The World's Biomes

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The World's Biomes

Biomes are defined as "the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment. (Campbell).

The importance of biomes cannot be underestimated. Biomes have changed and moved many times during the history of life on Earth. More recently, human activities have drastically altered these communities. Thus, conservation and preservation of biomes should be a major concern to all.

Biomes are classified in various ways. This page will group biomes into five major types:

Aquatic

Deserts

Forests

Grasslands

Tundra

The Importance and Conservation of Biomes

Because we share the world with many other species of plants and animals, we must consider the consequences of our actions. Over the past several decades, increasing human activity has rapidly destroyed or polluted many ecological habitats throughout the world. It is important to preserve all types of biomes as each houses many unique forms of life. However, the continued heavy exploitation of certain biomes, such as the forest and aquatic, may have more severe implications.

Forests are important as they are home to the most diverse biotic communities in the world. Hidden within these biomes are potential medicines and many thousands of unseen and undiscovered species. Also, forests have a global climate-buffering capacity, so their destruction may cause large-scale changes in global climate.

Logging has depleted many old-growth temperate forests. The increased demand for homes, paper, and other wood products have not allowed for much conservation. More recently, people have begun to realize that logging has cleared much of these forests. Wiser use of the forests and efforts to replant trees have helped to slow down the depletion of these communities.

Tropical forests have fallen victim to timber exploitation, slash and burn farming, and clearfelling for industrial use or cattle ranching, particularly in Latin America. Our increasing demand for meat products has spurred these events. For years, this destruction was occuring at a rapid rate. Over half of the world's original tropical forests are already gone. Public attention to this exploitation have helped to alleviate the problem somewhat, though many challenges are still to be faced.

Aquatic biomes are probably the most important of all the biomes. Their medium, water, is a major natural resource. Water is the basis of life, it supports life, and countless species live in it for all or part of their lives. Freshwater biomes supply us with our drinking water and water for crop irrigation. The world's oceans have an even greater effect on global climate than forests do. Water has a high capacity for heat, and because the Earth is mostly covered with water, the temperature of the atmosphere is kept fairly constant and able to support life. In addition to this climate-buffering capacity, the oceans contain several billion photosynthetic plankton which account for most of the photosynthesis occuring on Earth. Without these, there might not be enough oxygen to support such a large world population and complex animal life.

Freshwater biomes have suffered mainly from pollution. Runoff containing fertilizer and other wastes and industrial dumpings enter into rivers, ponds, and lakes and tend to promote abnormally rapid algae growth. When these algae die, dead organic matter accumulates in the water. This makes the water unusable and it kills many of the

organisms living in the habitat. Stricter laws have helped to slow down this thoughtless pollution.

Overfishing and pollution have threatened to make oceans into ecological disaster areas. Industrial pollutants that are dumped upstream of estuaries have rendered many marine habitats unsuitable for life. Again, tighter regulations have been used to prevent further destruction of the ocean biomes.

By educating people about the consequences of our actions, we can all gain a better understanding of how to preserve the earth's natural biomes. The areas that have been destroyed the most will never regain their original forms, but conservation will help to keep them from getting worse.

Aquatic

Water is the common link among the five biomes and it makes up the largest part of the biosphere, covering nearly 75% of the Earth's surface. Aquatic regions house numerous species of plants and animals, both large and small. In fact, this is where life began billions of years ago when amino acids first started to come together. Without water, most life forms would be unable to sustain themselves and the Earth would be a barren, desert-like place. Although water temperatures can vary widely, aquatic areas tend to be more humid and the air temperature on the cooler side.

The aquatic biome can be broken down into two basic regions, freshwater (i.e, ponds and rivers) and marine (i.e, oceans and estuaries).

Freshwater Regions
Freshwater is defined as having a low salt concentration—usually less than 1%. Plants and animals in freshwater regions are adjusted to the low salt content and would not be able to survive in areas of high salt concentration (i.e, ocean). There are different types of freshwater regions: ponds and lakes, streams and rivers, and wetlands. The following sections describe the characteristics of these three freshwater zones.

Ponds and Lakes

These regions range in size from just a few square meters to thousands of square kilometers. Scattered throughout the earth, several are remnants from the Pleistocene glaciation. Many ponds are seasonal, lasting just a couple of months (such as sessile pools) while lakes may exist for hundreds of years or more. Ponds and lakes may have limited species diversity since they are often isolated from one another and from other water sources like rivers and oceans. Lakes and ponds are divided into three different "zones" which are usually determined by depth and distance from the shoreline.

The topmost zone near the shore of a lake or pond is the littoral zone. This zone is the warmest since it is shallow and can absorb more of the Sun's heat. It sustains a fairly diverse community, which can include several species of algae (like diatoms), rooted and floating aquatic plants, grazing snails, clams, insects, crustaceans, fishes, and amphibians. In the case of the insects, such as dragonflies and midges, only the egg and larvae stages are found in this zone. The vegetation and animals living in the littoral zone are food for other creatures such as turtles, snakes, and ducks.

