# A.P. Environmental Science Summer Reading

# Introduction to Ecology

**Updated May 2020**

**If you have had Environmental Science, then this should just serve as a refresher. If you have not had Environmental Science, then you need to study this closely. You will be expected to know this material in September.**

## #1: The Biosphere

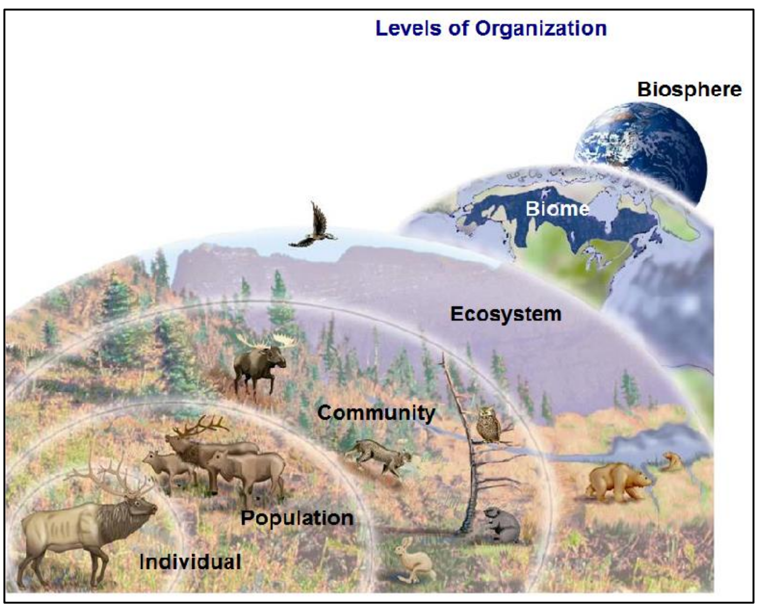
### Section 1: What is Ecology?

**Interactions and Interdependence**

**Ecology** is the scientific study of interactions among organisms and between organisms and their environment, or surroundings. The **biosphere** contains the combined portions of the planet in which all of life exists, including land, water, and air, or atmosphere. The biosphere extends from about 8 kilometers above Earth's surface to as far as 11 kilometers below the surface of the ocean. Interactions within the biosphere produce a web of **interdependence** between organisms and the environment in which they live. **The interdependence of life on Earth contributes to an ever-changing, or dynamic, biosphere.**

**Different levels of organization that ecologist's study**

**To understand relationships within the biosphere, ecologists ask questions about events and organisms that range in complexity from a single individual to the entire biosphere.** The levels of organization that ecologists study include: individuals, populations, communities, ecosystems, and biomes.



A **species** is a group of organisms so similar to one another that they can breed and produce fertile offspring. **Populations** are groups of individuals that belong to the same species and live in the same area. **Communities** are assemblages of different populations that live together in a defined area. An **ecosystem** is a collection of all the organisms that live in a particular place, together with their nonliving, or physical, environment. A **biome** is a group of ecosystems that have the same climate and similar dominant communities. **The highest level of organization that ecologist's study is the entire biosphere itself.**

**Methods used to study ecology**
**Ecological Methods**
Regardless of the tools they use, scientists conduct modern ecological research using three basic approaches: observing, experimenting, modeling. All of these approaches rely on the application of scientific methods to guide ecological inquiry.

**Observing**
Observing is often the first step in asking ecological questions. Some observations are simple. Others are complex and may form the first step in designing experiments and models.

**Experimenting**
Experiments can be used to test hypotheses. An ecologist may set up an artificial environment in a laboratory to imitate and manipulate conditions that organisms would encounter in the wild. Other experiments are conducted within natural ecosystems.

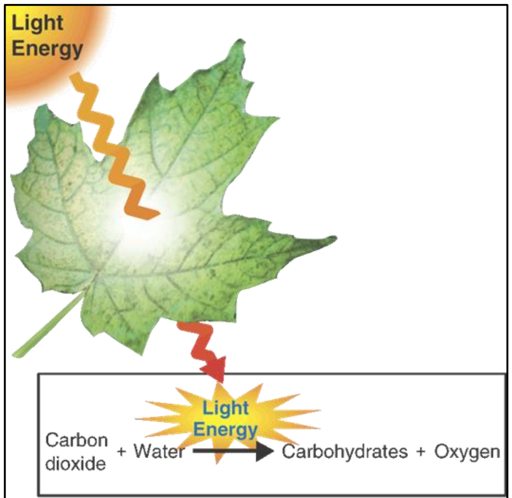
**Modeling**
Ecologists make models to gain insight into complex phenomena. Many ecological models consist of mathematical formulas based on data collected through observation and experimentation. The predictions made by ecological models are often tested by further observations and experiments.

## Section 2: Energy Flow
**The Origin of Energy for Life Processes**

**Producers**
Without a constant input of energy, living systems cannot function. **Sunlight is the main energy source for life on Earth.** In a few ecosystems, some organisms obtain energy from a source other than sunlight. **Some types of organisms rely on the energy stored in inorganic chemical compounds.** Only plants, some algae, and certain bacteria can capture energy from sunlight or chemicals and use that energy to produce food. These organisms are called **autotrophs. Autotrophs** use energy from the environment to fuel the assembly of simple inorganic compounds into complex organic molecules. These organic molecules combine and recombine to produce living tissue. Because they make their own food, **autotrophs** are called **producers**.

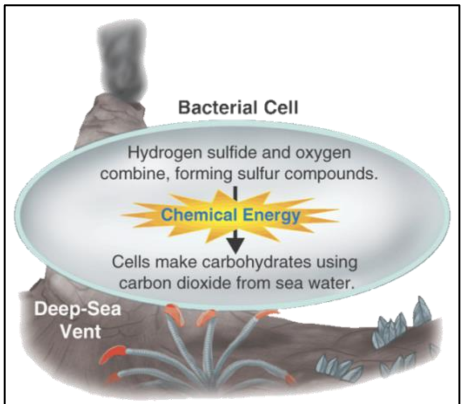
**Energy from the Sun**

The best-known autotrophs harness solar energy through a process known as photosynthesis. During **photosynthesis**, these autotrophs use light energy to convert carbon dioxide and water into oxygen and energy-rich carbohydrates. Photosynthesis is responsible for adding oxygen to—and removing carbon dioxide from—Earth's atmosphere. Plants are the main autotrophs on land. Algae are the main autotrophs in freshwater ecosystems and in the upper layers of the ocean. Photosynthetic bacteria are important in certain wet ecosystems such as tidal flats and salt marshes.



PHOTOSYNTHESIS IN PLANTS

**Life Without Light**
Some autotrophs can produce food in the absence of light. When organisms use chemical energy to produce carbohydrates, the process is called **chemosynthesis**.



CHEMOSYNTHESIS IN SULFUR BACTERIA

**Chemosynthesis** is performed by several types of bacteria. These bacteria represent a large proportion of living autotrophs. Some **chemosynthetic bacteria** live in very remote places on Earth, such as volcanic vents on the deep-ocean floor and hot springs. Others live in more common places, such as tidal marshes along the coast.

**Consumers**
Many organisms cannot harness energy directly from the physical environment. Organisms that rely on other organisms for their energy and food supply are called **heterotrophs**. **Heterotrophs** are also called **consumers**.

There are many different types of heterotrophs.

- **Herbivores eat plants.**
- **Carnivores eat animals.**
- **Omnivores eat both plants and animals.**
- **Detritivores feed on plant and animal remains and other dead matter.**
- **Decomposers, like bacteria and fungi, break down organic matter.**

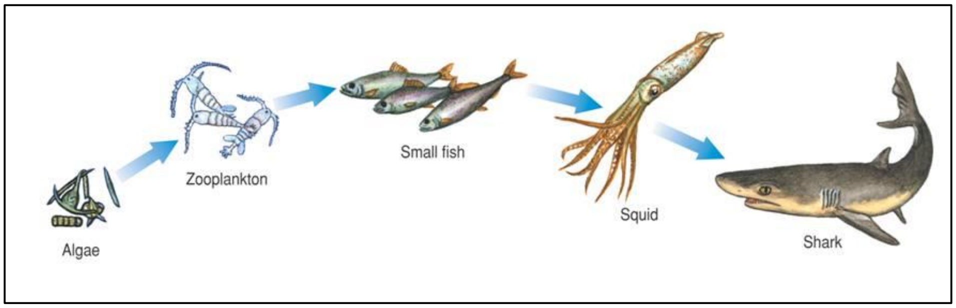
**Energy Flow Through Living Systems**

**Feeding Relationships**

The relationships between producers and consumers connect organisms into feeding networks based on who eats whom. **Energy flows through an ecosystem in one direction, from the sun or inorganic compounds to autotrophs (producers) and then to various heterotrophs (consumers).**

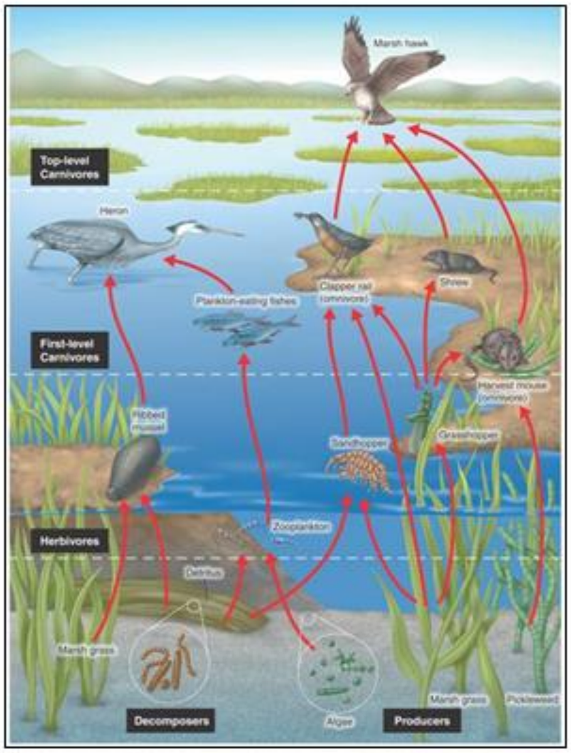
**Food Chains**

A **food chain** is a series of steps in which organisms transfer energy by eating and being eaten.
In some marine food chains, the producers are microscopic algae and the top carnivore is four steps removed from the producer.




**Food Webs**

Ecologists describe a feeding relationship in an ecosystem that forms a network of complex interactions as a **food web**. A **food web** links all the food chains in an ecosystem together.

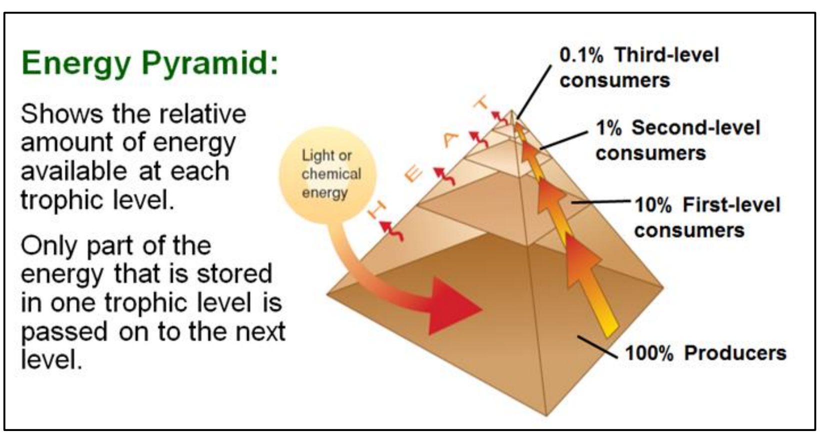



This food web shows some of the feeding relationships in a salt-marsh community.

