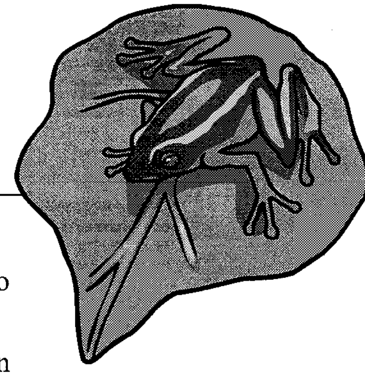
Changes in Ecosystems

Section 21.1
Population Factors



Pre-View 21.1

- **Carrying capacity** – the largest number of organisms that can be supported to live in an ecosystem
- **Logistic growth** – natural population growth the follows an S-shapped pattern
- **Limiting factors** – things that limit how many organisms can live in a population
- **Immigration** – the movement of organisms into an area
- **Emigration** – the movement of organisms out of an area
- **Density dependent factors** – limiting factors that depend on the number of organisms in a population; examples: available food, water, and suitable habitats
- **Density independent factors** – limiting factors that do not depend on the number of organisms in a population; examples: natural disasters or human activities
- **Exponential growth** – unrestricted population growth that follows a J-shaped pattern

Limiting Factors of Populations

Initially, all populations in an ecosystem tend to increase in number. In a population that is new to an ecosystem, the population may grow slowly at first and then more quickly since the population will initially have unlimited resources. After a while, the rate of population growth slows down until it stops or levels off. It levels off when the environment has reached its **carrying capacity**, which is the largest number of organisms of a species that can be supported by the environment. Natural populations have a pattern of growth that follows an S-shaped curve as shown in figure 21-1. This S-shaped pattern is called **logistic growth**.

Natural Population Growth (Logistic Growth)

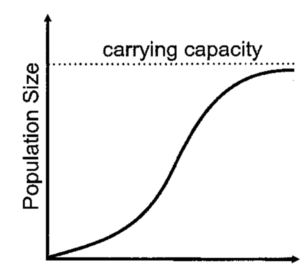
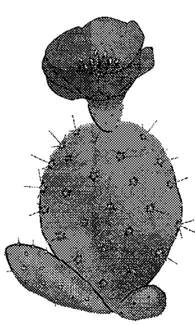


Fig. 21-1

The population growth is limited by several main factors: the birth/death rate of organisms in the population, the number of organisms entering and leaving the population, and the amount of available resources. These factors are called **limiting factors** because they limit how large a population can grow. If the birth and death rates are about even, and the immigration and emigration rates are even, then availability of resources becomes the main limiting factor. (**Immigration** is the movement of organisms into an area, and **emigration** is the movement of organisms out of an area.) Limiting factors can be biotic or abiotic. A biotic factor for animals could be competition for or the availability of food. For plants, these factors might be abiotic, such as sunlight, water, soil, and nutrients.



Example: Cacti grow in desert areas, but they are often well-spaced. Which of the following is the most likely limiting factor for cacti in a desert: sunlight, water, soil, or consumption by herbivores?

In a desert climate, the most common limiting factor for plants is the availability of water. Desert plants get plenty of sunlight and have lots of space and sand to grow. Consumption by herbivores is probably not a main limiting factor. Instead, the number of herbivores that can survive in the desert is most likely determined by the number of plants that can grow to feed them.

There are two main categories of limiting factors: density dependent and density independent. **Density dependent factors** are factors that depend on the density (the number of organisms per area) of a population. These factors include competition, predation, parasitism, and disease. **Density independent factors** are factors that do not depend on the density of a population. These factors include unusual weather, natural disasters, and human activities.