The near-surface open water surrounded by the littoral zone is the limnetic zone. The limnetic zone is well-lighted (like the littoral zone) and is dominated by plankton, both phytoplankton and zooplankton. Plankton are small organisms that play a crucial role in the food chain. Without aquatic plankton, there would be few living organisms in the world, and certainly no humans. A variety of freshwater fish also occupy this zone.

Plankton have short life spans—when they die, they fall into the deep-water part of the lake/pond, the profundal zone. This zone is much colder and denser than the other two. Little light penetrates all the way through the limnetic zone into the profundal zone. The fauna are heterotrophs, meaning that they eat dead organisms and use oxygen for cellular respiration.

Temperature varies in ponds and lakes seasonally. During the summer, the temperature can range from 4° C near the bottom to 22° C at the top. During the winter, the temperature at the bottom can be 4° C while the top is 0° C (ice). In between the two layers, there is a narrow zone called the thermocline where the temperature of the water changes rapidly. During the spring and fall seasons, there is a mixing of the top and bottom layers, usually due to winds, which results in a uniform water temperature of around 4° C. This mixing also circulates oxygen throughout the lake. Of course there are many lakes and ponds that do not freeze during the winter, thus the top layer would be a little warmer.

Streams and Rivers

These are bodies of flowing water moving in one direction. Streams and rivers can be found everywhere—they get their starts at headwaters, which may be springs, snowmelt or even lakes, and then travel all the way to their mouths, usually another water channel or the ocean. The characteristics of a river or stream change during the journey from the source to the mouth. The temperature

is cooler at the source than it is at the mouth. The water is also clearer, has higher oxygen levels, and freshwater fish such as trout and heterotrophs can be found there. Towards the middle part of the stream/river, the width increases, as does species diversity—numerous aquatic green plants and algae can be found. Toward the mouth of the river/stream, the water becomes murky from all the sediments that it has picked up upstream, decreasing the amount of light that can penetrate through the water. Since there is less light, there is less diversity of flora, and because of the lower oxygen levels, fish that require less oxygen, such as catfish and carp, can be found.

Wetlands

Wetlands are areas of standing water that support aquatic plants. Marshes, swamps, and bogs are all considered wetlands. Plant species adapted to the very moist and humid conditions are called hydrophytes. These include pond lilies, cattails, sedges, tamarack, and black spruce. Marsh flora also include such species as cypress and gum. Wetlands have the highest species diversity of all ecosystems. Many species of amphibians, reptiles, birds (such as ducks and waders), and furbearers can be found in the wetlands. Wetlands are not considered freshwater ecosystems as there are some, such as salt marshes, that have high salt concentrations—these support different species of animals, such as shrimp, shellfish, and various grasses.

After a few pages, you will see the gallery of wetlands images, which illustrate the amazing diversity of wetland ecosystems.

Marine Regions

Marine regions cover about three-fourths of the Earth's surface and include oceans, coral reefs, and estuaries. Marine algae supply much of the world's oxygen supply and take in a huge amount of atmospheric carbon dioxide. The evaporation of the seawater provides rainwater for the land.

Oceans

The largest of all the ecosystems, oceans are very large bodies of water that dominate the Earth's surface. Like ponds and lakes, the ocean regions are separated into separate zones: intertidal, pelagic, abyssal, and benthic. All four zones have a great diversity of species. Some say that the ocean contains the richest diversity of species even though it contains fewer species than there are on land.

The intertidal zone is where the ocean meets the land—sometimes it is submerged and at other times exposed, as waves and tides come in and out. Because of this, the communities are constantly changing. On rocky coasts, the zone is stratified vertically. Where only the highest tides reach, there are only a few species of algae and mollusks. In those areas usually submerged during high tide, there is a more diverse array of algae and small animals,

such as herbivorous snails, crabs, sea stars, and small fishes.

At the bottom of the intertidal zone, which is only exposed during the lowest tides, many invertebrates, fishes, and seaweed can be found. The intertidal zone on sandier shores is not as stratified as in the rocky areas. Waves keep mud and sand constantly moving, thus very few algae and plants can establish themselves—the fauna include worms, clams, predatory crustaceans, crabs, and shorebirds.

The pelagic zone includes those waters further from the land, basically the open ocean. The pelagic zone is generally cold though it is hard to give a general temperature range since, just like ponds and lakes, there is thermal stratification with a constant mixing of warm and cold ocean currents. The flora in the pelagic zone include surface seaweeds. The fauna include many species of fish and some mammals, such as whales and dolphins. Many feed on the abundant plankton.

The benthic zone is the area below the pelagic zone, but does not include the very deepest parts of the ocean (see abyssal zone below). The bottom of the zone consists of sand, slit, and/or dead organisms. Here temperature decreases as depth increases toward the abyssal zone, since light cannot penetrate through the deeper water. Flora are represented primarily by seaweed while the fauna, since it is very nutrient-rich, include all sorts of bacteria, fungi, sponges, sea anemones, worms, sea stars, and fishes.