**Trophic Levels**
Each step in a food chain or food web is called a **trophic level.** Producers make up the first trophic level. Consumers make up the second, third, or higher trophic levels. Each consumer depends on the trophic level below it for energy.

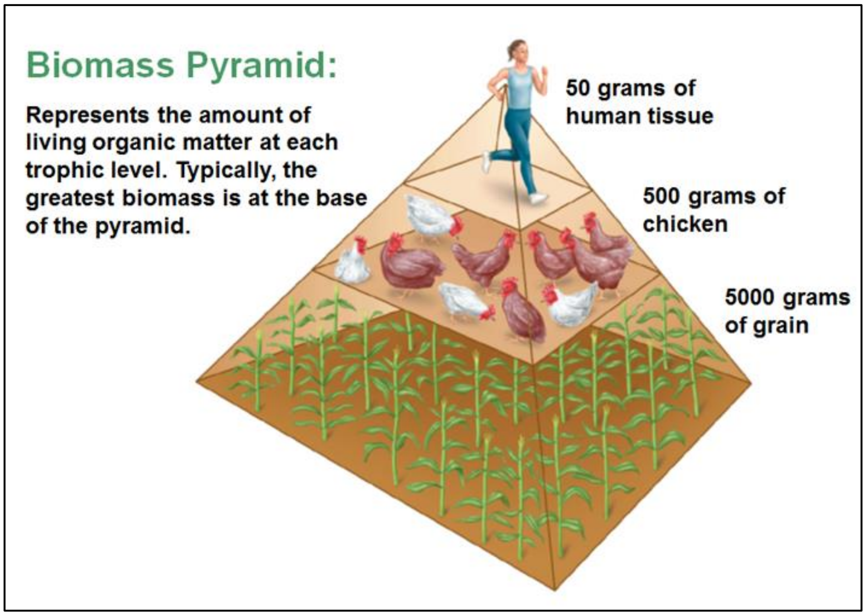
**The Efficiency of the Transfer of Energy Among Organisms in an Ecosystem**

**Ecological Pyramids**
The amount of energy or matter in an ecosystem can be represented by an **ecological pyramid.** An **ecological pyramid** is a diagram that shows the relative amounts of energy or matter contained within each trophic level in a food chain or food web. Ecologists recognize three different types of **ecological pyramids**, which include **energy pyramids**, **biomass pyramids**, and **pyramids of numbers.**

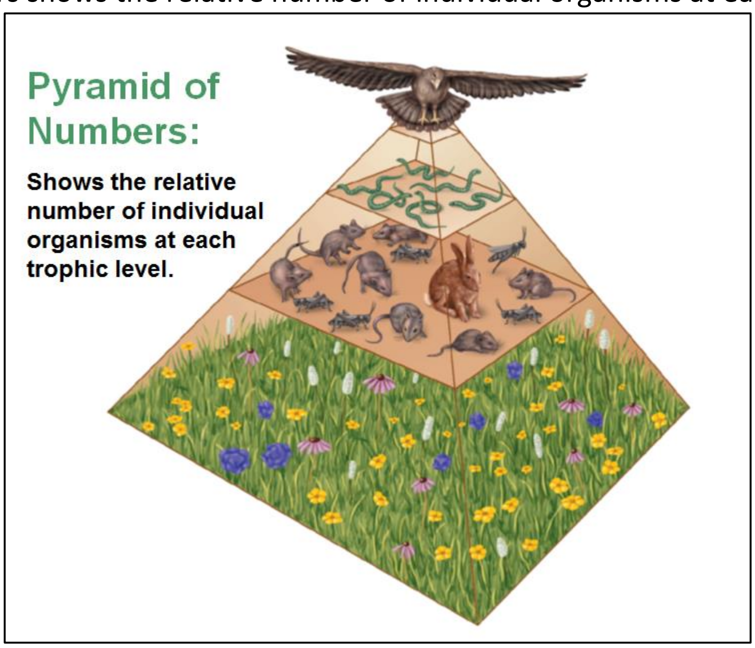


**Energy Pyramid:**
The more levels that exist between a producer and a top-level consumer in an ecosystem, the less energy that remains from the original amount. **Only about 10 percent of the energy available within one trophic level is transferred to organisms at the next trophic level.**

**Biomass Pyramid**
The total amount of living tissue within a given trophic level is called **biomass**. **Biomass** is usually expressed in terms of grams of organic matter per unit area. **A biomass pyramid** represents the amount of potential food available for each trophic level in an ecosystem.




**Pyramid of Numbers**
A pyramid of numbers shows the relative number of individual organisms at each trophic level.



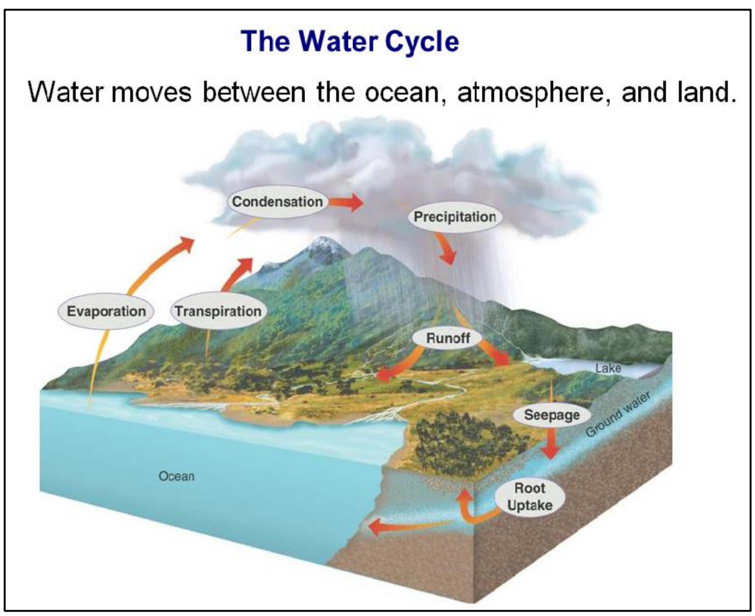
For some ecosystems, the shape of the pyramid of numbers is the same as that of the energy and biomass pyramids. However, in ecosystems where there are fewer producers than there are consumers, such as a forest ecosystem, the pyramid of numbers would not resemble a typical pyramid at all.

## Section 3: Cycles of Matter

**How Matter Moves Among the Living and Nonliving Parts of an Ecosystem**

**Recycling in the Biosphere**
Energy and matter move through the biosphere very differently. **Unlike the one-way flow of energy, matter is recycled within and between ecosystems.** Elements, chemical compounds, and other forms of matter are passed from one organism to another and from one part of the biosphere to another through biogeochemical cycles. Matter can cycle because biological systems do not use up matter, they transform it. Matter is assembled into living tissue or passed out of the body as waste products.

**The Water Cycle**
All living things require water to survive. Water molecules enter the atmosphere as water vapor, a gas, when they evaporate from the ocean or other bodies of water. The process by which water changes from a liquid form to an atmospheric gas is called **evaporation**. Water can also enter the atmosphere by evaporating from the leaves of plants in the process of **transpiration**. Water vapor condenses into tiny droplets that form clouds. The water returns to Earth's surface in the form of precipitation. Water enters streams or seeps into soil where it enters plants through their roots.

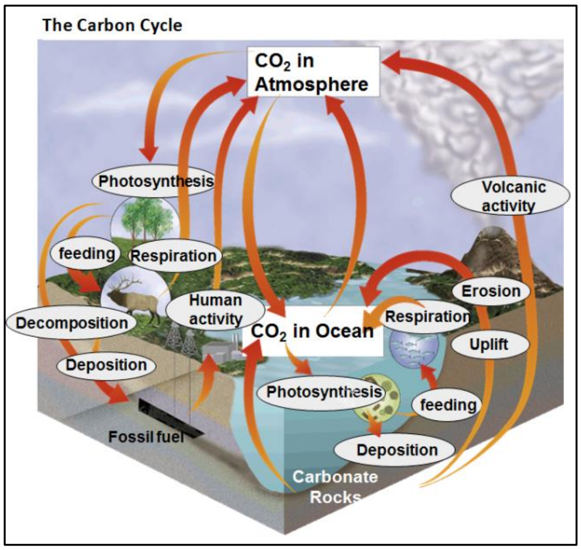


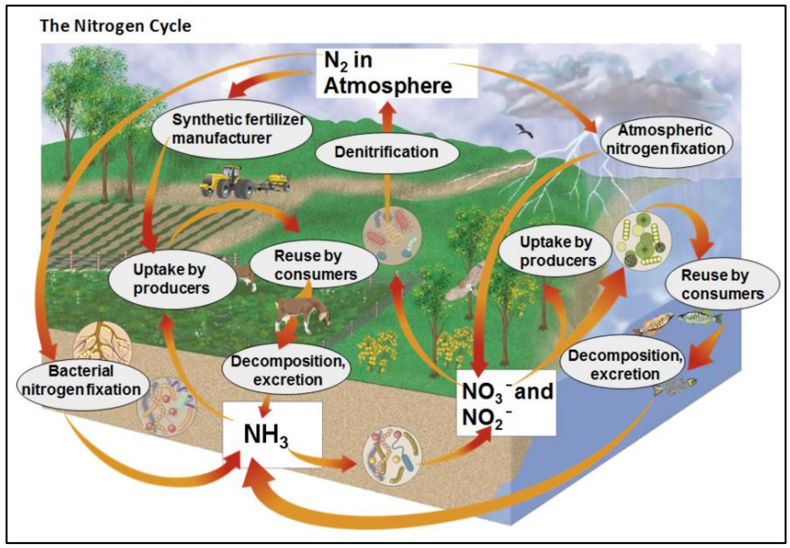

**The Importance of Nutrients in Living Systems**
**Nutrient Cycles**
All the chemical substances that an organism needs to sustain life are its nutrients. **Every living organism needs nutrients to build tissues and carry out essential life functions. Similar to water, nutrients are passed between organisms and the environment through *biogeochemical cycles*.** Primary producers, such as plants,

usually obtain nutrients in simple inorganic forms from their environment. Consumers obtain nutrients by eating other organisms.

**The Carbon Cycle**

Carbon is a key ingredient of living tissue. Biological processes, such as photosynthesis, respiration, and decomposition, take up and release carbon and oxygen. Geochemical processes, such as erosion and volcanic activity, release carbon dioxide to the atmosphere and oceans. Biogeochemical processes, such as the burial and decomposition of dead organisms and their conversion under pressure into coal and petroleum (fossil fuels), store carbon underground. Human activities, such as mining, cutting and burning forests, and burning fossil fuels, release carbon dioxide into the atmosphere.