Introducing Non-Native Species into an Ecosystem

The population curve in figure 21-1 is typical of a population that grows in its native environment, but what happens when a non-native species is introduced into a new ecosystem? Sometimes the resulting population growth does not follow an S-shaped curve. If the new species has few or no natural predators and the species has plenty of food available, the population curve looks more like a J-shape as in figure 21-2. This unrestricted J-shaped pattern is called **exponential growth.**

Unrestricted Population Growth (Exponential Growth)

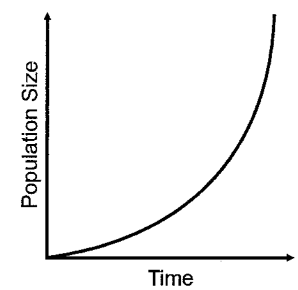
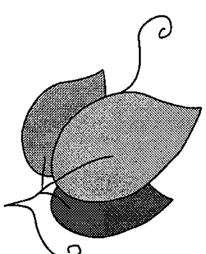


Fig. 21-2

Introducing a non-native species into an ecosystem can have disastrous results. Consider the problem of the rabbits in Australia. Rabbits were not native to Australia when some settlers took about two dozen rabbits there in the mid-1800s to use as game. The rabbits had no natural predators and now had a very large area of land with a huge food supply. They began to multiply quickly. Soon the rabbits were eating all of the grass that was intended for sheep and cattle. Even though "gentlemen hunters" could shoot as many as 1200 a day for sport, the rabbit population kept increasing. In about ten years, 2 million rabbits could be shot or trapped yearly with little effect on the rabbit population size. The rabbits destroyed vegetation and wiped out entire species of native plants. The extinction of certain plants led to the extinction of one-eighth (1/8th) of Australia's mammal species. Meanwhile, the rabbits continued to multiply. Eventually, Australians built miles of fences in an attempt to keep the rabbits from spreading into other parts of Australia. The rabbits are still a significant problem for Australian landowners today.

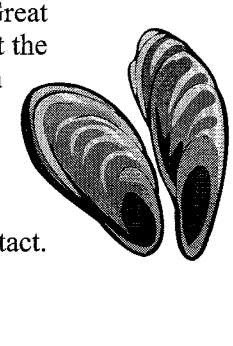


Kudzu

Kudzu is a good example of a non-native species that was introduced into the United States. Kudzu was intentionally brought into the United States from Japan in the late 1800s. Gardeners used it as an ornamental plant. Then in the 1930s, kudzu began being used for erosion control, especially in the Southeast. The government actually paid farmers to plant it! Unfortunately, kudzu vines grow too well in the Southeast. It can grow up to a foot per day during the summer and up to 60 feet per year. By the middle 1900s, it was considered an unwanted weed. Once it was established, though, it has proved to be almost impossible to kill. It is resistant to most herbicides (poisons that are designed to kill plants) and can only be chemically controlled after multiple treatments over many years' time. It indeed does control erosion as it was originally intended, but it also grows over anything that it contacts. Not only does it grow over telephone poles and abandoned houses, it can grow over trees and kill them by preventing them from getting sunlight. It crowds out native plants and wins the competition for resources. It appears that kudzu is here to stay in the Southeast, but many question the wisdom in promoting its growth years ago.

Zebra Mussels

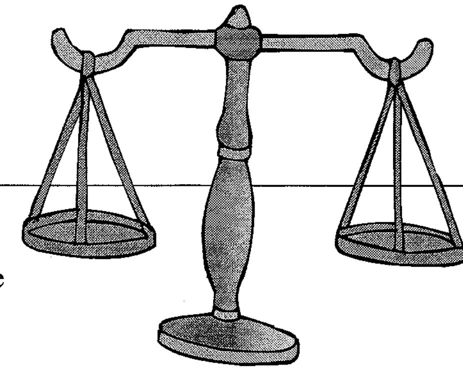
Zebra mussels are another invasive non-native species. They were introduced into the United States as recently as 1988. These small clam-like creatures are native to Asia and were accidentally introduced into the Great Lakes probably by commercial ships from Europe. These organisms have quickly spread throughout the Great Lakes region, down the Mississippi River, and into other major waterways. They reproduce in very large quantities, and although they are eaten by several types of animals, they multiply much faster than they are consumed. They have disrupted the native ecosystems. Native mussels cannot compete with the zebra mussels, so in some areas, native mussels have completely disappeared. Their prolific multiplication also damages harbors, boats, power plants that intake water, and water treatment plants because the free swimming larvae attach and grow to any solid object that they contact.