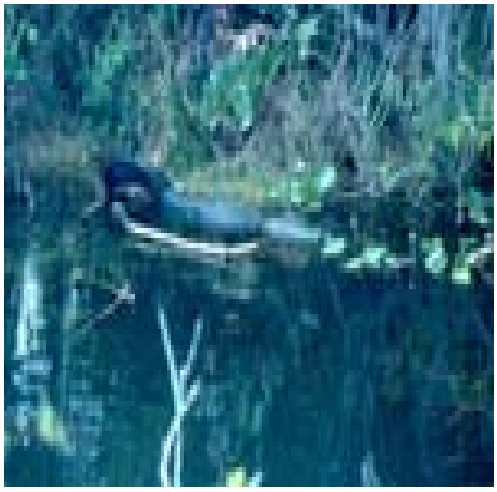
The deep ocean is the abyssal zone. The water in this region is very cold (around 3° C), highly pressured, high in oxygen content, but low in nutritional content. The abyssal zone supports many species of invertebrates and fishes. Mid-ocean ridges (spreading zones between tectonic plates), often with hydrothermal vents, are found in the abyssal zones along the ocean floors. Chemosynthetic bacteria thrive near these vents because of the large amounts of hydrogen sulfide and other minerals they emit. These bacteria are thus the start of the food web as they are eaten by invertebrates and fishes.

Coral Reefs

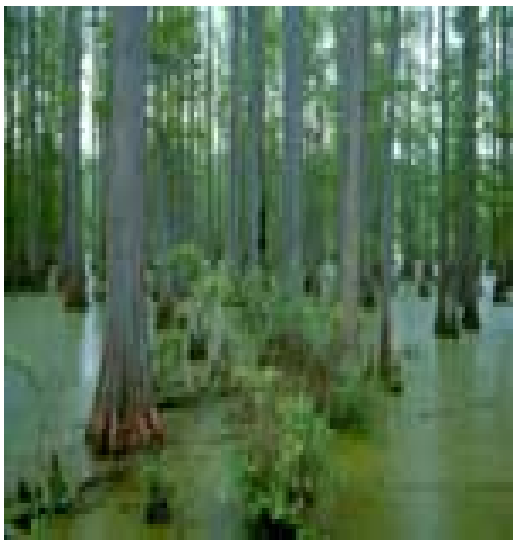
Coral reefs are widely distributed in warm shallow waters. They can be found as barriers along continents (e.g., the Great Barrier Reef off Australia), fringing islands, and atolls. Naturally, the dominant organisms in coral reefs are corals. Corals are interesting since they consist of both algae (zooanthellae) and tissues of animal polyp. Since reef waters tend to be nutritionally poor, corals obtain nutrients through the algae via photosynthesis and also by extending tentacles to obtain plankton from the water. Besides corals, the fauna include several species of microorganisms, invertebrates, fishes, sea urchins, octopuses, and sea stars.

Estuaries
Estuaries are areas where freshwater streams or rivers merge with the ocean. This mixing of waters with such different salt concentrations creates a very interesting and unique ecosystem. Microflora like algae, and macroflora, such as seaweeds, marsh grasses, and mangrove trees (only in the tropics), can be found here. Estuaries support a diverse fauna, including a variety of worms, oysters, crabs, and waterfowl.

The Wetlands Gallery


Alligator in the Everblades


Bald Cypress Swamp, Florida


Bald Cypress Swamp, Southern Illinois


Black Spruce Bog, Canada


Coastal Salt Marsh, Massachusettes


Everglades with Birds

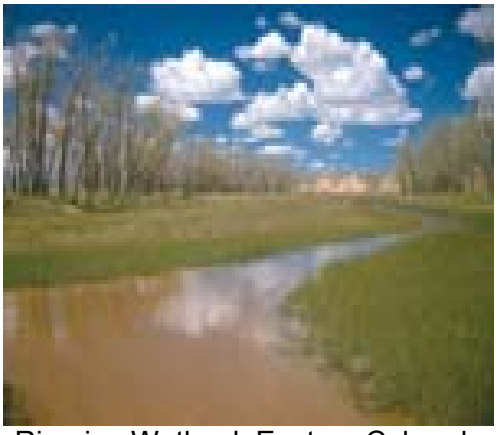

Fen, South Park Colorado


Great Egret, Everblades


Mangrove, Florida Bay


Minnesota March


Prairie Pothole, South Dakota


Riparian Wetland, Eastern Colorado


Sedges in Yellowstone, National Park


Shoreland Wetland, Minnesota


Tamarack Bog with Boardwalk
in Minnesota


Wet Meadow with Wild Irisis

Deserts

Deserts cover about one fifth of the Earth's surface and occur where rainfall is less than 50 cm/year. Although most deserts, such as the Sahara of North Africa and the deserts of the southwestern U.S., Mexico, and Australia, occur at low latitudes, another kind of desert, cold deserts, occur in the basin and range area of Utah and Nevada and in parts of western Asia. Most deserts have a considerable amount of specialized vegetation, as well as specialized vertebrate and invertebrate animals. Soils often have abundant nutrients because they need only water to become very productive and have little or no organic matter. Disturbances are common in the form of occasional fires or cold weather, and sudden, infrequent, but intense rains that cause flooding.

