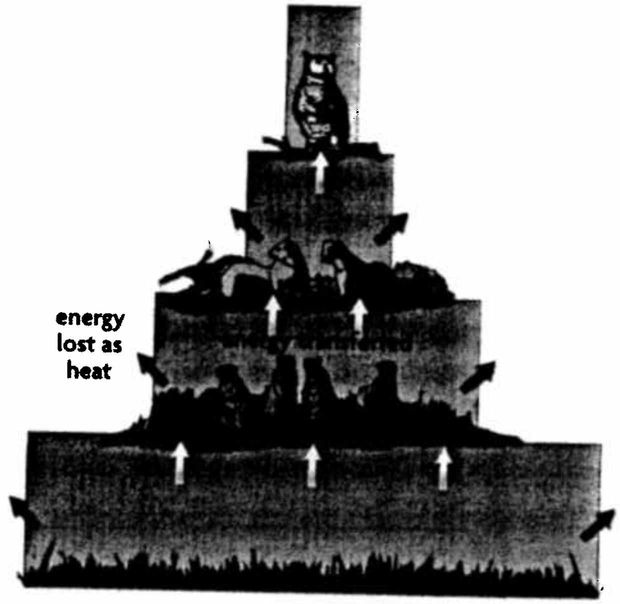
When herbivores eat plants, most of the energy is not used by the organisms at all. Instead, it is lost as heat. When carnivores then eat the herbivores, again, most of the energy is lost as heat.

This loss of energy at each feeding level can be illustrated by an energy pyramid. An **energy pyramid** is a diagram that compares the energy used by producers and different levels of consumers. In other words, an energy pyramid shows how much energy is available at each feeding level. Because energy is lost at each level, a typical energy pyramid has a large base of producers. Each level above gets smaller, because as energy is lost as heat, there is less energy available as food. The more types of organisms involved, the more energy is lost between the bottom and top of the pyramid. An example of an energy pyramid is shown in Figure 7.4.

Main Idea: The chemical elements such as carbon, hydrogen, nitrogen, and oxygen, that make up the molecules of living things pass through food webs and are combined and recombined in different ways.

All matter cycles in and out of an ecosystem. For example, water moves continuously through the water cycle. The water cycle is the circular pathway of water on Earth—from the atmosphere, to the surface, below ground, and back into the atmosphere again. As you have learned, part of that pathway involves humans and other organisms, which all have bodies made mostly of water.

Figure 7.4 An energy pyramid shows the energy flow between levels in an ecosystem. Energy is lost as heat along the way.



Carbon, oxygen, nitrogen, hydrogen, phosphorus, and sulfur also cycle through ecosystems.

Carbon atoms are a good example of molecules that cycle through an ecosystem. You have learned that carbon can be found in sugars. Sugars, also known as carbohydrates, are just one type of carbon-containing energy source. Carbon is found in proteins, fats, and all the other molecules that make up living things. Carbon can be found in many different forms—as gas in the atmosphere, dissolved in water, in fossil fuels such as oil and coal, in rocks such as limestone, and in the soil. Processes such as respiration and the burning of fossil fuels return carbon to the atmosphere.

NYS Regents Questions

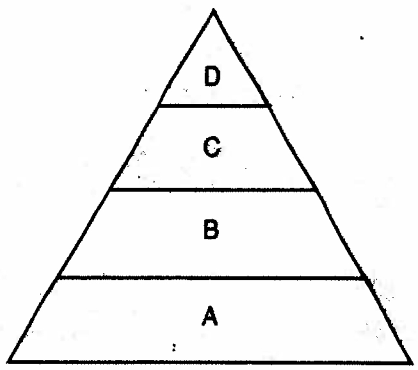
4 In an ecosystem, what happens to the atoms of certain chemical elements such as carbon, oxygen, and nitrogen?

(1) They move into and out of living systems.
(2) They are never found in living systems
(3) They move out of living systems and never return.
(4) They move into living systems and remain there.

5 Which process usually uses carbon dioxide molecules?

(1) cellular respiration
(2) asexual reproduction
(3) active transport
(4) autotrophic nutrition

6 Which statement about the energy pyramid is correct?



(1) The amount of energy needed to sustain the pyramid enters at level D.
(2) The total amount of energy decreases with each successive feeding level from D to A.
(3) The amount of energy is identical in each level of the pyramid.
(4) The total amount of energy at level D is less than the total amount of energy at level B.