Rarely is introducing a non-native species beneficial to an ecosystem; however, in some cases, people may choose to do so for special reasons. An important reason for introducing a non-native species is pest control. For example, fire ants were introduced into the southern United States from South America and have become persistent pests. Several states are pursuing a biological control of fire ants that would mean importing parasitic flies. In South America, these parasitic flies are natural predators of the fire ants. The hope is that introducing these non-native predators would help to control the fire ant population in the United States. Introduction of non-native species may also be considered for economic reasons. The state of Maryland is considering introducing a non-native species of oyster into the Chesapeake Bay area to revive the oyster industry.

Changes in Ecosystems

Section 21.2
Population Interdependence



Pre-View 21.2

- **Dynamic equilibrium** – a state of stability in an ecosystem when the populations do not change very much
- **Biomass** – the mass of living matter

Remember that the size of a population depends on its interactions with other species and on available resources. A change that affects one population in an ecosystem will almost always affect other populations. Over a period of time, an ecosystem reaches a **dynamic equilibrium**, which is a state of stability and balance. *Equilibrium* means that the sizes of the populations remain fairly constant. *Dynamic* means that the population changes over time and does not remain static. Organisms are born, and other organisms die. When a significant change occurs in one population, the populations of other species tend to adjust to bring the ecosystem back into balance.

Example 1: Consider the food web in figure 21-3. What do you think might happen if a tree fungus killed many of the trees during the summer of one year? How would that change affect the ecosystem?

As you can see in this food web, the deer depend on the trees for one of their food sources. If the food they receive from the trees is scarce, they will be forced to seek more of their food from farmers' crops. The farmers probably won't be too happy about that, and they would probably take measures to keep deer away. It is easy to see how a change in the tree population would most likely cause a decrease in the deer population. With less food available, fewer deer can survive. The deer is one of the food sources for the mountain lion. With fewer deer, the mountain lion population must eat more rabbits and mice, so it is very probable that the rabbit and mouse populations would also decrease.

Food Web

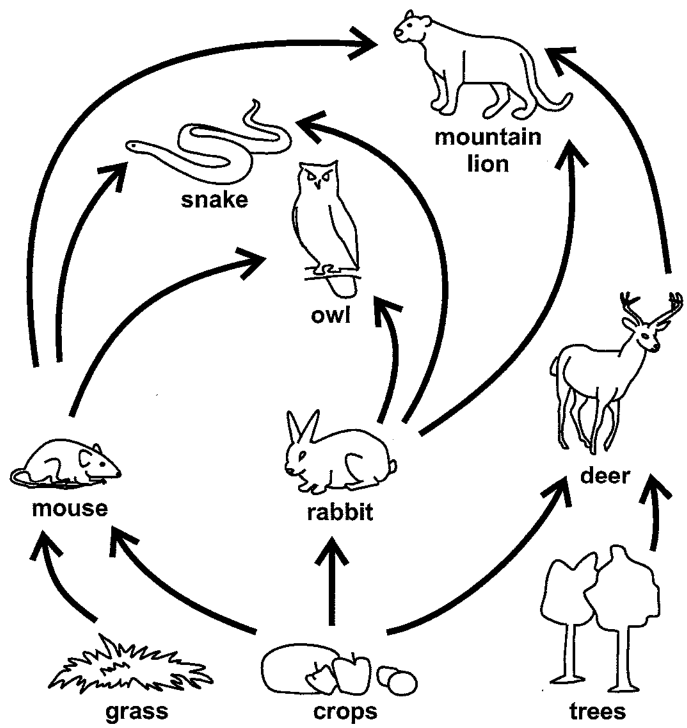


Fig. 21-3

What might be other effects from the tree fungus? The rabbits and mice that eat crops and grass now have increased competition from the deer for one of their food sources. The populations of mice and rabbits may also decrease due to increased competition for food. If the mouse and rabbit populations decrease, what happens to the owl, snake, and mountain lion populations that depend on them for their food sources? These populations would also decrease. The decreases in the populations bring about a new equilibrium in the ecosystem.

Example 2: What would happen to this same ecosystem (represented by figure 21-3) if it receives greater than normal rainfall one year and all vegetation, including the tree population, flourished?

More grass, crops, and trees mean more food is available for the mice, rabbits, and deer. More food available means that the ecosystem can support greater numbers, so the populations of these first level consumers would likely increase. This increase in first level consumer populations would likely affect and cause an increase in the second level consumer populations as well. Again, these increases in the other populations help to bring the ecosystem into balance.