There are relatively few large mammals in deserts because most are not capable of storing sufficient water and withstanding the heat. Deserts often provide little shelter from the sun for large animals. The dominant animals of warm deserts are nonmammalian vertebrates, such as reptiles. Mammals are usually small, like the kangaroo mice of North American deserts.

Desert biomes can be classified according to several characteristics. There are four major types of deserts:

Hot and Dry
Semiarid

Coastal

Cold
Hot and Dry Desert

The four major North American deserts of this type are the Chihuahuan, Sonoran, Mojave and Great Basin. Others outside the U.S. include the Southern Asian realm, Neotropical (South and Central America), Ethiopian (Africa) and Australian.

The seasons are generally warm throughout the year and very hot in the summer. The winters usually bring little rainfall. Temperatures exhibit daily extremes because the atmosphere contains little humidity to block the Sun's rays. Desert surfaces receive a little more than twice the solar radiation received by humid regions and lose almost twice as much heat at night. Many mean annual temperatures range from 20-25° C. The extreme maximum ranges from 43.5-49° C. Minimum temperatures sometimes drop to -18° C.

Rainfall is usually very low and/or concentrated in short bursts between long rainless periods. Evaporation rates regularly exceed rainfall rates. Sometimes rain starts falling and evaporates before reaching the ground. Rainfall is lowest on the Atacama Desert of Chile, where it averages less than 1.5 cm. Some years are even rainless. Inland Sahara also receives less than 1.5 cm a year. Rainfall in American deserts is higher—almost 28 cm a year.

Soils are course-textured, shallow, rocky or gravely with good drainage and have no subsurface water. They are coarse because there is less chemical weathering. The finer dust and sand particles are blown elsewhere, leaving heavier pieces behind.

Canopy in most deserts is very rare. Plants are mainly ground-hugging shrubs and short woody trees. Leaves are "replete" (fully supported with nutrients) with water-conserving characteristics. They tend to be small, thick and covered with a thick cuticle (outer layer). In the cacti, the leaves are much-reduced (to spines) and photosynthetic activity is restricted to the stems. Some plants open their stomata (microscopic openings in the epidermis of leaves that allow for gas exchange) only at night when evaporation rates are lowest. These plants include: yuccas, ocotillo, turpentine bush, prickly pears, false mesquite, sotol, ephedras, agaves and brittlebush.

The animals include small nocturnal (active at night) carnivores. The dominant animals are burrowers and kangaroo rats. There are also insects, arachnids, reptiles and birds. The animals stay inactive in protected hideaways during the hot day and come out to forage at dusk, dawn or at night, when the desert is cooler.

Semiarid Desert
The major deserts of this type include the sagebrush of Utah, Montana and Great Basin. They also include the Nearctic realm (North America, Newfoundland, Greenland, Russia, Europe and northern Asia).

The summers are moderately long and dry, and like hot deserts, the winters normally bring low concentrations of rainfall. Summer temperatures usually average between 21-27° C. It normally does not go above 38° C and evening temperatures are cool, at around 10° C. Cool nights help both plants and animals by reducing moisture loss from transpiration, sweating and breathing. Furthermore, condensation of dew caused by night cooling may equal or exceed the rainfall received by some deserts. As in the hot desert, rainfall is often very low and/or concentrated. The average rainfall ranges from 2-4 cm annually. The soil can range from sandy and fine-textured to loose rock fragments, gravel or sand. It has a fairly low salt concentration, compared to deserts which receive a lot of rain (acquiring higher salt concentrations as a result). In areas such as mountain slopes, the soil is shallow, rocky or gravely with good drainage. In the upper bajada (lower slopes) they are coarse-textured, rocky, well-drained and partly “laid by rock bench.” In the lower bajada (bottom land) the soil is sandy and fine-textured, often with “caliche hardpan.” In each case there is no subsurface water.

The spiny nature of many plants in semiarid deserts provides protection in a hazardous environment. The large numbers of spines shade the surface enough to significantly reduce transpiration. The same may be true of the hairs on the woolly desert plants. Many plants have silvery or glossy leaves, allowing them to reflect more radiant energy. These plants often have an unfavorable odor or taste. Semiarid plants include: Creosote bush, bur sage (Franseria dumosa or F. deltoidea), white thorn, cat claw, mesquite, brittle bushes (Encelia farinosa), lyciums, and jujube.

During the day, insects move around twigs to stay on the shady side; jack rabbits follow the moving shadow of a cactus or shrub. Naturally, many animals find protection in underground burrows where they are insulated from both heat and aridity. These animals include mammals such as the kangaroo rats, rabbits, and skunks; insects like grasshoppers and ants; reptiles are represented by lizards and snakes; and birds such as burrowing owls and the California thrasher.

Coastal Desert

These deserts occur in moderately cool to warm areas such as the Nearctic and Neotropical realm. A good example is the Atacama of Chile.
The cool winters of coastal deserts are followed by moderately long, warm summers. The average summer temperature ranges from 13-24° C; winter temperatures are 5° C or below. The maximum annual temperature is about 35° C and the minimum is about -4° C. In Chile, the temperature ranges from -2 to 5° C in July and 21-25° C in January.