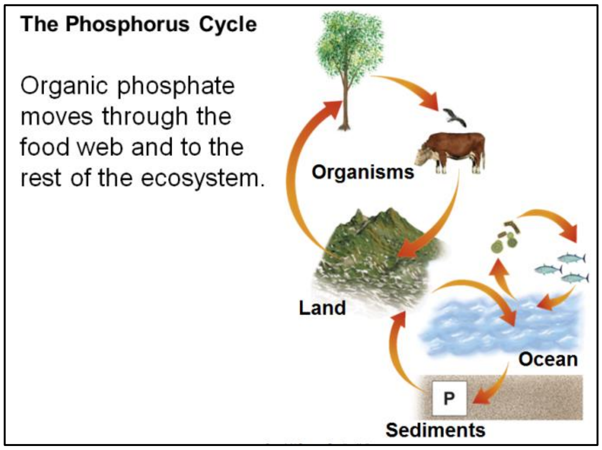




**The Nitrogen Cycle**

All organisms require nitrogen to make proteins. Although nitrogen gas is the most abundant form of nitrogen on Earth, only certain types of bacteria can use this form directly. Such bacteria live in the soil and on the roots of plants called legumes. They convert nitrogen gas into ammonia in a process known as **nitrogen fixation.** Other bacteria in the soil convert ammonia into nitrates and nitrites. Once these products are available, producers can use them to make proteins. Consumers then eat the producers and reuse the nitrogen to make their own proteins. When organisms die, decomposers return nitrogen to the soil as ammonia. The ammonia may be taken up again by producers. Other soil bacteria convert nitrates into nitrogen gas in a process called **denitrification**. This process releases nitrogen into the atmosphere once again.

**The Phosphorus Cycle**

Phosphorus is essential to organisms because it helps forms important molecules like DNA and RNA. Most phosphorus exists in the form of inorganic phosphate. Inorganic phosphate is released into the soil and water as sediments wear down. Phosphate, eventually enters the ocean, where it is used by marine organisms. Some phosphate stays on land and cycles between organisms and the soil. Plants bind the phosphates into organic compounds.




**Nutrient Limitation**

The **primary productivity** of an ecosystem is the rate at which organic matter is created by producers. One factor that controls the primary productivity of an ecosystem is the amount of available nutrients. If a nutrient is in short supply, it will limit an organism's growth. When an ecosystem is limited by a single nutrient that is scarce or cycles very slowly, this substance is called a **limiting nutrient.** When an aquatic ecosystem receives a large input of a limiting nutrient—such as runoff from heavily fertilized fields—the result is often an immediate increase in the amount of algae and other producers. This result is called an **algal bloom.** Algal blooms can disrupt the equilibrium of an ecosystem.

# Chapter 4: Ecosystems and Communities

## Section 1: The Role of Climate

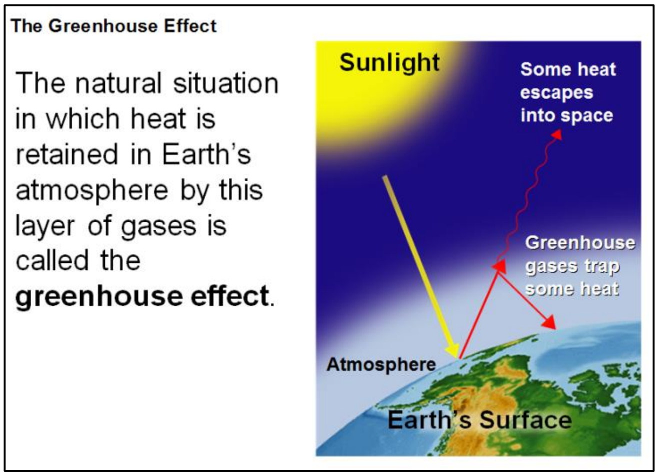
**What Is Climate?**

**Weather** is the day-to-day condition of Earth's atmosphere at a particular time and place. **Climate** refers to the average year-after-year conditions of temperature and precipitation in a particular region. Climate is caused by trapping of heat by the atmosphere, latitude, transport of heat by winds and ocean currents, amount of precipitation, and shape and elevation of landmasses.

**The Greenhouse Effect on Maintaining the Biosphere's Temperature Range**

**The Greenhouse Effect**

**Atmospheric gases that trap the heat energy of sunlight and maintain Earth's temperature range include carbon dioxide, methane, and water vapor.**



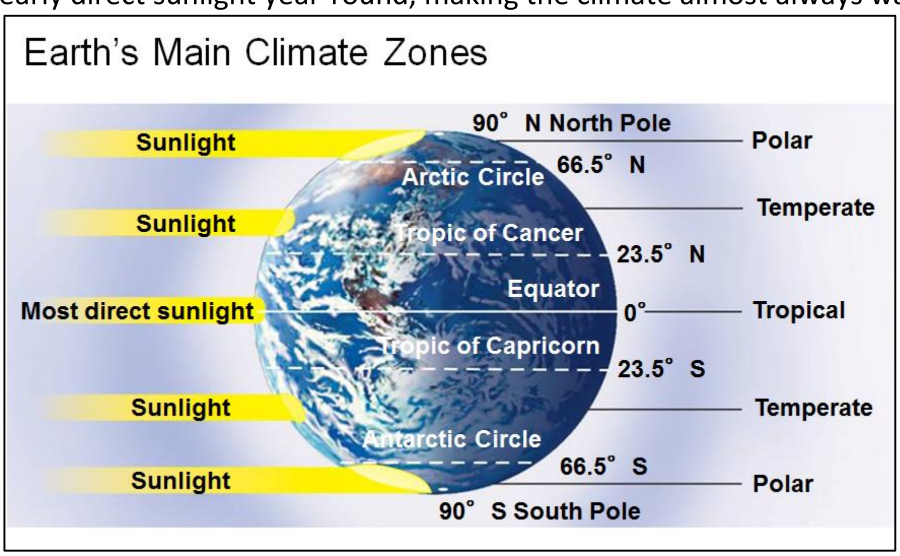

**The Effect of Latitude on Climate**
Solar radiation strikes different parts of Earth's surface at an angle that varies throughout the year. At the equator, energy from the sun strikes Earth almost directly. At the North and South Poles, the sun's rays strike Earth's surface at a lower angle.

**Earth's Three Main Climate Zones**
**As a result of differences in latitude and thus the angle of heating, Earth has three main climate zones: polar, temperate, and tropical.**

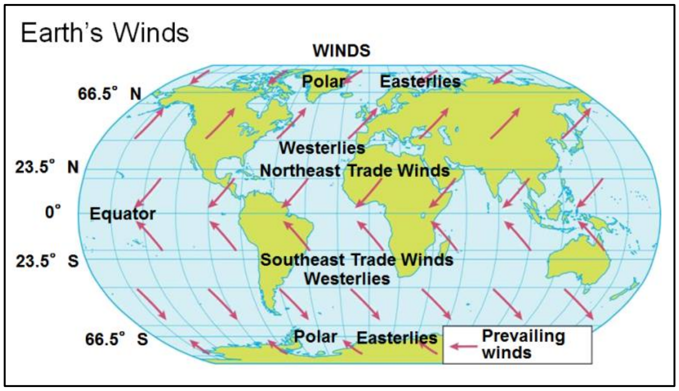
The **polar zones** are cold areas where the sun's rays strike Earth at a very low angle. Polar zones are located in the areas around the North and South poles, between 66.5° and 90° North and South latitudes.

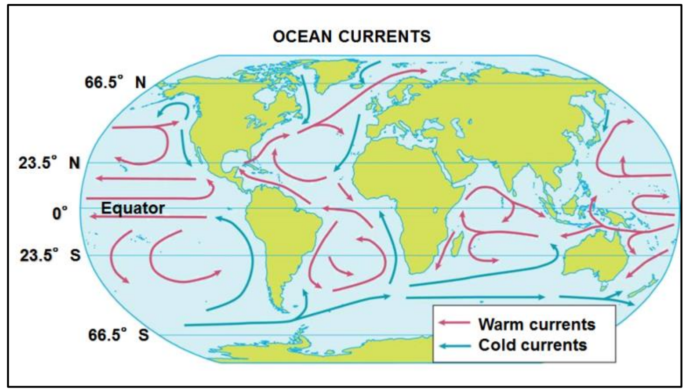
The **temperate zones** sit between the polar zones and the tropics. Temperate zones are more affected by the changing angle of the sun over the course of a year. As a result, the climate in these zones ranges from hot to cold, depending on the season.

The **tropical zone,** or tropics, is near the equator, between 23.5° North and 23.5° South latitudes. The tropics receive direct or nearly direct sunlight year-round, making the climate almost always warm



**Heat Transport in the Biosphere**
Unequal heating of Earth's surface drives winds and ocean currents, which transport heat throughout the biosphere. Warm air over the equator rises, while cooler air over the poles sinks toward the ground. The upward and downward movement of air creates air currents, or winds, that move heat throughout the atmosphere.




Similar patterns of heating and cooling occur in Earth's oceans. Cold water near the poles sinks, then flows parallel to the ocean bottom, and rises in warmer regions. Water is also moved at the surface by winds. The movement of the water creates ocean currents, which transport heat energy throughout the biosphere. Surface ocean currents warm or cool the air above them, affecting the weather and climate of nearby landmasses.

## Section 2: What Shapes an Ecosystem?

**Biotic and Abiotic Factors**
Ecosystems are influenced by a combination of **biological** and **physical** factors. The **biological** influences on organisms within an ecosystem are called **biotic factors**. **Biotic factors** include all the living things with which an organism might interact.

**Physical**, or nonliving, factors that shape ecosystems are called **abiotic factors**. **Abiotic factors** include temperature, precipitation, humidity, wind, nutrient availability, soil type, and sunlight

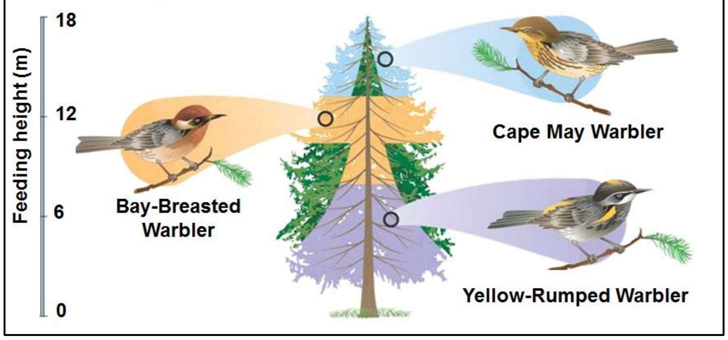
**The influence of biotic and abiotic factors on an ecosystem**
**Biotic and abiotic factors determine the survival and growth of an organism and the productivity of the ecosystem in which the organism lives.** The area where an organism lives is called its **habitat**. A habitat includes both biotic and abiotic factors.

**The Niche**
A **niche** is the full range of physical and biological conditions in which an organism lives and the way in which the organism uses those conditions. The range of temperatures that an organism needs to survive and its place in the food web are part of its niche. The combination of biotic and abiotic factors in an ecosystem often determines the number of different niches in that ecosystem. No two species can share the same niche in the same habitat. Different species can occupy niches that are very similar.

**Interactions within communities**
When organisms live together in ecological communities, they interact constantly. **Community interactions, such as competition, predation, and various forms of symbiosis, can affect an ecosystem.**

**Competition**
**Competition** occurs when organisms of the same or different species attempt to use an ecological resource in the same place at the same time. A **resource** is any necessity of life, such as water, nutrients, light, food, or space. Direct competition in nature often results in a winner and a loser—with the losing organism failing to survive. **The competitive exclusion principle** states that no two species can occupy the same niche in the same habitat at the same time.

The distribution of these warblers avoids direct competition, because each species feeds in a different part of the tree.




**Predation**
An interaction in which one organism captures and feeds on another organism is called **predation**.
The organism that does the killing and eating is called the **predator**, and the food organism is the **prey**.