7 Which statement best describes what happens to energy and molecules in a stable ecosystem?

(1) Both energy and molecules are recycled in an ecosystem.
(2) Neither energy nor molecules are recycled in an ecosystem.
(3) Energy is recycled and molecules are continuously added to the ecosystem.
(4) Energy is continuously added to the ecosystem and molecules are recycled.

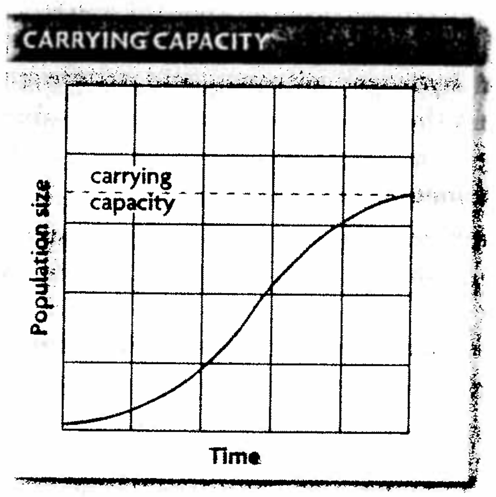
Ecosystem Interactions

Main Idea: The number of organisms any habitat can support (carrying capacity) is limited by the available energy, water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organisms through the activities of bacteria and fungi.

The size of a population is usually changing. If there are plenty of resources such as food and water, a population may grow. If there are few resources, the population may decrease in size. The rate of growth for a population depends on the resources available. The **carrying capacity** of an environment, shown in Figure 7.5, is the maximum number of individuals of a particular species that the environment can support. If the environment changes, the carrying capacity can change, too. For example, a disease might destroy a population's main food source. This situation may cause the population to crash.

Many factors affect the carrying capacity of an environment for a population. The factor that has the greatest effect on limiting population growth is called the **limiting factor.** For example, if a lack of space is the biggest factor limiting population growth, then space would be the limiting factor. Any resource an organism needs to survive can be a limiting factor—including

Figure 7.5 As a population grows, resources become more and more limited. The population eventually levels off.



water, oxygen, minerals, and the nutrients recycled through an ecosystem by decomposer activity. In an ocean ecosystem, the amount of light that can reach a certain depth is often a limiting factor.

Main Idea: Living organisms have the capacity to produce populations of unlimited size, but environments and resources are finite. This has profound effects on the interactions among organisms.

The size of a population is not the only thing that can be limited by environmental factors. The rate of population growth is also a function of the environment. A population may grow very rapidly, or it may take a bit of time to grow. When resources are abundant, a population has the opportunity to grow rapidly. This may occur when a species moves into a previously uninhabited environment.

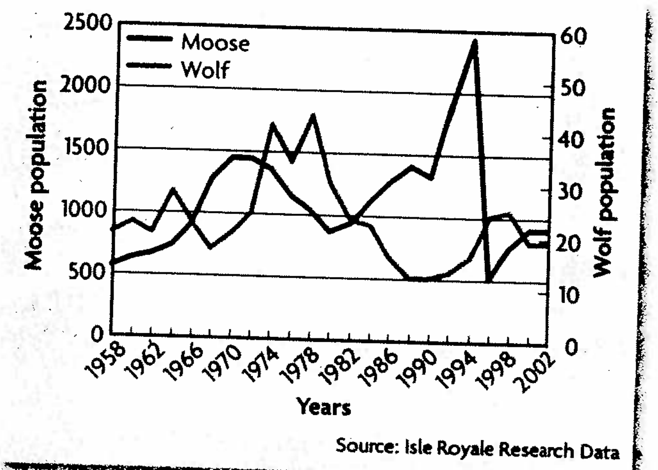
Most populations, however, face limited resources. The interactions between species can be affected by the number of individuals in a given area. **Competition** occurs when two organisms fight for the same limited resources. Members of populations compete with one another for resources such as food and shelter. As a population becomes denser, the resources are used up, limiting how large the population can grow.