The average rainfall measures 8-13 cm in many areas. The maximum annual precipitation over a long period of years has been 37 cm with a minimum of 5 cm. The soil is fine-textured with a moderate salt content. It is fairly porous with good drainage. Some plants have extensive root systems close to the surface where they can take advantage of any rain showers. All of the plants with thick and fleshy leaves or stems can take in large quantities of water when it is

available and store it for future use. In some plants, the surfaces are corrugated with longitudinal ridges and grooves. When water is available, the stem swells so that the grooves are shallow and the ridges far apart. As the water is used, the stem shrinks so that the grooves are deep and ridges close together. The plants living in this type of desert include the salt bush, buckwheat bush, black bush, rice grass, little leaf horsebrush, black sage, and chrysothamnus.

Some animals have specialized adaptations for dealing with the desert heat and lack of water. Some toads seal themselves in burrows with gelatinous secretions and remain inactive for eight or nine months until a heavy rain occurs. Amphibians that pass through larval stages have accelerated life cycles, which improves their chances of reaching maturity before the waters evaporate. Some insects lay eggs that remain dormant until the environmental conditions are suitable for hatching. The fairy shrimps also lay dormant eggs. Other animals include: insects, mammals (coyote and badger), amphibians (toads), birds (great horned owl, golden eagle and the bald eagle), and reptiles (lizards and snakes).

Cold Desert

These deserts are characterized by cold winters with snowfall and high overall rainfall throughout the winter and occasionally over the summer. They occur in the Antarctic, Greenland and the Nearctic realm. They have short, moist, and moderately warm summers with fairly long, cold winters. The mean winter temperature is between -2 to 4° C and the mean summer temperature is between 21-26° C.

The winters receive quite a bit of snow. The mean annual precipitation ranges from 15-26 cm. Annual precipitation has reached a maximum of 46 cm and a minimum of 9 cm. The heaviest rainfall of the spring is usually in April or May. In some areas, rainfall can be heavy in autumn. The soil is heavy, silty, and salty. It contains alluvial fans where soil is relatively porous and drainage is good so that most of the salt has been leached out.

The plants are widely scattered. In areas of shad-scale, about 10 percent of the ground is covered, but in some areas of sagebush it approaches 85 percent. Plant heights vary between 15 cm and 122 cm. The main plants are deciduous, most having spiny leaves. Widely distributed animals are jack rabbits, kangaroo rats, kangaroo mice, pocket mice, grasshopper mice, and antelope ground squirrels. In areas like Utah, population density of these animals can range from 14-41 individuals per hectare. All except the jack rabbits are burrowers. The burrowing habit also applies to carnivores like the badger, kit fox, and coyote. Several lizards do some burrowing and moving of soil. Deer are found only in the winter.

Forests

"I'm telling you. People come and go in this Forest."
- Eeyore, The House at Pooh Corner.

About 420 million years ago, during the Silurian Period, ancient plants and arthropods began to occupy the land. Over the millions of years that followed, these land colonizers developed and adapted to their new habitat. The first forests were dominated by giant horsetails, club mosses, and ferns that stood up to 40 feet tall.

Life on Earth continued to evolve, and in the late Paleozoic, gymnosperms appeared. By the Triassic Period (245-208 mya), gymnosperms dominated the Earth's forests. In the Cretaceous Period (144-65m mya), the first flowering plants (angiosperms) appeared. They evolved together with insects, birds, and mammals and radiated rapidly, dominating the landscape by the end of the Period. The landscape changed again during the Pleistocene Ice Ages—the surface of the planet that had been dominated by tropical forests for millions of years changed, and temperate forests spread in the Northern Hemisphere.
Today, forests occupy approximately one-third of Earth's land area, account for over two-thirds of the leaf area of land plants, and contain about 70% of carbon

present in living things. They have been held in reverence in folklore and worshipped in ancient religions. However, forests are becoming major casualties of civilization as human populations have increased over the past several thousand years, bringing deforestation, pollution, and industrial usage problems to this important biome.

Present-day forest biomes, biological communities that are dominated by trees and other woody vegetation (Spurr and Barnes), can be classified according to numerous characteristics, with seasonality being the most widely used. Distinct forest types also occur within each of these broad groups.

There are three major types of forests, classed according to latitude:
tropical
temperate
boreal forests (taiga)

Tropical Forests
Tropical forests are characterized by the greatest diversity of species. They occur near the equator, within the area bounded by latitudes 23.5 degrees N and 23.5 degrees S. One of the major characteristics of tropical forests is their distinct seasonality: winter is absent, and only two seasons are present (rainy and dry). The length of daylight is 12 hours and varies little.

Temperature is on average 20-25° C and varies little throughout the year: the average temperatures of the three warmest and three coldest months do not differ by more than 5 degrees.
Precipitation is evenly distributed throughout the year, with annual rainfall exceeding 2000 mm.

Soil is nutrient-poor and acidic. Decomposition is rapid and soils are subject to heavy leaching.