**Symbiosis**
Any relationship in which two species live closely together is called **symbiosis**. **Symbiotic relationships** include: **mutualism**, **commensalism**, and **parasitism**

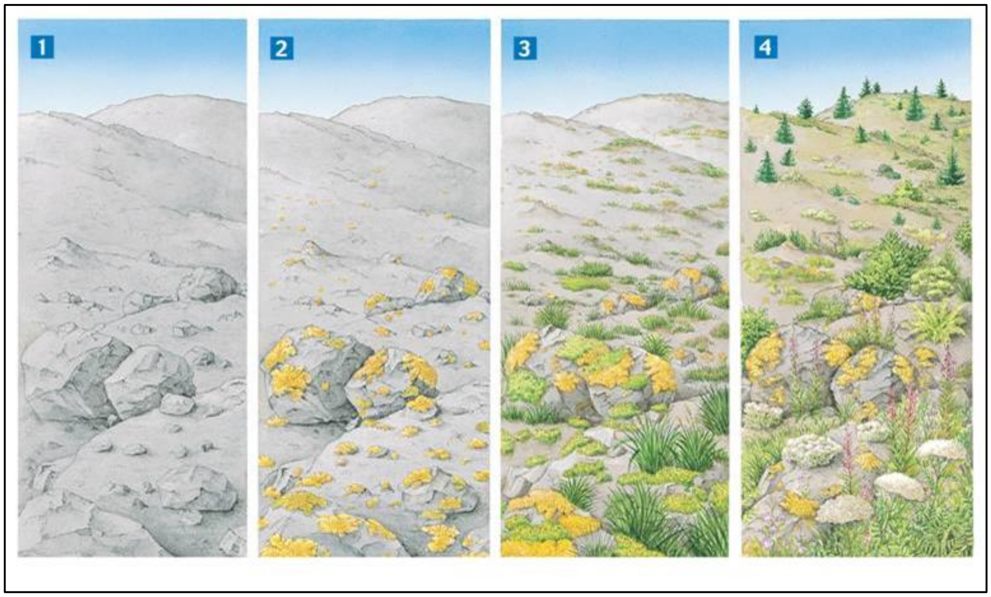
- **Mutualism**: both species benefit from the relationship.
- **Commensalism**: one member of the association benefits and the other is neither helped nor harmed.
- **Parasitism**: one organism lives on or inside another organism and harms it.

**Ecological succession**
**Ecosystems are constantly changing in response to natural and human disturbances. As an ecosystem changes, older inhabitants gradually die out and new organisms move in, causing further changes in the community.** This series of predictable changes that occurs in a community over time is called **ecological succession.** Sometimes, an ecosystem changes in response to an abrupt disturbance. At other times, change occurs as a more gradual response to natural fluctuations in the environment.

**Primary Succession**
On land, succession that occurs on surfaces where no soil exists is called **primary succession.** For example, primary succession occurs on rock surfaces formed after volcanoes erupt. The first species to populate the area are called **pioneer species**.

**In this example,**

1. a volcanic eruption has destroyed the previous ecosystem.
2. The first organisms to appear are lichens
3. Mosses soon appear, and grasses take root in the thin layer of soil.
4. Eventually, tree seedlings and shrubs sprout among the plant community.




**Secondary Succession**

Components of an ecosystem can be changed by natural events, such as fires. When the disturbance is over, community interactions tend to restore the ecosystem to its original condition through **secondary succession.** Healthy ecosystems usually recover from natural disturbances, but may not recover from long-term, human-caused disturbances.

**Succession in a Marine Ecosystem**

Succession can occur in any ecosystem, even in the permanently dark, deep ocean. In 1987, scientists documented an unusual community of organisms living on the remains of a dead whale. The community illustrates the stages in the succession of a whale-fall community. Succession begins when a whale dies and sinks to the ocean floor. Within a year, most of the whale's tissues have been eaten by scavengers and decomposers.

Succession begins when a whale dies and sinks to the ocean floor. Within a year, most of the whale's tissues have been eaten by scavengers and decomposers.

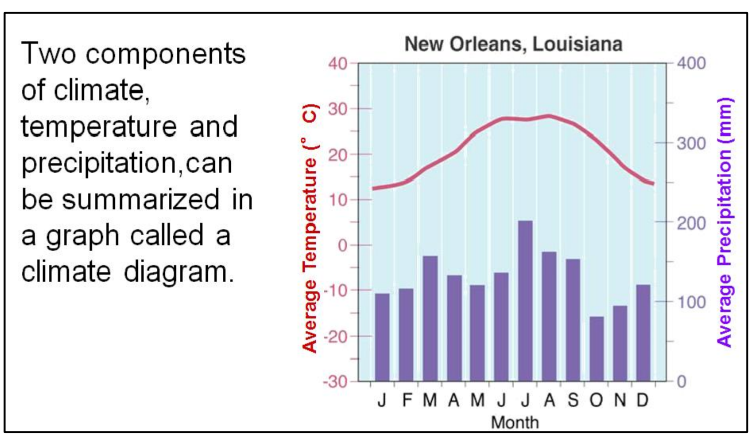
The decomposition of the whale's body enriches the surrounding sediments with nutrients.  When only the skeleton remains, heterotrophic bacteria decompose oils in the whale bones.  This releases compounds that serve as energy sources for chemosynthetic autotrophs.   The chemosynthetic bacteria support a diverse community of organisms.

## Section 3:   Biomes

A **biome** is a complex of terrestrial communities that covers a large area and is characterized by certain soil and climate conditions and particular assemblages of plants and animals.  Variations in plants and animals help different species survive under different conditions in different biomes.   Plants and animals exhibit variations in **tolerance**, or the ability to survive and reproduce under conditions that differ from their optimal conditions.

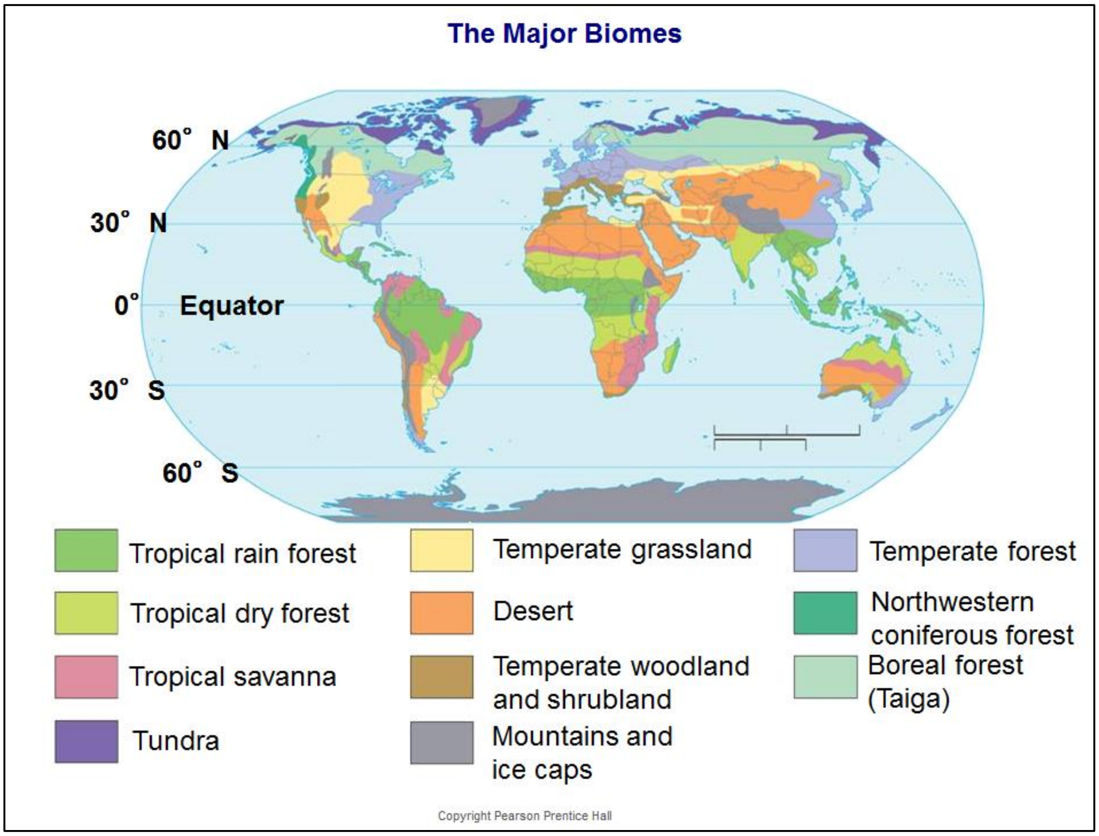
**Biomes and Climate**

The climate of a region is an important factor in determining which organisms can survive there.  Within a biome, temperature and precipitation can vary over small distances.  The climate in a small area that differs from the climate around it is called a **microclimate**.  Two components of climate, temperature and precipitation, can be summarized in a graph called a **climate diagram, as shown below**:



**The Major Biomes**
**The world's major biomes include: tropical rain forest, tropical dry forest, tropical savanna, desert, temperate grassland, temperate woodland and shrubland, temperate forest, northwestern coniferous forest, boreal forest, and tundra.**

**Unique characteristics of the world's major biomes**
**Biomes are defined by a unique set of abiotic factors—particularly climate—and a characteristic assemblage of plants and animals.**




**Tropical Rain Forest**
**Tropical rain forests** are home to more species than all other biomes combined. The tops of tall trees, extending from 50 to 80 meters above the forest floor, form a dense covering called a **canopy**. In the shade below the canopy, a second layer of shorter trees and vines forms an **understory**.
Organic matter that falls to the forest floor quickly decomposes, and the nutrients are recycled.
**Abiotic factors**: hot and wet year-round; thin, nutrient-poor soils
**Dominant plants:** broad-leaved evergreen trees; ferns; large woody vines and climbing plants
**Dominant wildlife**: sloths, capybaras, jaguars, anteaters, monkeys, toucans, parrots, butterflies, beetles, piranhas, Caymans, boa constrictors, and anacondas
**Geographic distribution:** parts of South and Central America, Southeast Asia, parts of Africa, southern India, and northeastern Australia

**Tropical Dry Forest**
**Tropical dry forests** grow in places where rainfall is highly seasonal rather than year-round. During the dry season, nearly all the trees drop their leaves to conserve water. A tree that sheds its leaves during a particular season each year is called **deciduous**.

**Abiotic factors:** generally warm year-round; alternating wet and dry seasons; rich soils subject to erosion
**Dominant plants**: tall, deciduous trees; drought-tolerant plants; aloes and other succulents
**Dominant wildlife:** tigers, monkeys, elephants, Indian rhinoceroses, hog deer, great pied hornbills, pied harriers, spot-billed pelicans, termites, snakes and monitor lizards
**Geographic distribution:** parts of Africa, South and Central America, Mexico, India, Australia, and tropical islands.