Main Idea: Relationships between organisms may be negative, neutral, or positive. Some organisms may interact with one another in several ways.

There are other types of interactions between species in an ecosystem besides competition. **Predation** is the process by which one organism captures and feeds upon another organism. The population of a predator can be limited by the available prey, and the population of prey—often herbivores—can be limited by being caught for food. A relationship between predator and prey is shown in Figure 7.6.

Another type of relationship between organisms is parasitism. **Parasitism** is a relationship in which one organism benefits while the other is harmed. Parasites and diseases can spread more quickly through dense populations. The more crowded an area becomes, the easier it is for parasites or disease to spread. The parasites or diseases can then cause the size of the population to decrease.

Figure 7.6 When the population of a predator such as a wolf declines, the prey—such as a population of moose—increases. This can be seen most dramatically in the graph around the year 1990.



Sometimes a close ecological relationship forms that benefits two or more organisms of different species. One example is the relationship between certain bees and flowering plants. Bees collect pollen or nectar from flowers, and in the process they pollinate the flower.

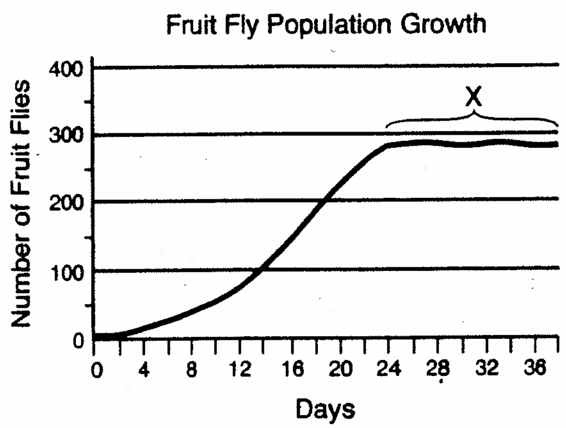
In another type of relationship, one organism benefits from a close association, and the other organism neither benefits nor is harmed. This type of relationship is positive for one species and neutral for the other species.

NYS Regents Questions

8 In most habitats, the removal of predators will have the most immediate impact on a population of

(1) producers
(2) decomposers
(3) herbivores
(4) microbes

9 Which statement best describes the fruit fly population in the part of the curve labeled X in the graph shown below?



(1) The fruit fly population has reached the number of organisms the habitat can support.
(2) The fruit fly population can no longer mate and produce fertile offspring.
(3) The fruit fly population has an average life span of 36 days.
(4) The fruit fly population is no longer able to adapt to the changing environmental conditions.

10 Cattail plants in freshwater swamps in New York State are being replaced by purple loosestrife plants. The two species have very similar requirements. This observation best illustrates

(1) variations within a species
(2) dynamic equilibrium
(3) random recombination
(4) competition between species

Ecosystem Diversity

Main Idea: As a result of evolutionary processes, there is a diversity of organisms and roles in ecosystems. This diversity of species increases the chance that at least some will survive in the face of large environmental changes. Biodiversity increases the stability of the ecosystem.

The ability of an individual to survive and reproduce is the driving force behind evolution. 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 if two species use the same resources within a habitat, there will be competition between the two species. When two species are competing for the same resources, one species will be better suited to the niche, and the other species will either be pushed into another niche or will become extinct. Excluding one species can also result when two species share different parts of a niche. Over time, two species sharing resources could evolve adaptations that decrease competition. This is one process that increases the biodiversity on Earth.

CONNECTING CONCEPTS

Adaptation Recall that an adaptation is an inherited trait that is naturally selected over time because it allows organisms to better survive in their environment. The species that are best adapted to an environment are likely to outcompete other species.

Biodiversity is the variety of living things in an ecosystem. An area with a high level of biodiversity, such as a rain forest, has a large assortment of different species living near one another. The amount of biodiversity found in an area depends on many factors, including moisture and temperature. Biodiversity gives stability to an ecosystem. In other words, biodiversity helps an ecosystem adjust to changes.