Canopy in tropical forests is multilayered and continuous, allowing little light penetration.

Flora is highly diverse: one square kilometer may contain as many as 100 different tree species. Trees are 25-35 m tall, with buttressed trunks and shallow roots, mostly evergreen, with large dark green leaves. Plants such as orchids, bromeliads, vines (lianas), ferns, mosses, and palms are present in tropical forests.

Fauna include numerous birds, bats, small mammals, and insects.
Further subdivisions of this group are determined by seasonal distribution of rainfall:

Evergreen rainforest: no dry season.

Seasonal rainforest: short dry period in a very wet tropical region (the forest exhibits definite seasonal changes as trees undergo developmental changes simultaneously, but the general character of vegetation remains the same as in evergreen rainforests).

Semievergreen forest: longer dry season (the upper tree story consists of deciduous trees, while the lower story is still evergreen).

Moist/dry deciduous forest (monsoon): the length of the dry season increases further as rainfall decreases (all trees are deciduous).

More than ½ of tropical forests have already been destroyed.

Temperate Forests
Temperate forests occur in eastern North America, northeastern Asia, and western and central Europe. Well-defined seasons with a distinct winter characterize this forest biome. Moderate climate and a growing season of 140-200 days during 4-6 frost-free months distinguish temperate forests.

Temperature varies from -30° C to 30° C.
Precipitation (75-150 cm) is distributed evenly throughout the year.
Soil is fertile, enriched with decaying litter.
Canopy is moderately dense and allows light to penetrate, resulting in well-developed and richly diversified understory vegetation and stratification of animals.

Flora is characterized by 3-4 tree species per square kilometer. Trees are distinguished by broad leaves that are lost annually and include such species as oak, hickory, beech, hemlock, maple, basswood, cottonwood, elm, willow, and spring-flowering herbs.

Fauna is represented by squirrels, rabbits, skunks, birds, deer, mountain lion, bobcat, timber wolf, fox, and black bear.

Further subdivisions of this group are determined by seasonal distribution of rainfall:

Moist conifer and evergreen broad-leaved forests: wet winters and dry summers (rainfall is concentrated in the winter months and winters are relatively mild).

Dry conifer forests: dominate higher elevation zones; low precipitation.

Mediterranean forests: precipitation is concentrated in winter, less than 1000 mm per year.

Temperate coniferous: mild winters, high annual precipitation (greater than 2000 mm). temperate broad-leaved rainforests: mild, frost-free winters, high precipitation (more than 1500 mm) evenly distributed throughout the year. Only scattered remnants of original temperate forests remain.

Boreal forests, or taiga, represent the largest terrestial biome. Occuring between 50 and

60 degrees north latitudes, boreal forests can be found in the broad belt of Eurasia and North America: two-thirds in Siberia with the rest in Scandinavia, Alaska, and Canada. Seasons are divided into short, moist, and moderately warm summers and long, cold, and dry winters. The length of the growing season in boreal forests is 130 days.

Temperatures are very low.
Precipitation is primarily in the form of snow, 40-100 cm annually.
Soil is thin, nutrient-poor, and acidic.
Canopy permits low light penetration, and as a result, understory is limited.
Flora consist mostly of cold-tolerant evergreen conifers with needle-like leaves, such as pine, fir, and spruce.
Fauna include woodpeckers, hawks, moose, bear, weasel, lynx, fox, wolf, deer, hares, chipmunks, shrews, and bats.

Current extensive logging in boreal forests may soon cause their disappearance.

Grasslands

Grasslands are characterized as lands dominated by grasses rather than large shrubs or trees. In the Miocene and Pliocene Epochs, which spanned a period of about 25 million years, mountains rose in western North America and created a continental climate favorable to grasslands. Ancient forests declined and grasslands became widespread. Following the Pleistocene Ice Ages, grasslands expanded in range as hotter and drier climates prevailed worldwide. There are two main divisions of grasslands: (1) tropical grasslands, called savannas, and (2) temperate grasslands.

Savanna

Savanna is grassland with scattered individual trees. Savannas of one sort or another cover almost half the surface of Africa (about five million square miles, generally central Africa) and large areas of Australia, South America, and India. Climate is the most important factor in creating a savanna. Savannas are always found in warm or hot climates where the annual rainfall is from about 50.8 to 127 cm (20-50 inches) per year. It is crucial that the rainfall is concentrated in six or eight months of the year, followed by a long period of drought when fires can occur. If the rain were well distributed throughout the year, many such areas would become tropical forest. Savannas which result from climatic conditions are called climatic savannas. Savannas that are caused by

soil conditions and that are not entirely maintained by fire are called edaphic savannas. These can occur on hills or ridges where the soil is shallow, or in valleys where clay soils become waterlogged in wet weather. A third type of savanna, known as derived savanna, is the result of people clearing forest land for cultivation. Farmers fell a tract of forest, burn the dead trees, and plant crops in the ashes for as long as the soil remains fertile. Then, the field is abandoned and, although forest trees may recolonize, grass takes over on the bare ground (succession), becoming luxuriant enough to burn within a year or so. In Africa, a heavy concentration of elephants in protected parkland have created a savanna by eating leaves and twigs and breaking off the branches, smashing the trunks and stripping the bark of trees. Elephants can convert a dense woodland into an open grassland in a short period of time. Annual fires then maintain the area as a savanna.