**Tropical Savanna**
**Tropical savannas,** or **grasslands**, receive more rainfall than deserts but less than tropical dry forests. They are covered with grasses. Compact soils, fairly frequent fires, and the action of large animals prevent them from becoming dry forest.
**Abiotic factors:** warm temperatures; seasonal rainfall; compact soil; frequent fires set by lightning
**Dominant plants**: tall, perennial grasses; drought-tolerant and fire-resistant trees or shrubs
**Dominant wildlife**: lions, leopards, cheetahs, hyenas, jackals, aardvarks, elephants, giraffes, antelopes, zebras, baboons, eagles, ostriches, weaver birds, and storks
**Geographic distribution:** large parts of eastern Africa, southern Brazil, and northern Australia

**Desert**
All **deserts** are dry, defined as having annual precipitation of less than 25 centimeters. Deserts vary greatly, some undergoing extreme temperature changes during the course of a day. The organisms in this biome can tolerate extreme conditions.
**Abiotic factors**: low precipitation; variable temperatures; soils rich in minerals but poor in organic material
**Dominant plants:** cacti and other succulents; plants with short growth cycles
**Dominant wildlife:** mountain lions, gray foxes, bobcats, mule deer, pronghorn antelopes, desert bighorn sheep, kangaroo rats, bats, owls, hawks, roadrunners, ants, beetles, butterflies, flies, wasps, tortoises, rattlesnakes, and lizards
**Geographic distribution:** Africa, Asia, the Middle East, United States, Mexico, South America, and Australia

**Temperate Grassland**
**Temperate grasslands** are characterized by a rich mix of grasses and under laid by fertile soils. Periodic fires and heavy grazing by large herbivores maintain the characteristic plant community.
**Abiotic factors**: warm to hot summers; cold winters; moderate, seasonal precipitation; fertile soils; occasional fires
**Dominant plants**: lush, perennial grasses and herbs; most are resistant to drought, fire, and cold
**Dominant wildlife**: coyotes, badgers, pronghorn antelopes, rabbits, prairie dogs, introduced cattle, hawks, owls, bobwhites, prairie chickens, mountain plovers, snakes, ants, and grasshoppers
**Geographic distribution:** central Asia, North America, Australia, central Europe, and upland plateaus of South America

**Temperate Woodland and Shrubland**
**Temperate Woodlands** and **Shrubland** are characterized by semiarid climates and a mix of shrub communities and open woodlands. Large areas of grasses and wildflowers are interspersed with oak trees. Communities that are dominated by shrubs are also known as chaparral. The growth of dense, low plants that contain flammable oils makes fires a constant threat.
**Abiotic factors:** hot, dry summers; cool, moist winters; thin, nutrient-poor soils; periodic fires
**Dominant plants**: woody evergreen shrubs; herbs that grow during winter and die in summer

**Dominant wildlife**: coyotes, foxes, bobcats, mountain lions, black-tailed deer, rabbits, squirrels, hawks, California quails, warblers, lizards, snakes, and butterflies
**Geographic distribution**: western coasts of North and South America, areas around the Mediterranean Sea, South Africa, and Australia

**Temperate Forest**
**Temperate forests** contain a mixture of **deciduous** and **coniferous** trees. **Coniferous** trees, or conifers, produce seed-bearing cones and most have leaves shaped like needles. These forests have cold winters that halt plant growth for several months. In autumn, the **deciduous** trees shed their leaves. Soils of temperate forests are often rich in **humus**, a material formed from decaying leaves and other organic matter that makes soil fertile.
**Abiotic factors:** cold to moderate winters; warm summers; year-round precipitation; fertile soils
**Dominant plants**: broadleaf deciduous trees; some conifers; flowering shrubs; herbs; a ground layer of mosses and ferns
**Dominant wildlife**: Deer, black bears, bobcats, squirrels, raccoons, skunks, numerous songbirds, turkeys
**Geographic distribution**: eastern United States; southeastern Canada; most of Europe; and parts of Japan, China, and Australia

**Northwestern Coniferous Forest**
**Northwestern Coniferous Forests** occur in areas where mild, moist air from the Pacific Ocean provide abundant rainfall. The forest is made up of a variety of trees, including giant redwoods, spruce, fir, hemlock, and dogwood. Because of its lush vegetation, the northwestern coniferous forest is sometimes called a "**temperate rain forest."**
**Abiotic factors**: mild temperatures; abundant precipitation during fall, winter, and spring; relatively cool, dry summer; rocky, acidic soils
**Dominant plants**: Douglas fir, Sitka spruce, western hemlock, redwood
**Dominant wildlife**: bears, elk, deer, beavers, owls, bobcats, and members of the weasel family
**Geographic distribution:** Pacific coast of northwestern United States and Canada, from northern California to Alaska

**Boreal Forest**
Dense evergreen forests of coniferous trees are found along the northern edge of the temperate zone. These forests are called **boreal forests,** or **taiga**. Winters are bitterly cold. Summers are mild and long enough to allow the ground to thaw. Boreal forests occur mostly in the Northern Hemisphere.
**Abiotic factors**: long, cold winters; short, mild summers; moderate precipitation; high humidity; acidic, nutrient-poor soils
**Dominant plants**: needle leaf coniferous trees; some broadleaf deciduous trees; small, berry-bearing shrubs
**Dominant wildlife:** lynxes, timber wolves, members of the weasel family, small herbivorous mammals, moose, beavers, songbirds, and migratory birds
**Geographic distribution**: North America, Asia, and northern Europe

**Tundra**
The **tundra** is characterized by **permafrost**, a layer of permanently frozen subsoil. During the short, cool summer, the ground thaws to a depth of a few centimeters and becomes soggy and wet. In winter, the topsoil freezes again. Cold temperatures, high winds, the short growing season, and humus-poor soils also limit plant height.

**Abiotic factors:** strong winds; low precipitation; short and soggy summers; long, cold, and dark winters; poorly developed soils; permafrost
**Dominant plants:** ground-hugging plants such as mosses, lichens, sedges, and short grasses
**Dominant wildlife:** birds, mammals that can withstand the harsh conditions, migratory waterfowl, shore birds, musk ox, Arctic foxes, caribou, lemmings and other small rodents
**Geographic distribution:** northern North America, Asia, and Europe

**Other Land Areas**
**Mountain ranges** and **polar icecaps** do not fit neatly into any of Earth's major biomes.

**Mountain Ranges**
Abiotic and biotic conditions vary with elevation. Temperatures become colder as you move from base to summit. The amount of precipitation increases as you move from base to summit. Plants and animals also change, adapting to the changing environment.

**Polar Ice Caps**
The polar regions are cold all year round. In the north polar region, the Arctic Ocean is covered with sea ice and a thick ice cap. Dominant organisms include mosses, lichens, polar bears, seals, insects, and mites. In the south polar region, Antarctica is covered by a layer of ice nearly 5 kilometers thick in some places. The dominant wildlife includes penguins and marine mammals.

## Section 4: Aquatic Ecosystems

Nearly three-fourths of the Earth's surface is covered with water. Almost all bodies of water contain a wide variety of communities governed by biotic and abiotic factors including light, nutrient availability, and oxygen.

**Main factors governing aquatic ecosystems**
**Aquatic ecosystems are determined primarily by their depth, the speed of the flow of water, temperature, and chemistry of the overlying water.** Aquatic ecosystems are often grouped according to the abiotic factors that affect them. The depth of water determines the amount of light that organisms receive. Water chemistry refers to the amount of dissolved chemicals on which life depends. Communities of organisms found in shallow water close to shore can be very different from the communities that occur away from shore in deep water. Latitude is an important abiotic factor to both land biomes and aquatic ecosystems.

**Two types of freshwater ecosystems**
**Freshwater ecosystems can be divided into two main types: flowing-water ecosystems standing-water ecosystems**. **Flowing-water** ecosystems include rivers and streams. Flowing-water ecosystems originate in mountains or hills. As the water flows downhill, it carries nutrients and organisms with it. Lakes and ponds **are standing-water** ecosystems. Still waters provide habitats for organisms such as **plankton**. **Plankton** is a general term for free-floating organisms that live in both freshwater and saltwater environments. Unicellular algae, or **phytoplankton**, are supported by nutrients in the water and form the base of many aquatic food webs. **Zooplankton** are unicellular animals that feed on phytoplankton.

**Freshwater Wetlands**
A **wetland** is an ecosystem in which water covers the soil or is present at or near the surface of the soil at least part of the year. The water in wetlands may be flowing or standing and fresh, salty, or brackish. Many

wetlands are productive ecosystems that serve as breeding grounds for many types of wildlife. **The three main types of freshwater wetlands are bogs, marshes, and swamps. Bogs** are wetlands that typically form in depressions where water collects. **Marshes** are shallow wetlands along rivers. In **swamps**, which often look like flooded forests, water flows slowly.

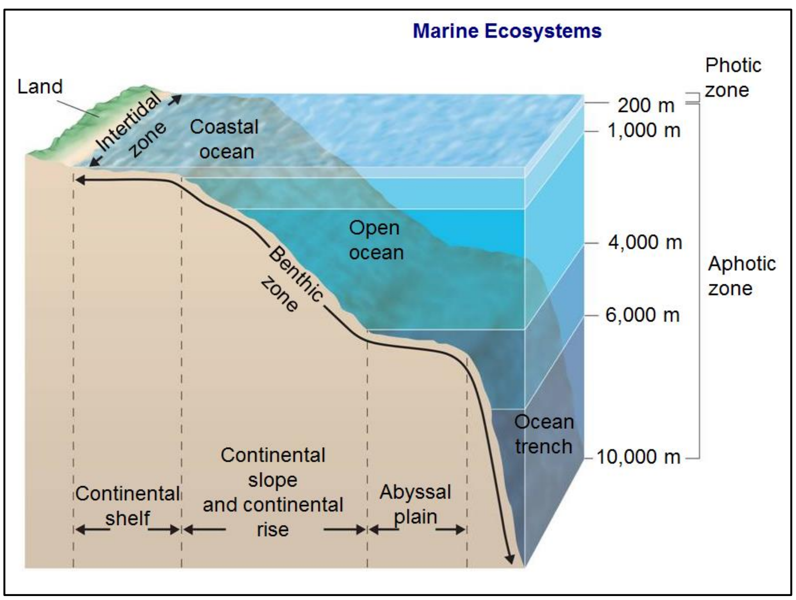
**Estuaries** are wetlands formed where rivers meet the sea. They contain a mixture of fresh and salt water, and are affected by the ocean tides. The main producers in estuaries include plants, algae, and bacteria. In estuary food webs, most primary production is not consumed by herbivores. Instead, much of that organic material enters the food web as **detritus**. **Detritus** is made up of tiny pieces of organic material that provide food for organisms at the base of the estuary's food web.

**Salt marshes** are temperate-zone estuaries dominated by salt-tolerant grasses above the low-tide line, and by seagrasses under water. Salt marshes occur in estuaries along seacoasts in the temperate zone.

**Mangrove swamps** are coastal wetlands that occur in bays and estuaries across tropical regions, including southern Florida and Hawaii. The dominant plants are salt-tolerant trees, called mangroves, with seagrasses common below the low-tide line.

**Marine Ecosystems**
The well-lit upper layer of the ocean is known as the **photic zone.** Algae and other producers can grow only in this thin surface layer. Below the photic zone is the **aphotic zone**, which is permanently dark. Chemosynthetic autotrophs are the only producers that can survive in the aphotic zone.

**Characteristics of the different marine zones**
**In addition to the division between photic and aphotic zones, marine biologists divide the ocean into zones based on the depth and distance from shore. These include the intertidal zone, the coastal ocean, and the open ocean.**




**Intertidal Zone**
Organisms that live in the intertidal zone are exposed to regular and extreme changes in their surroundings.

Competition among organisms in the rocky intertidal zone often leads to **zonation**, the prominent arrangement of organisms in a particular habitat in horizontal bands.

**Coastal Ocean**

The **coastal ocean** extends from the low-tide mark to the outer edge of the continental shelf. It falls within the photic zone, and photosynthesis occurs throughout its depth. The coastal ocean is often rich in plankton and many other organisms. **Kelp forests** are named for their dominant organism, a giant brown alga. Kelp forests are one of the most productive coastal ocean communities. Kelp forests support a complex food web.

**Coral Reefs**

**Coral reefs**, found in tropical coastal waters, are named for the coral animals whose calcium carbonate skeletons make up their primary structure. An extraordinary diversity of organisms flourishes among coral reefs. Reef-building corals grow with the help of algae that live symbiotically within their tissues.