Figure 21-4 is a graph that shows how minnow biomass has changed in a lake over a period of ten years. **Biomass** is the mass of living matter. The more biomass in a population, the greater or larger the number of organisms. Study the graph and consider the following example questions.

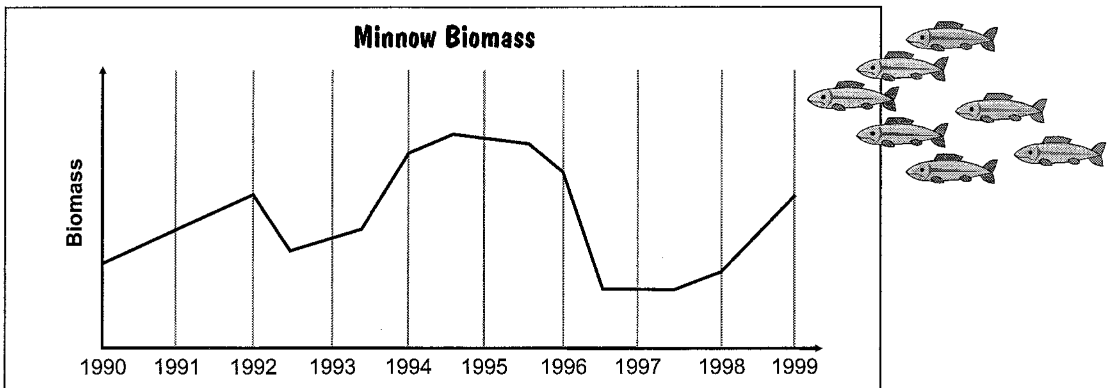


Fig. 21-4

Example 3: In what years did the minnow biomass increase?

To answer this question, look at the starting point and the ending point of each year. If the ending point is above the starting point, the net biomass increased. The biomass increased in 1990, 1991, 1993, 1994, 1997, and 1998.

Example 4: What are possible reasons that the biomass increased in those years?

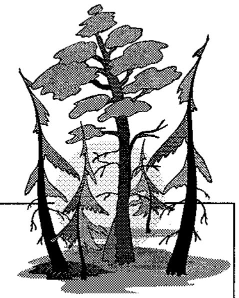
When biomass increases, the minnow population is also increasing. What would cause an increase in minnow population? More food or fewer predators. The most likely reason for the increase in biomass is an increase in algae or insect larva populations, the minnows' main food supplies. Minnows are food for many kinds of other organisms, such as birds, larger fish, and turtles. If the large fish were over-harvested by fishermen, it could possibly result in an increase in minnow population. Can you think of other reasons?

Example 5: What are possible reasons that the biomass decreased in other years?

The most obvious answer to this question is increased predation by other organisms. For example, if this lake was stocked with large game fish in the middle of 1995, it might explain the large decrease in minnow biomass through the middle of 1996.

Changes in Ecosystems

Section 21.3
Ecological Succession



Pre-View 21.3

- **Ecological succession** – predictable changes in an ecosystem
- **Primary succession** – the type of changes that occurs in an ecosystem that has no soil; occurs after a major disturbance
- **Pioneer species** – the first organisms to live in an ecosystem
- **Climax community** – the final community of organisms in an ecosystem once it becomes stable
- **Secondary succession** – the type of changes that occurs in an ecosystem after a disturbance that does not remove the soil

Ecosystems are always changing. Some changes are short-term; they occur suddenly, and the ecosystem recovers quickly. Other changes are gradual, and their effects may last for many years. Both long-term and short-term changes can result from natural causes, such as weather disturbances or even a volcanic eruption. Other changes are due to human actions, such as strip mining or clearing large areas of land.

Ecological succession is a series of predictable changes in an ecosystem. There are two types of succession: primary succession and secondary succession.

Primary Succession

Primary succession starts on the earth's surface where there is no soil. This type of succession occurs after a major disturbance, such as a volcano eruption that has removed or covered all of the soil. The following is a list of steps that may occur in primary succession.