The soil of the savanna is porous, with rapid drainage of water. It has only a thin layer of humus (the organic portion of the soil created by partial decomposition of plant or animal matter), which provides vegetation with nutrients. Savannas are sometimes classified as forests. The predominant vegetation consists of grasses and forbs (small broad-leaved plants that grow with grasses). Different savannas support different grasses due to disparities in rainfall and soil conditions. Because the savanna supports such a large number of species competing for living space, usually only one or a few kinds of grass are more successful than the others in a particular area.

For example, in drier savannas such as those on the Serengeti plains or Kenya's Laikipia plateau, the dominant grasses on well-drained soils are Rhodes grass and red oat grass; throughout the East African savannas, star grasses are dominant; the lemon grasses are common in many western Uganda savannas. Deciduous trees and shrubs are scattered across the open landscape. One type of savanna common in southwestern Kenya, Tanzania, and Uganda, known as grouped-tree grassland, has trees growing only on termite mounds—the intervening soil being too thin or poorly drained to support the growth of trees at all. Frequent fires and large grazing mammals kill seedlings, thus keeping the density of trees and shrubs low. Savannas receive an average annual rainfall of 76.2-101.6 cm (30-40 inches). However, certain savannas can receive as little as 15.24 cm (6 inches) or as much as 25.4 cm (10 inches) of rain a year.

Savanna has both a dry and a rainy season. Seasonal fires play a vital role in the savanna's biodiversity. In October, a series of violent thunderstorms, followed by a strong drying wind, signals the beginning of the dry season. Fire is prevalent around January, at the height of the dry season. Fires in savannas are often caused by poachers who want to clear away dead grass to make it easier to see their prey. The fires do not devastate the community. Most of the animals killed by the fires are insects with short life spans. A fire is a feast for some animals, such as birds that come to sites of fires to eat grasshoppers, stick insects, beetles, mice, and lizards that are killed or driven out by the fire. Underground holes and crevices provide a safe refuge for small creatures. Larger animals are usually able to run fast enough to escape the fire. Although the dry stems and leaves of grasses are consumed by fire, the grasses' deep

roots remain unharmed. These roots, with all their starch reserves, are ready to send up new growth when the soil becomes more moist. The scattered shrubs can also subsist on food reserves in their roots while they await the time to venture above the soil again. Unlike grasses and shrubs, trees survive a fire by retaining some moisture in all their above-ground parts throughout the dry season. Sometimes they have a corky bark or semisucculent trunk covered with smooth resinous bark, both being fire resistant. A fire leaves scorched earth covered with a fine layer of powdery black ash in its wake. During March, violent thunderstorms occur again, this time heralding the rainy season. When the rains come, savanna bunch grasses grow vigorously. Some of the larger grasses grow an inch or more in 24 hours. The savannas experiences a surge of new life at this time. For example, many antelope calves are born. With so much grass to feed on, mothers have plenty of milk. Calves die if the rains fail to come.

Other animals (which do not all occur in the same savanna) include giraffes, zebras, buffaloes, kangaroos, mice, moles, gophers, ground squirrels, snakes, worms, termites, beetles, lions, leopards, hyenas, and elephants.
There are also some environmental concerns regarding savannas such as poaching, overgrazing, and clearing of the land for crops.

Temperate Grassland
Temperate grasslands are characterized as having grasses as the dominant vegetation. Trees and large shrubs are absent. Temperatures vary more from summer to winter, and the amount of rainfall is less in temperate grasslands than in savannas. The major manifestations are the veldts of South Africa, the puszta of Hungary, the pampas of Argentina and Uruguay, the steppes of the former Soviet Union, and the plains and prairies of central North America. Temperate grasslands have hot summers and cold winters.

Rainfall is moderate. The amount of annual rainfall influences the height of grassland vegetation, with taller grasses in wetter regions. As in the savanna, seasonal drought and occasional fires are very important to biodiversity. However, their effects aren't as dramatic in temperate grasslands as they are in savannas. The soil of the temperate grasslands is deep and dark, with fertile upper layers. It is nutrient-rich from the growth and decay of deep, many-branched grass roots. The rotted roots hold the soil together and provide a food source for living plants. Each different species of grass grows best in a particular grassland environment (determined by temperature, rainfall, and soil conditions). The seasonal drought, occasional fires, and grazing by large mammals all prevent woody shrubs and trees from invading and becoming established. However, a few trees, such as cottonwoods, oaks, and willows grow in river valleys, and some nonwoody plants, specifically a few hundred species of flowers, grow among the grasses. The various species of grasses include purple needlegrass, blue grama, buffalo grass, and galleta. Flowers include asters, blazing stars, coneflowers, goldenrods, sunflowers, clovers, psoraleas, and wild indigos.