**Open Ocean**

The open ocean, the oceanic zone, extends from the edge of the continental shelf outward. It is the largest marine zone. Most of the photosynthetic activity on Earth occurs in the photic zone of the open ocean by the smallest producers. Fishes of all shapes and sizes dominate the open ocean. Marine mammals live there but must stay close to the surface to breathe.

**Benthic Zone**

The ocean floor contains organisms that live attached to or near the bottom. These organisms are called **benthos**. The ocean floor is called the **benthic zone**. This zone extends horizontally along the ocean floor from the coastal ocean through the open ocean. Benthic ecosystems often depend on food from organisms that grow in the photic zone. Chemosynthetic primary producers support life without light near deep-sea vents.

# #2: Populations

## Section 1: How Populations Grow

### Characteristics Used to Describe a Population

**Three important characteristics of a population are its geographic distribution, density, and growth rate.**

Geographic distribution, or range, describes the area inhabited by a population. **Population density** is the number of individuals per unit area. Growth rate is the increase or decrease of the number of individuals in a population over time.

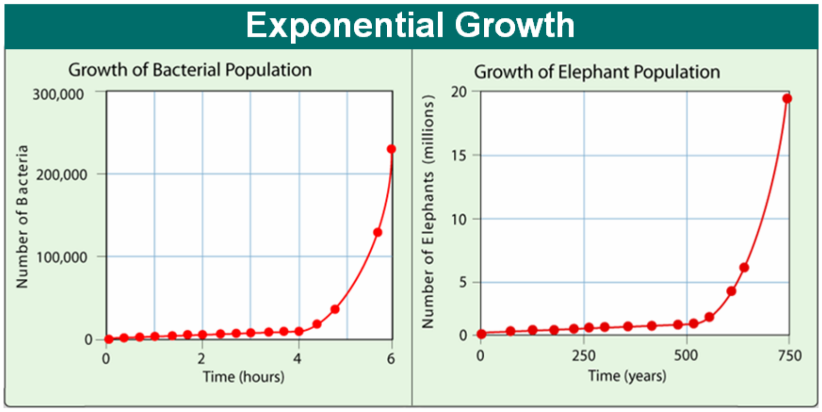
### Factors that Affect Population Size

**Three factors can affect population size are the number of births, the number of deaths, and the number of individuals that enter or leave the population.** A population can grow when its **birthrate** is greater than its **death rate**. **Immigration**, the movement of individuals into an area, is another factor that can cause a population to grow. Populations can increase by immigration as animals in search of mates or food arrive from outside. **Emigration**, the movement of individuals out of an area, can cause a population to decrease in size.   Emigration can occur when animals leave to find mates and establish new territories.   A shortage of food in one area may also lead to emigration.

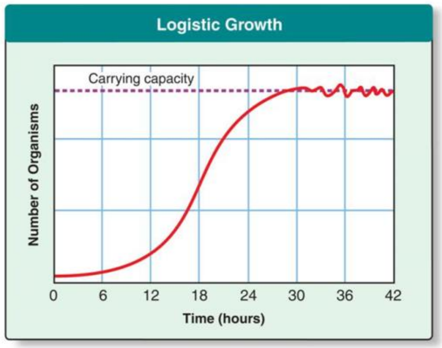
**The Difference between Exponential Growth and Logistical Growth**.

**Exponential Growth**

Under ideal conditions with unlimited resources, a population will grow **exponentially**.  **Exponential growth** occurs when the individuals in a population reproduce at a constant rate.  The population becomes larger and larger until it approaches an infinitely large size.




Logistic growth is characterized by an S-shaped curve.




**Logistic Growth**

In nature, exponential growth does not continue in a population for very long.  **As resources become less available, the growth of a population slows or stops.**   **Logistic growth** occurs when a population's growth slows or stops following a period of exponential growth.

**Carrying Capacity**

The largest number of individuals of a population that a given environment can support is called its **carrying capacity**.  When a population reaches the carrying capacity of its environment, its growth levels off. The average growth rate is zero.

## Section 2:   Limits to Growth

**Factors That Limit Population Growth**

**The primary productivity of an ecosystem can be reduced when there is an insufficient supply of a particular nutrient.   Ecologists call such substances limiting nutrients.** A limiting nutrient is an example of a more general ecological concept: a limiting factor.   In the context of populations, a **limiting factor** is a factor that causes population growth to decrease.

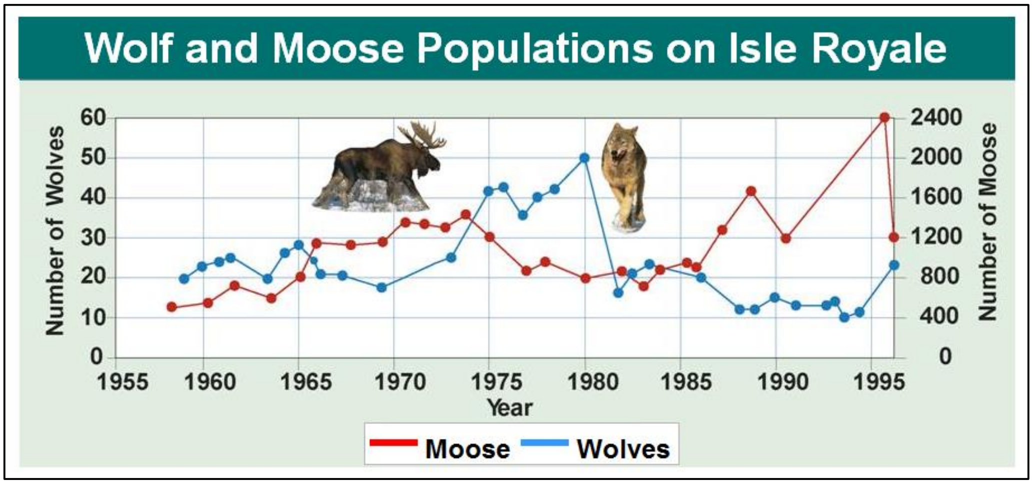
**Density-Dependent Factors**

A limiting factor that depends on population size is called a **density-dependent limiting factor**.   **Density-dependent limiting factors include competition, predation, parasitism, and  disease.** Density-dependent factors operate only when the population density reaches a certain level. These factors operate most strongly when a population is large and dense.  They do not affect small, scattered populations as greatly.

**Competition**

When populations become crowded, organisms compete for food, water space, sunlight, and other essentials.  Competition among members of the same species is a density-dependent limiting factor.  Competition can also occur between members of different species.  This type of competition can lead to evolutionary change.  Over time, the species may evolve to occupy different niches.

**Predation**
Populations in nature are often controlled by predation. The regulation of a population by predation takes place within a **predator-prey relationship**, one of the best-known mechanisms of population control.

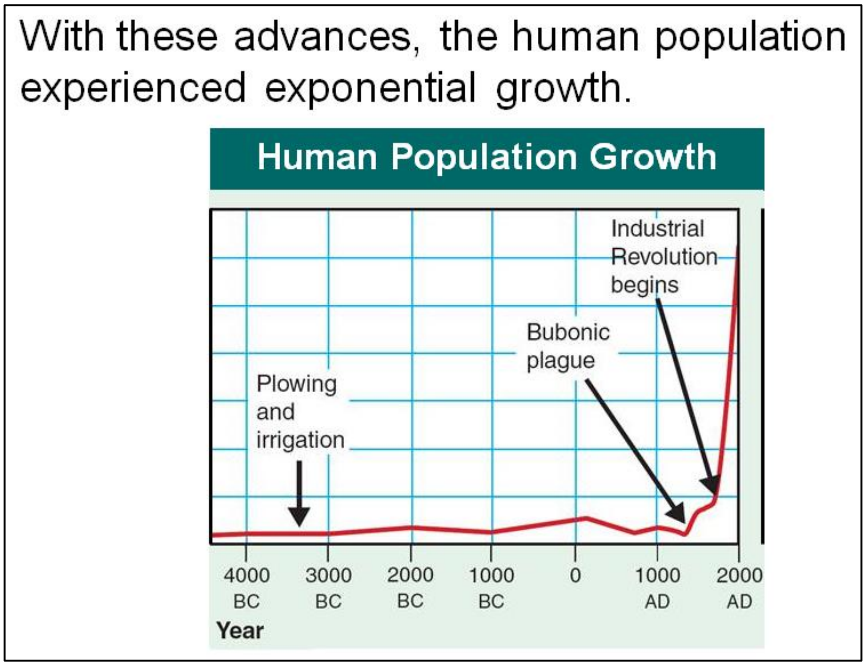



**Parasitism and Disease**
Parasites can limit the growth of a population. A parasite lives in or on another organism (the host) and consequently harms it.

**Density-Independent Factors**
**Density-independent limiting factors** affect all populations in similar ways, regardless of the population size. **Examples of density-independent limiting factors include unusual weather, natural disasters, seasonal cycles, and certain human activities—such as damming rivers and clear-cutting forests.**

## Section 3: Human Population Growth

**How the Size of the Human Population has Changed Over Time**
**Like the populations of many other living organisms, the size of the human population tends to increase with time.** For most of human existence, the population grew slowly. Limiting factors kept population sizes low. About 500 years ago, the human population began growing more rapidly. Life was made easier and safer by advances in agriculture and industry. Death rates were dramatically reduced due to improved sanitation, medicine, and healthcare, while birthrates remained high.

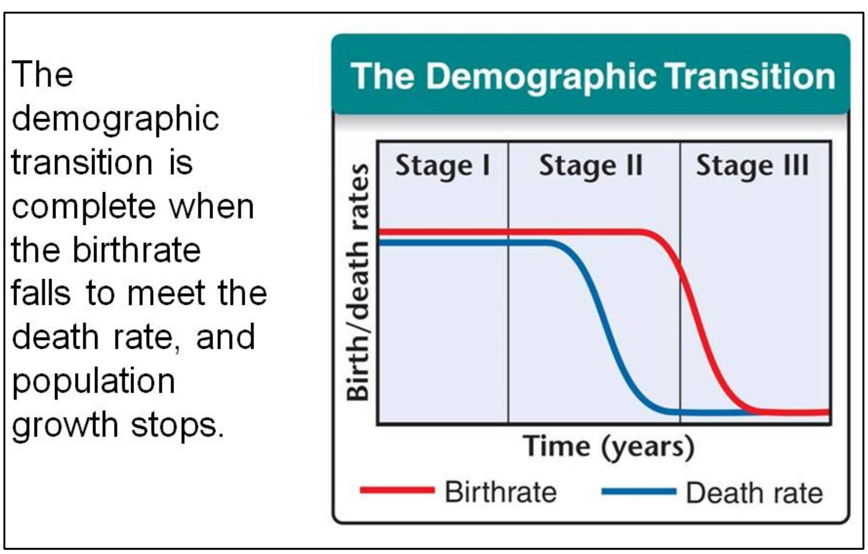



**Patterns of Population Growth**
The scientific study of human populations is called **demography.** Demography examines the characteristics of human populations and attempts to explain how those populations will change over time.

**Why Population Growth Rates Differs in Countries Throughout the World**
**Birthrates, death rates, and the age structure of a population help predict why some countries have high growth rates while other countries grow more slowly.**

**The Demographic Transition**
Over the past century, population growth in the United States, Japan, and much of Europe has slowed dramatically. According to demographers, these countries have completed the **demographic transition**, a dramatic change in birth and death rates. The demographic transition has three stages.