Example of Primary Succession in a Terrestrial Community

lichens → mosses → grasses → shrubs and seedlings → trees

- The first organisms to live in the area are called **pioneer species**, and many times they are lichens. As the lichens grow on bare rocks, they help to form a thin layer of soil by breaking up the surface of the rock and by depositing organic material.
- The shallow soil allows the growth of mosses, which are followed by small plants such as grasses. The shallow soil may allow animal populations, such as earthworms, roundworms, and insects, to begin growing.
- The worms enrich the soil, and the insects may help pollinate the plants. As the layer of soil gets deeper, shrubs and small seedlings can establish themselves.
- Birds and small mammals may move into the area.
- If the climate allows, pine trees may then replace grasses and shrubs since these trees thrive in direct sunlight. These trees may provide shelter for larger mammals. The shade of the pine trees also provides favorable growing conditions for hardwood trees, like maple and oak.
- The hardwood trees eventually crowd out the pine trees.
- The ecosystem will eventually reach a stable stage in its community development. This final community of organisms is known as the **climax community**. Climax communities change so little that they seem to be permanent and unchanging, but they are still affected by changes in climate and by other factors, such as the invasion of non-native species.

The climax community in a temperate deciduous forest biome might be a forest of maple and oak trees with a wide variety of animal life. In a grassland biome, the climax community might be grasses and the animals that thrive in the grasslands, but the climate would prevent trees from ever growing there.

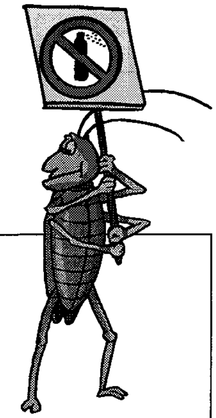
As a community undergoes primary succession, a pond may form. Ponds are never climax communities. In a pond ecosystem, blue-green bacteria and algae may be the primary producers. These producers will then support zooplankton, small fish, amphibians, and a variety of invertebrates. On the shore of the pond, water plants may begin to grow. Sediment will continuously fall to the bottom of the pond, and the pond will become more and more shallow. Eventually, the pond will be filled in completely. Grasses will yield to trees, and the climax community will be a forest.

Secondary Succession

Secondary succession is a different type of succession. It occurs when something changes an existing community but does so without removing the soil. A large wildfire or clearing and plowing could cause secondary succession. Secondary succession occurs more quickly than primary succession because the ecosystem isn't starting from scratch. Seeds and organisms that survive underground may already by present. The stages of secondary succession are usually about the same as with primary succession, but without the stage of forming soil. The end result is a climax community.

Changes in Ecosystems

Section 21.4
Human Impact on Ecosystems



Pre-View 21.4

- **Algal bloom** – an excessive growth of algae due to fertilizer run-off
- **Biological magnification** – the buildup of chemicals in consumers as the chemicals are passed up the food chain
- **Biodiversity** – the variety of life in an area
- **Ozone layer** – a layer in the upper atmosphere that protects the earth's surface from ultraviolet radiation coming from the sun
- **CFCs (chlorofluorocarbons)** – chemical compounds used in aerosol cans that destroy atmospheric ozone
- **Natural resources** – materials found in nature and used by humans
- **Conservation** – preserving and restoring natural habitats
- **Biodegradable** – describes objects that easily decompose in the environment

Humans and modern technology have greatly impacted ecosystems, and many times, we prevent succession and recovery from taking place. As the human population has increased, humans have competed with other organisms for space, food, and water. The increased competition has disrupted the flow of energy within ecosystems and has interrupted how nutrients are recycled.

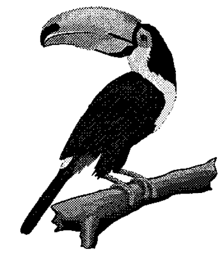
Decreasing Biodiversity

For many years, humans were hunters and gatherers and had little impact on the environment. Eventually people looked for a more reliable source of food, and this search led to the first farmers. As people grew less dependent on hunting and gathering, they started to live closer together in settlements. To produce the food needed for more people, larger areas of land had to be cleared. Clearing the land disrupted many natural habitats.