Main Idea: **Biodiversity also ensures the availability of a rich variety of genetic material that may lead to future agricultural or medical discoveries with significant value to humankind. As diversity is lost, potential sources of these materials may be lost with it.**

Consider a planted field of crops. Because each of the plants are practically identical genetically, the field has low biodiversity. However, some areas of the world have an unusually large amount of biodiversity. For example, tropical rain forests, which are moist and warm environments, cover only a small percentage of Earth's ground surface. However, they account for over half of the planet's plant and animal species. This large amount of biodiversity emphasizes the importance of conserving such areas. Tropical rain forests are one of the several areas referred to as hot spots. These hot spots, located across the globe, are ecosystems that are rich in biodiversity, but are threatened by human activities.

Biodiversity is important for many reasons, including the future of medicine and technology. Nearly half of all prescribed medicines are based on plant substances. Natural substances are also important models for many technologies. But biodiversity is not just measured in dollars. Biodiversity ensures the future health of Earth.

Many human actions threaten biodiversity. Loss of habitat and pollution are harming animal and plant populations around the world. Rain forests have the most biodiversity and are the most threatened ecosystems in the world. Preserving rain forests is an important part of preserving the biodiversity of our planet.

NYS Regents Questions

11 In an ecosystem, the presence of many different species is critical for the survival of some forms of life when

(1) ecosystems remain stable over long periods of time
(2) significant changes occur in the ecosystem
(3) natural selection does not occur
(4) the finite resources of Earth increase

12 The ecological niches of three bird species are shown in the diagram below.

What is the advantage of each bird species having a different niche?

(1) As the birds feed higher in the tree, available energy increases.
(2) More abiotic resources are available for each bird.
(3) Predators are less likely to feed on birds in a variety of locations.
(4) There is less competition for food.

Ecosystem Change

Main Idea: **Through ecological succession, all ecosystems progress through a sequence of changes during which one ecological community modifies the environment, making it more suitable for another community. These long-term gradual changes result in the community reaching a point of stability that can last for hundreds or thousands of years.**

Succession, also referred to as *ecological succession,* is a process of change in the species that make up a community. It is a sequence of changes that reestablishes an ecosystem that has been damaged or establishes a new ecosystem in an area that was not inhabited before. Succession might begin on cooled lava, after a volcano erupts. Or it might begin on bare rock that is exposed when a glacier melts. Lichens and some mosses are often the first organisms that move into a barren area. Lichens are formed by a relationship between algae cells and a fungus. The algae cells provide food to the fungus by photosynthesis, and the fungus provides a place for the algae to live. Lichens and mosses live on rock, and can break rock down into smaller pieces. Dead lichens and mosses mix with rock pieces to form a thin soil. Over time, seeds get blown in and grow in the soil. The soil continues to thicken, and eventually can support trees.

Succession also results in the regrowth of a damaged ecosystem in an area that still has healthy soil. This may occur after a small event, such as a tree falling, or after a larger event, such as a hurricane or fire.

Main Idea: A stable ecosystem can be altered, either rapidly or slowly, through the activities of organisms (including humans), or through climatic changes or natural disasters. The altered ecosystem can usually recover through gradual changes back to a point of long–term stability.

Some aspects of the environment can disturb an ecosystem's stability. Unusual weather, for example, can affect an ecosystem.

One example of this is the El Niño effect. 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. Other populations of organisms may increase as they fill niches in the now unstable ecosystem.

Natural disasters such as volcanoes, tsunamis, tornados, and hurricanes can wipe out ecosystems. For example, the large wave of a tsunami can damage fragile coral reefs, knock down entire mangrove forests, and destroy sea turtle nesting beaches. Over time, ecosystems often, although not always, recover from these natural disturbances.

Human activities also disrupt ecosystems. By clearing forests, filling wetlands, and polluting the air, land, and water, humans threaten habitats and the organisms that live in them. Because humans have the ability to greatly alter ecosystems in a short amount of time, it is harder for ecosystems to recover from human–made disturbances.