- In stage 1, there are high death rates and high birthrates.
- In stage 2, the death rate drops, while the birthrate remains high. The population increases rapidly.
- In stage 3, the birthrate decreases, causing population growth to slow.

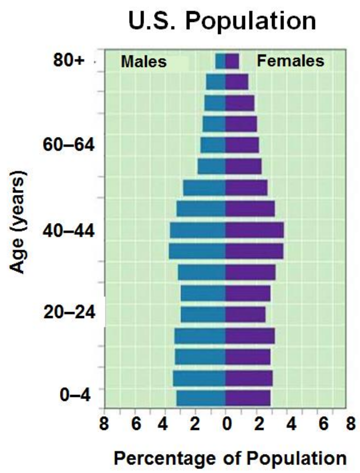


**Age Structure**

Population growth depends, in part, on how many people of different ages make up a given population. Demographers can predict future growth using models called **age-structure diagrams.** Age-structure diagrams show the population of a country broken down by gender and age group.

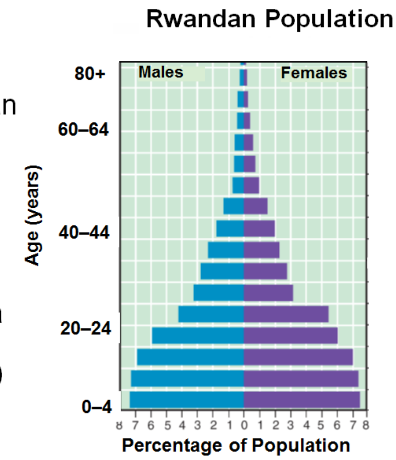
In the United States, there are nearly equal numbers of people in each age group.

This age structure diagram predicts a slow but steady growth rate for the near future.




In Rwanda, there are many more young children than teenagers, and many more teenagers than adults.

This age structure diagram predicts a population that will double in about 30 years.




**Future Population Growth**

To predict human population growth, demographers must consider the age structure of each country, as well as the prevalence of life-threatening diseases. If growing countries move toward the demographic transition, growth rate may level off or decrease. Ecologists suggest that if growth does not slow down, there could be serious damage to the environment and global economy. Economists assert that science, technology, and changes in society may control the negative impact of population growth.

**World Population: 1950–2050**

| Year | Average Annual Growth Rate (%) | Population |
|---|---|---|
| 2000 | 1.23 | 6,078,684,329 |
| 2010 | 1.06 | 6,812,009,338 |
| 2020 | 0.87 | 7,515,218,898 |
| 2030 | 0.68 | 8,127,277,506 |
| 2040 | 0.54 | 8,646,671,023 |
| 2050 | 0.43 | 9,078,850,714 |

# #3: Humans in the Biosphere

## Section 1: A Changing Landscape

**Earth as an Island**

All organisms on Earth share a limited resource base and depend on it for their long-term survival. To protect these resources, we need to understand how humans interact with the biosphere.

**The Effect of Human Activities on the Biosphere**

From the ecosystems in which they live, humans obtain such necessities as clean water and recycled nutrients. Ecologists refer to such necessities as "ecosystem goods and services" because they have value to individuals and societies. **Some human activities that affect the biosphere include hunting and gathering, agriculture, industry, and urban development.**

**Hunting and Gathering**

For most of history, humans obtained food by hunting and gathering. Today, groups of people in scattered parts of the world still follow the hunter-gatherer way of life.

**Agriculture**

**Agriculture** is the practice of farming. It includes the production of crops and the raising of livestock. Agriculture provides human societies with a dependable supply of food that can be produced in large quantity and stored for later use.

**From Traditional to Modern Agriculture**

In the 1800s and 1900s, advances in science and technology set the stage for a remarkable change in agriculture. Large-scale irrigation turned deserts into fertile farmlands. New machinery helped farmers increase yields. New varieties of crops produced higher yields. Chemical fertilizers boosted plant growth. Pesticides controlled crop-damaging insects. New crops were often grown using a practice called **monoculture,** in which large fields are planted with a single variety of crop year after year.

**The Green Revolution**

The green revolution was an effort in the mid-twentieth century to increase global food production through modern plant breeding and agricultural techniques. Over the last 50 years, the green revolution has helped world food production double.

**Challenges for the Future**

While increasing world food supplies, modern agriculture has created ecological challenges. For example, monoculture leads to problems with insect pests and diseases and finding enough water for irrigation is difficult.

**Industrial Growth and Urban Development**

Human society and its impact on the biosphere were transformed by the Industrial Revolution, which added machines and factories to civilization. The energy to power machinery comes mostly from fossil fuels—coal, oil, and natural gas. Industrial growth and urban development affect both the local and global environment. Discarded industrial waste pollutes air, water, and soil. Dense human communities also produce waste. Suburban growth consumes farmland and stresses native plants and animals.

## Section 2: Renewable and Nonrenewable Resources

**Classifying Resources**

**Environmental goods and services may be classified as either renewable or nonrenewable. Renewable resources** can regenerate if they are alive, or can be replenished by biochemical cycles if they are nonliving. A tree is an example of a renewable resource because a new tree can be planted in place of an old tree that dies or is cut down. A **nonrenewable resource** is one that cannot be replenished by natural processes. Fossil fuels such as coal, oil, and natural gas are nonrenewable resources. Once these fuels are depleted, they are gone forever.

**The Effects of Human Activities on Natural Resources**
**Human activities can affect the quality and supply of renewable resources such as land, forests, fisheries, air, and fresh water.**

**Sustainable Development**
**Sustainable development is a way of using natural resources without depleting them, and of providing for human needs without causing long-term environmental harm.**

**Land Resources**
Land provides space for human communities and raw materials for industry. Land also includes the soils in which crops are grown. If managed properly, soil is a renewable resource. Food crops grow best in fertile soil—a mixture of sand, clay, rock particles, and humus (material from decayed organisms). **Soil erosion** is the wearing away of surface soil by water and wind. Plowing the land removes the roots that hold the soil in place, and therefore increases the rate of soil erosion. **Desertification** is the process by which productive areas are turned into deserts. Desertification is caused by a combination of farming, overgrazing, and drought. A variety of sustainable-development practices can prevent problems such as soil erosion and desertification.

**Sustainable-development practices include:**

- **contour plowing—fields are plowed across the slope of the land to reduce erosion**
- **leaving stems and roots of the previous year's crop in place to help hold the soil**
- **planting a field with rye rather than leaving it unprotected from erosion**

**Forest Resources**
Earth's forests are an important resource for the products they provide and for the ecological functions they perform.
**Forests:**

- **provide wood for products and fuel.**
- **remove carbon dioxide and produce oxygen.**
- **store nutrients.**
- **provide habitats and food for organisms.**
- **moderate climate.**
- **limit soil erosion.**
- **protect freshwater supplies.**

Whether a forest can be considered a renewable resource depends partly on the type of forest. Temperate forests of the Northeast are renewable because they have been logged and have grown back naturally. Old-growth forests, such as those in Alaska and the Pacific Northwest, are nonrenewable because it takes centuries to produce them.

**Deforestation**
Loss of forests, or deforestation, has several effects:

- Erosion can wash away nutrients in the topsoil.
- Grazing or plowing can permanently change local soils and microclimates, which prevents the regrowth of trees.

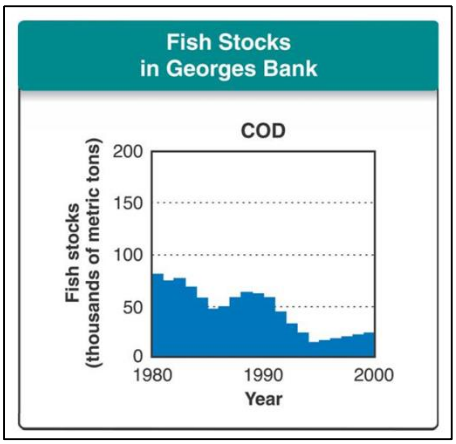
**Forest Management**

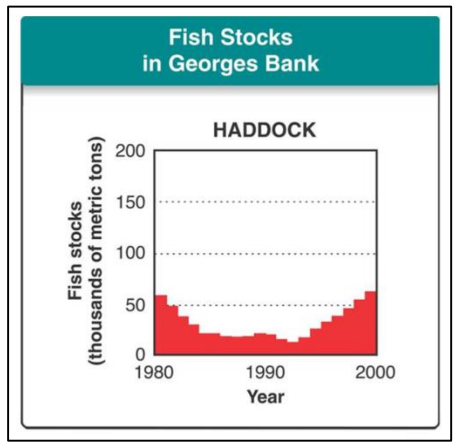
Mature trees can be harvested selectively to promote the growth of younger trees and preserve the forest ecosystem. Tree geneticists are breeding new, faster-growing trees that produce high-quality wood.

**Fishery Resources**
Fishes and other animals that live in water are a valuable source of food.

**Overfishing**
Overfishing, or harvesting fish faster than they can be replaced by reproduction, has greatly reduced the amount of fish in parts of the world's oceans. Until recently, fisheries seemed to be a renewable resource, but overfishing has limited that resource.

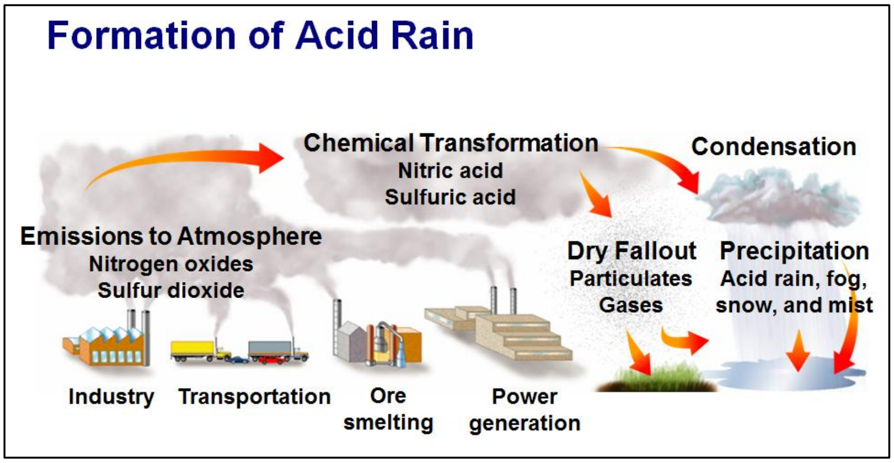
**Sustainable Development**
The U.S. National Marine Fisheries Service has issued guidelines that specify how many fish, and of what size, can be caught in various parts of the oceans. The regulations have helped fish populations recover.




**Aquaculture**
The raising of aquatic animals for human consumption, which is called **aquaculture**, is also helping to sustain fish resources.

**Air Resources**
The condition of the air affects people's health. **Smog** is a mixture of chemicals that occurs as a gray-brown haze in the atmosphere. Smog is due to automobile exhausts and industrial emissions and considered a pollutant because it threatens people's health. A **pollutant** is a harmful material that can enter the biosphere through the land, air, or water. The burning of fossil fuels can release pollutants that cause smog and other problems in the atmosphere. Strict automobile emissions standards and clean-air regulations have improved air quality in many cities, but air pollution is still a problem. Many combustion processes release nitrogen and sulfur compounds into the atmosphere. These compounds combine with water vapor to form **acid rain**.




**Acid rain** kills plants by damaging their leaves and changing the chemistry of soils and standing-water ecosystems**. Acid rain** may dissolve and releases toxic elements, such as mercury, from the soil, freeing the elements to enter other portions of the biosphere.