Precipitation in the temperate grasslands usually occurs in the late spring and early summer. The annual average is about 50.8 to 88.9 cm (20-35 inches). The temperature range is very large over the course of the year. Summer temperatures can be well over 38° C (100 degrees Fahrenheit), while winter temperatures can be as low as -40° C (-40 degrees Fahrenheit).
The fauna (which do not all occur in the same temperate grassland) include gazelles, zebras, rhinoceroses, wild horses, lions, wolves, prairie dogs, jack rabbits, deer, mice, coyotes, foxes, skunks, badgers, blackbirds, grouses, meadowlarks, quails, sparrows, hawks, owls, snakes, grasshoppers, leafhoppers, and spiders.

There are also environmental concerns regarding the temperate grasslands. Few natural prairie regions remain because most have been turned into farms or grazing land. This is because they are flat, treeless, covered with grass, and have rich soil.

Temperate grasslands can be further subdivided. Prairies are grasslands with tall grasses while steppes are grasslands with short grasses. Prairie and steppes are somewhat similar but the information given above pertains specifically to prairies—the following is a specific description of steppes. Steppes are dry areas of grassland with hot summers and cold winters. They receive 25.4-50.8 cm (10-20 inches) of rainfall a year. Steppes occur in the interiors of North America and Europe. Plants growing in steppes are usually greater than 1 foot tall. They include blue grama and buffalo grass, cacti, sagebrush, speargrass, and small relatives of the sunflower. Steppe fauna includes badgers, hawks, owls, and snakes. Today, people use steppes to graze livestock and to grow wheat and other crops. Overgrazing, plowing, and excess salts left behind by irrigation waters have harmed some steppes. Strong winds blow loose soil from the ground after plowing, especially during droughts. This causes the dust storms of the Great Plains of the U.S.

Tundra

Tundra is the coldest of all the biomes. Tundra comes from the Finnish word tunturia, meaning treeless plain. It is noted for its frost-molded landscapes, extremely low temperatures, little precipitation, poor nutrients, and short growing seasons. Dead organic material functions as a nutrient pool. The two major nutrients are nitrogen and phosphorus. Nitrogen is created by biological fixation, and phosphorus is created by precipitation. Tundra is separated into two types: arctic tundra and alpine tundra.

Characteristics of Tundra
- Extremely cold climate
- Low biotic diversity
- Simple vegetation structure
- Limitation of drainage
- Short season of growth and reproduction
- Energy and nutrients in the form of dead organic material
- Large population oscillations

Arctic
Arctic tundra is located in the northern hemisphere, encircling the north pole and extending south to the coniferous forests of the taiga. The arctic is known

for its cold, desert-like conditions. The growing season ranges from 50 to 60 days. The average winter temperature is -34° C (-30° F), but the average summer temperature is 3-12° C (37-54° F) which enables this biome to sustain life. Rainfall may vary in different regions of the arctic. Yearly precipitation, including melting snow, is 15 to 25 cm (6 to 10 inches). Soil is formed slowly. A layer of permanently frozen subsoil called permafrost exists, consisting mostly of gravel and finer material. When water saturates the upper surface, bogs and ponds may form, providing moisture for plants. There are no deep root systems in the vegetation of the arctic tundra, however, there are still a wide variety of plants that are able to resist the cold climate. There are about 1,700 kinds of plants in the arctic and subarctic, and these include:

low shrubs, sedges, reindeer mosses, liverworts, and grasses
400 varieties of flowers
crustose and foliose lichen

All of the plants are adapted to sweeping winds and disturbances of the soil. Plants are short and group together to resist the cold temperatures and are protected by the snow during the winter. They can carry out photosynthesis at low temperatures and low light intensities. The growing seasons are short and most plants reproduce by budding and division rather than sexually by flowering.

The fauna in the arctic is also diverse:

Herbivorous mammals: lemmings, voles, caribou, arctic hares and squirrels
Carnivorous mammals: arctic foxes, wolves, and polar bears
Migratory birds: ravens, snow buntings, falcons, loons, ravens, sandpipers, terns, snow birds, and various species of gulls
Insects: mosquitoes, flies, moths, grasshoppers, blackflies and arctic bumble bees
Fish: cod, flatfish, salmon, and trout

Animals are adapted to handle long, cold winters and to breed and raise young quickly in the summer. Animals such as mammals and birds also have additional insulation from fat. Many animals hibernate during the winter because food is not abundant. Another alternative is to migrate south in the winter, like birds do. Reptiles and amphibians are few or absent because of the extremely cold temperatures. Because of constant immigration and emigration, the population continually oscillates.

Alpine

Alpine tundra is located on mountains throughout the world at high altitude where trees cannot grow. The growing season is approximately 180 days. The nighttime temperature is usually below freezing. Unlike the arctic tundra, the soil in the alpine is well drained. The plants are very similar to those of the arctic ones and include:

tussock grasses, dwarf trees, small-leafed shrubs, and heaths

Animals living in the alpine tundra are also well adapted:

Mammals: pikas, marmots, mountain goats, sheep, elk
Birds: grouselike birds
Insects: springtails, beetles, grasshoppers, butterflies

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