People need places to live, and they compete with other organisms for that space. When large developments are built, many natural habitats are destroyed, and the earth's biodiversity decreases. **Biodiversity** is defined as the variety of life in an area, and the effects of urban development on biodiversity can be seen quickly. Many of the habitats that remain after urban development are so fragmented that they cannot support as many species as larger areas. Let's look at some examples.

Small Scale Changes

Humans have impacted ecosystems and decreased biodiversity on both a small scale and a large scale. On a small scale, people do things such as fertilize and chemically treat their lawns and gardens. These actions impact natural habitats. Native species of plants that are considered weeds in a grass lawn are killed. Garden pests, like slugs, aphids, and grasshoppers, may be killed by man-made pesticides. These chemicals eventually make their way into and pollute the groundwater or local water supplies. Construction projects can increase sediment added to nearby lakes and ponds, which in turn, decreases water quality and harms aquatic wildlife. As homes and businesses are landscaped, non-native species (sometimes called exotic species) can be introduced, and they can compete with native species. Sometimes people even purchase exotic species of animals as pets and then release them into the wild when the animals grow too large or when they can no longer care for them. When released, these animals have no natural predators and may take over niches of native species. So the individual actions of one person, one family, or one company can have a measurable effect on ecosystems and cause a decrease in biodiversity.



Clearing Tropical Rainforests

On a larger scale, humans have also impacted ecosystems. Huge amounts of tropical rainforests are cleared every year. Remember that the tropical rainforests are the biomes that have the largest amount of biodiversity; they have the most different types of organisms. As rainforests are cleared for their timber and as the land is then converted to farmland, thousands of different species are being lost each year. Since many of today's medicines are discovered from plants that grow in the rainforest, the loss of these plant species means losing potentially life-saving ingredients. The large-scale loss of trees and plants also decreases photosynthesis and impacts the carbon and oxygen cycles. Carbon dioxide increases in the atmosphere, and oxygen decreases.

Draining Everglades

Another example of a large-scale human impact on an ecosystem is the draining of the Florida Everglades. The marshy wetlands in Florida were not a suitable place to build homes, so in the 1930s, developers decided to drain the land. By draining these wetlands, much of the fragile ecosystem was disrupted or destroyed. People could now inhabit the drained land, but the many species of plants and animals that depended on the marsh could not.

Strip Mining

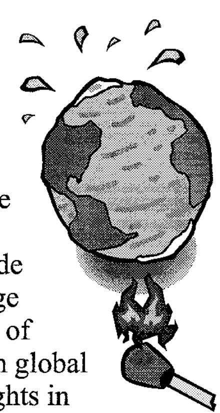
When resources, such as coal and valuable minerals, are near the surface of the earth, companies will often remove the top layer of earth to get to the resources below. This practice is called **strip mining**. Strip mining changes the surface of the land, can divert rivers and streams, and destroys the vegetation growing in the area. Although this type of mining is valuable in obtaining needed resources, it is also harmful to ecosystems.

Effects of Chemicals

With advancements in agriculture, water supplies are diverted for irrigation, chemical fertilizers are added to the soil, and chemical pesticides are applied to crops. Run-off from fertilizers increases the growth of algae (called **algal bloom**) in ponds and streams. When the algae die, the process of decomposition depletes the water of available oxygen that is needed by fish and other aquatic animals. As a result, many of the fish and aquatic animals die.

Chemical pesticides cause problems as well. Some pests have developed a resistance to the chemicals so that stronger and stronger pesticides must be used to achieve the desired effects. Other pesticides, like DDT, which is now banned in the United States, are not excreted from the tissues of organisms but build up in them instead. This build-up causes **biological magnification**, meaning that the toxic chemical becomes highly concentrated in the tissues. For example, when a big fish eats many small fish that have DDT in them, the DDT becomes even more concentrated in the tissues of the large fish. If an eagle eats several large fish, the DDT concentration may be so high that the eggs of the eagle are affected. The biological magnification of DDT is blamed for contributing to the near-extinction of the bald eagle before the chemical was banned. Biological magnification can occur in any man-made chemical that does not quickly break down in the environment. It can also occur with toxic heavy metals, such as mercury and lead.