**Freshwater Resources**
Americans use billions of liters of fresh water daily for everything from drinking and washing to watering crops and making steel. Although water is a renewable resource, the total supply of fresh water is limited and is threatened by pollution.

**Sources of pollution include:**

- **improperly discarded chemicals that enter streams and rivers.**
- **wastes discarded on land that seep through soil and enter underground water supplies.**
- **domestic sewage containing compounds that encourage growth of algae and bacteria.**
- **sewage containing microorganisms that spread disease.**

**Sustainable Use of Water**
One way to ensure the sustainable use of water is to protect the natural systems involved in the water cycle that help purify water. These include wetlands, forests, and other vegetation. Also, by conserving water in home, industry, and agriculture.

## Section 3: Biodiversity

**The Value of Biodiversity**
Biological diversity, or **biodiversity**, is the sum total of the genetically based variety of all organisms in the biosphere. **Ecosystem diversity** includes the variety of habitats, communities, and ecological processes in the living world. **Species diversity** is the number of different species in the biosphere. **Genetic diversity** is the sum total of all the different forms of genetic information carried by all organisms living on Earth today.

**The Importance of Biodiversity**
**Biodiversity is one of Earth's greatest natural resources. Species of many kinds have provided us with foods, industrial products, and medicines—including painkillers, antibiotics, heart drugs, antidepressants, and anticancer drugs.**

**Threats to Biodiversity**

**Human activity can reduce biodiversity by altering habitats, hunting species to extinction, introducing toxic compounds into food webs, and introducing foreign species to new environments. Extinction** occurs when a species disappears from all or part of its range. A species whose population size is declining in a way that places it in danger of extinction is called an **endangered species**. As the population of an endangered species declines, the species loses genetic diversity.

**Habitat Alteration**

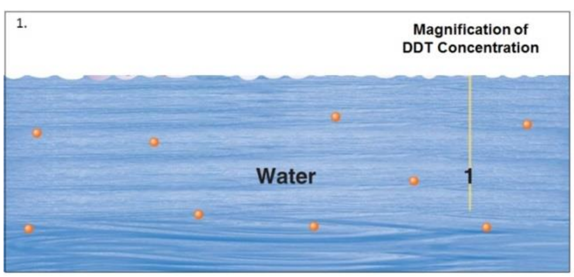
When land is developed, natural habitats may be destroyed. Development often splits ecosystems into pieces, a process called **habitat fragmentation**. The smaller a species' habitat is, the more vulnerable the species is to further disturbance.

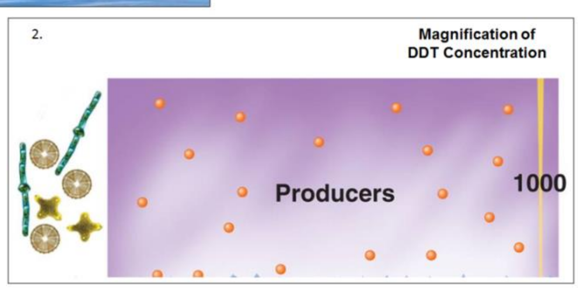
**Demand for Wildlife Products**

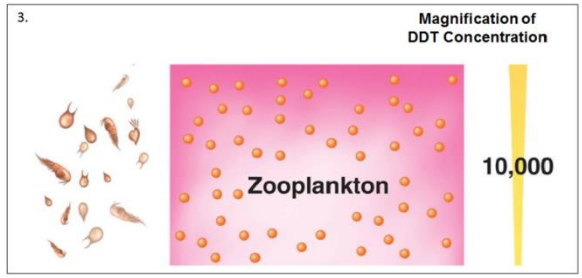
Throughout history, humans have pushed some animal species to extinction by hunting them for food or other products. Today, in the U.S., endangered species are protected from hunting. The Convention on International Trade in Endangered Species, CITES, bans international trade in products derived from endangered species

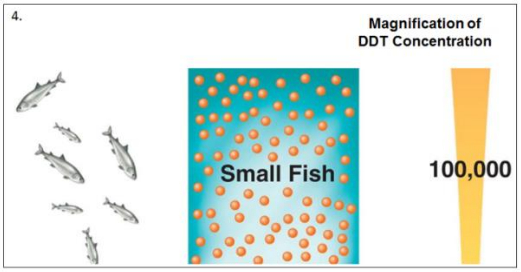
**Pollution**

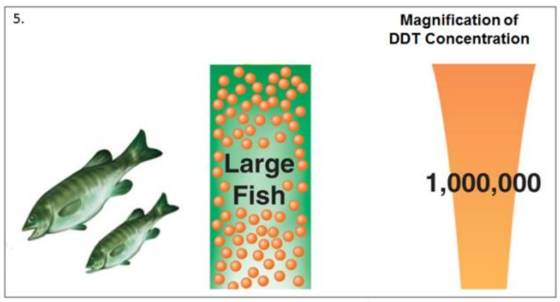
Many forms of pollution can threaten biodiversity. One of the most serious problems occurs when toxic compounds accumulate in the tissues of organisms. DDT, one of the first pesticides, is a good example of this. For a long time DDT was considered harmless, and it drained into rivers and streams in low concentrations. However, DDT has two hazardous properties: It is non- biodegradable, which means that it cannot be broken down by organisms. Once DDT is picked up by organisms, it cannot be eliminated from their bodies. When DDT enters food webs, it undergoes biological magnification. In **biological magnification**, concentrations of a harmful substance increase in organisms at higher trophic levels in a food chain or food web. In 1962, biologist Rachel Carson wrote *Silent Spring,* which alerted people to the dangers of biological magnification.

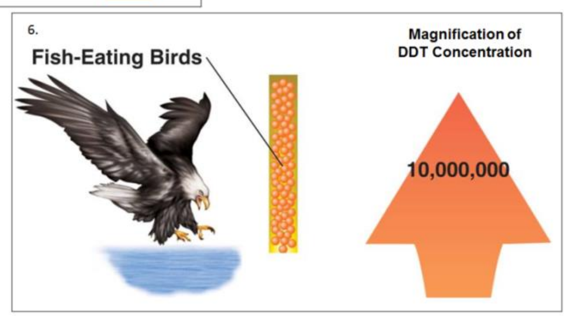





The widespread use of DDT threatened populations of many animals—especially fish-eating birds like the bald eagle—with extinction. By the early 1970s, DDT was banned in the U.S. and in most other industrialized countries; as a result, affected bird populations have recovered.

**Introduced Species**

Another threat to biodiversity comes from plants and animals that humans transport around the world either accidentally or intentionally. **Invasive species** are introduced species that reproduce rapidly because their new habitat lacks the predators that would control their population. Hundreds of invasive species—including zebra mussels in the Great Lakes and the leafy spurge across the Northern Great Plains—are already causing ecological problems in the United States.

**Conserving Biodiversity**

**Conservation** is the wise management of natural resources, including the preservation of habitats and wildlife.

**Strategies for Conservation**

Many conservation efforts are aimed at managing individual species to keep them from becoming extinct.

**Conservation efforts focus on protecting entire ecosystems as well as single species. Protecting an ecosystem will ensure that the natural habitats and the interactions of many different species are preserved at the same time.**

**Conservation Challenges**

**Protecting resources for the future can require people to change the way they earn their living today. Conservation regulations must be informed by solid research and must try to maximize benefits while minimizing economic costs.**

## Section 4: Charting a Course for the Future

**Two Types of Global Change that Concern Biologists**

**Researchers are gathering data to monitor and evaluate the effects of human activities on important systems in the biosphere. Two of these systems are the ozone layer high in the atmosphere and the global climate system.**

**Ozone Depletion**

Between 20 and 50 kilometers above Earth's surface, the atmosphere contains a relatively high concentration of ozone gas. This layer of the atmosphere is called the **ozone layer**. The **ozone layer** absorbs a good deal of harmful ultraviolet, or UV, radiation from sunlight before it reaches Earth's surface.

Exposure to UV can cause cancer, damage eyes, decrease organisms' resistance to disease, and damage plant leaf tissue and phytoplankton in the oceans.

**Early Evidence**

In the 1970s, scientists discovered a hole in the ozone layer over Antarctica. After it was first discovered, the ozone hole grew larger. A similar ozone hole also appeared over the Arctic. In 1974, a research team published data showing that gases called chlorofluorocarbons, or CFCs, could damage the ozone layer.

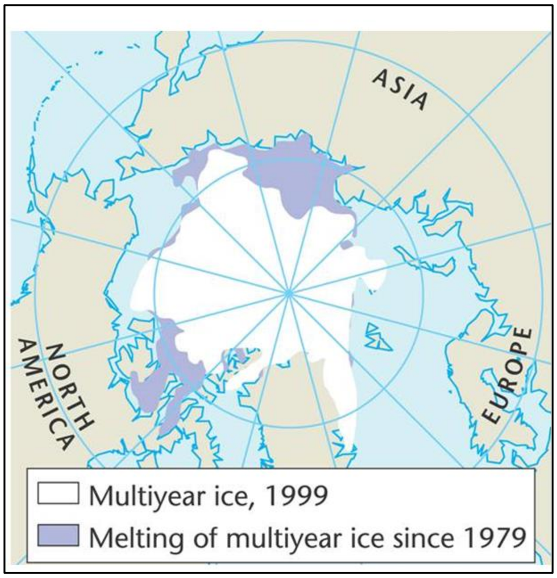
**One Solution**

CFCs were once widely used as propellants in aerosol cans, as coolant in refrigerators, freezers, and air conditioners, and in the production of plastic foams. The U.S. and other nations began reducing the use of CFCs in 1987, and eventually banned them. Since the ban, the level of CFCs in the atmosphere has decreased, indicating that the ban will have positive, long-term effects on the global environment.

Current data predict that the ozone holes should shrink and disappear within 50 years.

**Global Climate Change**

All life on Earth depends on climate conditions such as temperature and rainfall. Many ecologists are concerned about strong evidence that climate is changing. Since the late 19$^{th}$ century, average temperatures have risen about 0.6 Celsius degrees. Data indicate that since 1980, average temperatures have risen between 0.2 and 0.3 Celsius degrees. The term used to describe the increase in the average temperature of the biosphere is **global warming.** One sign of global warming is melting polar ice.




**Evidence of Global Warming**

The geological record shows that Earth's climate has changed repeatedly during its history. Researchers must determine whether the current warming trend is part of a larger, natural cycle of climate change, or whether it is caused by human activity. A widely accepted hypothesis is that current warming is related, in part, to human activities that add carbon dioxide and other greenhouse gases to the atmosphere. The burning of fossil fuels, along with the cutting and burning of forests, adds carbon dioxide to the atmosphere faster than the carbon cycle removes it. Data show that concentrations of carbon dioxide in the atmosphere have been rising for 200 years. As a result, the atmosphere's natural greenhouse effect is intensified, causing the atmosphere to retain more heat.

**Possible Effects of Global Warming**

Most recent computer models suggest that average global surface temperatures will increase by 1 to 2 Celsius degrees by the year 2050. Sea levels may rise enough to flood coastal areas, affecting coastal ecosystems as well as human communities. Parts of North America may experience more droughts during the summer growing season. New organisms may be able to live in places where they once could not. Other organisms may become threatened or extinct in areas where they once thrived.

**The Value of a Healthy Biosphere**

Ecosystems provide many goods and services, such as water purification and waste recycling. Ecosystems are also a reservoir of organisms that may one day provide humans with new medicines and new crops. People can make wise choices in the use and conservation of resources. People should avoid using more water than necessary, plant trees to replace those that have been cut down, recycle and reuse trash and other wastes, and safely remove hazardous materials.