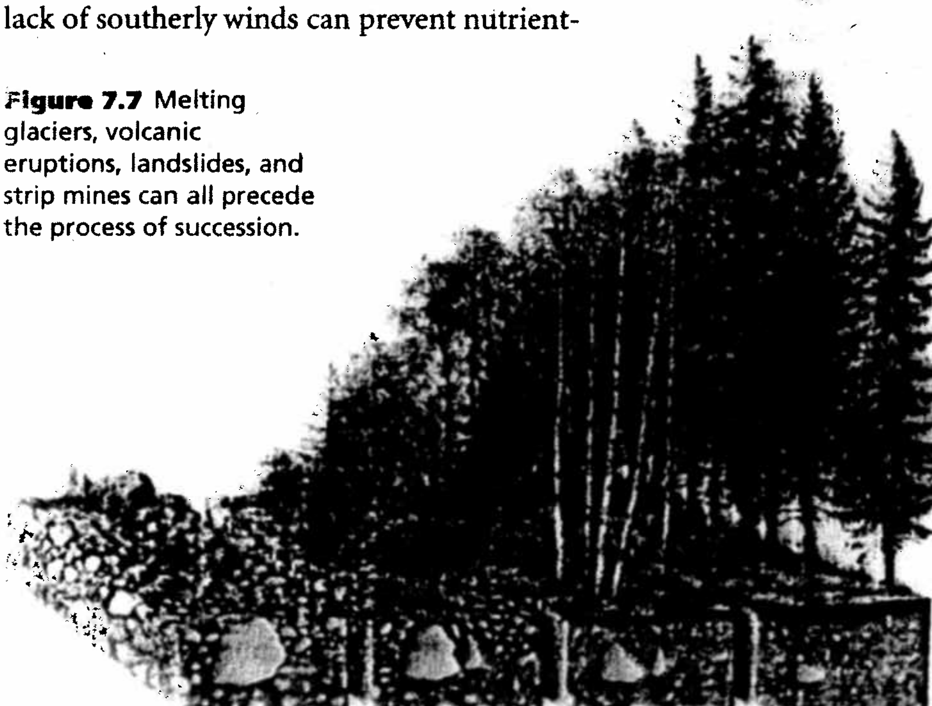


Figure 7.7 Melting glaciers, volcanic eruptions, landslides, and strip mines can all precede the process of succession.

NYS Regents Questions

13 What would most likely occur after an ecosystem is disrupted by fire?

(1) The ecosystem would eventually return to its original state.
(2) The ecosystem would return to its previous state immediately.
(3) The ecosystem would evolve into a new ecosystem that is totally different from the original.
(4) The ecosystem would become an ever–changing environment with no stability.

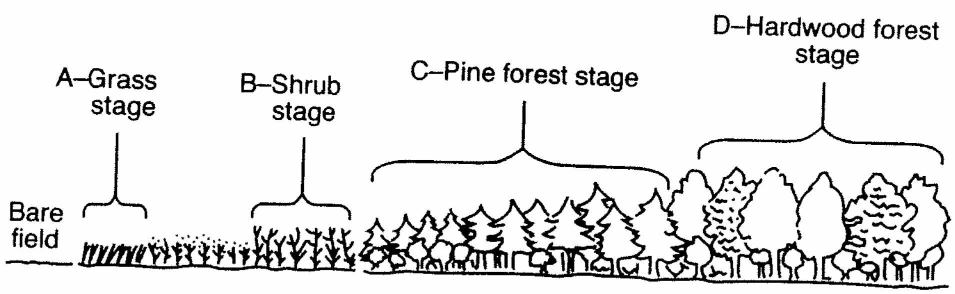
14 El Niño is a short-term climatic change that causes ocean waters to remain warm when they should normally be cool. The warmer temperatures disrupt food webs and alter weather patterns. Which occurrence would most likely result from these changes?

(1) Some species would become extinct, and other species would evolve to take their place.
(2) Some populations in affected areas would be reduced, while other populations would increase temporarily.
(3) The flow of energy through the ecosystem would remain unchanged.
(4) The genes of individual organisms would mutate to adapt to the new environmental conditions.

15 Lichens and mosses are the first organisms to grow in an area. Over time, grasses and shrubs will grow where these organisms have been. The grasses and shrubs are able to grow in the area because the lichens and mosses

(1) synthesize food needed by producers in the area
(2) are at the beginning of every food chain in a community
(3) make the environment suitable for complex plants
(4) provide the enzymes needed for plant growth

16 Stage D in the diagram below is located on land that was once a bare field.



The sequence of stages leading from bare field to stage D best illustrates the process known as

(1) replication
(2) recycling
(3) feedback
(4) succession