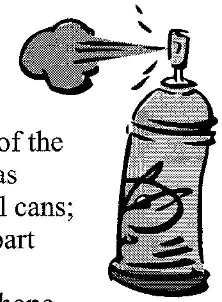
Global Warming



The two world-wide environmental issues that are causing the most concern among scientists are global warming and the thinning ozone layer. You may have heard a lot about global warming recently. Although some scientists say that rising global temperatures are part of the natural temperature cycles in climate, others are concerned that temperatures are increasing more quickly due to the effects of human activities. Greenhouse gases in the atmosphere, which include ozone, carbon dioxide, water vapor, and methane, trap heat in the atmosphere, but it is carbon dioxide that is most often cited as increasing global warming. In the past 200 years, carbon dioxide concentrations in the atmosphere have increased due to burning fossil fuels and cutting down large areas of forests. Both of these activities disrupt the carbon cycle. Although the predicted increase of global temperature by 1 to 2 degrees Celsius seems small, it would have a considerable impact on global climate. Melting of polar ice caps, rising ocean levels, flooding of coastal areas, and severe droughts in parts of North America have been predicted based on this increase in temperature.

Thinning Ozone

About 20 kilometers above the surface of the earth is a layer of ozone gas called the **ozone layer.** Ozone is made of three oxygen atoms and is considered a pollutant at ground level. However, the ozone layer in the atmosphere is very important because it protects the earth's surface from harmful ultraviolet (UV) radiation. UV radiation causes sunburn, damages eyes, can cause cancer, damages plant tissues, and lowers resistance to disease.



About 30 years ago, scientists noticed that the ozone layer over Antarctica has a hole in it, and a hole appeared over the Arctic later. By 1995 the hole over the Arctic had grown so large that parts of the United States were exposed to higher levels of UV radiation. This problem with the ozone layer was caused by compounds called **CFCs** (**chlorofluorocarbons**) that were used as propellants in aerosol cans; in air conditioners, freezers, and refrigerators; and in making plastic foam products. CFCs break apart ozone molecules, and although the use of CFCs is being phased out in the United States and other countries, the CFCs that are already in the atmosphere will remain for 200 to 300 years. Scientists hope that the ozone layer will begin to recover from some of the damage by the middle of the 21st century.

The Use of Natural Resources

The Industrial Revolution started many environmental changes. Increased use of machines means that extra energy is needed to operate the equipment. People began using natural resources to get energy. **Natural resources** can be classified as renewable or non-renewable. **Non-renewable resources**, like coal, oil, and natural gas, take millions of years of form. If they are completely used up, then it would take the earth millions of years to replenish them. **Renewable resources**, such as fresh water and trees, can be replenished more quickly, but they are not available in unlimited amounts. Since both renewable and non-renewable natural resources are limited, humans need to conserve all resources.

Most of the energy used by industry comes either directly or indirectly from using fossil fuels. Burning fossil fuels not only uses a non-renewable resource, it also results in acid precipitation, which damages plants and many natural habitats. The products and wastes produced by many industries also cause "land pollution." Many of these are materials that are not easily decomposed by microorganisms and thus take up space longer than most natural materials. Natural products, like banana peels, cotton clothing, and most papers, are **biodegradable**, which means they can be decomposed by microorganisms and returned to the soil in a matter of days, weeks, or months. Products made of man-made rubber and plastics, chemicals, and metals may take hundreds of years or longer to decompose.

Conservation and Increasing Biodiversity

Does the information you've read so far sound as if the earth is doomed and that nothing can be done unless we start living in caves? It's not like that at all. Now that scientists and people in general are more aware of how human actions impact ecosystems, they are now studying and using **conservation**. Conservation is the act of preserving and restoring natural habitats and using resources from the land more carefully. Large scale and small scale efforts towards conservation can increase and restore biodiversity.

Thanks to conservation efforts, endangered species and their habitats are now protected. Biologists are reintroducing species into areas where they once lived. Parts of the Florida Everglades are being restored. The government protects many habitats so that they can't be developed and changed by humans. The United States government is working with other governments in South and Central America to help restore the habitats needed for migratory birds.

Everyone can practice conservation. We can reuse and recycle. We can be aware of everyday activities that can affect the ecosystem in which we live. Making wise choices as individuals may not seem like much, but collectively these actions can put us back on the right track to a healthy and productive biosphere.