



Chapter 5 **Climate and Terrestrial Biodiversity**



“It’s A Small World After All”

Outline

Climate: A Brief Introduction

- A. Weather is a local area’s short-term physical conditions such as temperature and precipitation, typically considered in hours or days, and climate is a region’s average weather conditions over a long time, typically considered over decades. Average temperature and average precipitation are the two major factors that determine climate of a region, together with the related factors of latitude and elevation.
- B. Global air circulation is affected by the uneven heating of the earth’s surface by solar energy, seasonal changes in temperature and precipitation, rotation of the earth on its axis, and the properties of air, water, and land.
 - 1. Uneven heating of earth’s surface, the equator is heated more than the poles. This is due to the angle of the sun’s rays on different parts of the earth.
 - 2. Seasonal changes in temperature and precipitation due to the tilt of the earth.
 - 3. Rotation of the earth on its axis results in the earth moving faster beneath air masses at the equator and slower at the poles. Belts of prevailing winds are the result.
 - 4. Properties of air, water, and land affect global air circulation. Water evaporation sets up cyclical convection cells. These occur both vertically and from place to place in the troposphere. The result is an irregular distribution of climates and patterns of vegetation from pole to pole.
- C. Ocean currents influence climate by distributing heat from place to place and mixing and distributing nutrients.
 - 1. Differences in water density and heat create ocean currents that are warm/cold.
 - 2. Currents, such as the Gulf Stream, redistribute absorbed solar heat from one place to another, influence vegetation and climate near coastal regions.
 - 3. Currents also help mix ocean waters to distribute nutrients and dissolved oxygen needed for aquatic organisms.
 - 4. Winds and the earth’s rotation drive the currents.
- D. Water vapor, carbon dioxide, and other gases influence climate by warming the lower atmosphere and the earth’s surface.
 - 1. These gasses (water vapor, carbon dioxide, methane, and nitrous oxide) are known as greenhouse gasses. They allow mostly visible light, some infrared radiation and ultraviolet radiation to pass through the troposphere. This natural warming is the greenhouse effect.
 - 2. The earth would be a cold, mostly lifeless place without this effect.
 - 3. Human activities have added to the carbon dioxide, methane and nitrous oxide in the atmosphere. The fear is that this can increase the natural greenhouse effect and lead to global warming.
 - 4. Precipitation patterns, sea levels and crop growing areas could be altered.
- E. Interactions between land and oceans and disruptions of airflows by mountains and cities affect local climates. Various topographic features can create local and regional climates different from the general climate of a region.
 - 1. One example of this is the rainshadow effect, where an air mass moves inland from an ocean, reaches a mountain range, and as the air is forced to rise, it cools and loses moisture on the windward side. The leeward side of the mountain will be drier due to the loss of moisture on the windward side.
 - 2. Bricks, asphalt and other building materials create distinct microclimates in cities that are warmer, have more haze and smog and lower wind speeds than the countryside around them.

Biomes: Climate and Life on Land

- A. Different climates lead to different communities of organisms, especially vegetation. Differences in average temperature and precipitation due to global air and water circulation lead to differences in climate. Scientists divide the world into several major biomes (Figure. 5-9).
 - 1. Average annual precipitation, temperature and soil type are the most important factors in producing tropical, temperate, or polar deserts, grasslands, and forests.
 - 2. Biomes are actually a mosaic of different biological communities, but with similarities unique

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to the biome (forest, grassland, desert).

3. Climate and vegetation vary with latitude and elevation of an area. Latitude measures distance from the equator, elevation measures elevation above sea level.

Desert Biomes

- A. Deserts have little precipitation and little vegetation and are found in tropical, temperate, and polar regions. Deserts cover about 30% of the earth’s land surface, mostly in tropical and subtropical regions. The largest ones are found in the interior of continents. Others form because of the rain shadow effect on the down side of mountains.
 1. Tropical deserts are hot, dry most of the year with few plants, rocks and sand.
 2. Temperate deserts have high day temperatures in summer, low temperatures in winter with more rain than in tropical deserts. Plants are widely spaced, mostly drought-resistant shrubs, cacti/succulents.
 3. Cold deserts have cold winters, warm summers with low rainfall.
- B. Desert plants and animals have adaptations that help them stay cool and get enough water to survive. Adaptations include:
 1. Plants that drop leaves during hot dry spells to survive in dormant state.
 2. Plants may have no leaves, they store water in fleshy tissue, and open pores to have gas exchange only at night.
 3. Some plants have very long taproots to reach groundwater.
 4. Evergreen plants have thick, waxy leaves to reduce evapotranspiration.
 5. Annuals store biomass in seeds that may be dormant for years.
 6. Most animals are small. They may only come out at night or early morning. Others become dormant during extreme heat or drought.
 7. Insects/reptiles have thick outer coverings to conserve water. Wastes are dry feces and concentrated urine.
 8. Desert ecosystems are fragile and take a long time to recover from disturbances due to slow plant growth, low species diversity, slow nutrient cycling, and lack of water. Human impact on deserts due to overgrazing and off-road vehicles may take decades to overcome.

Grassland and Chaparral Biomes

- A. Grasslands have enough precipitation support grasses but not enough to support large stands of trees, and are found in tropical, temperate and polar regions. They persist because of seasonal drought, grazing by large herbivores, occasional fires that keep shrubs and trees from growing. The three main types of grasslands are tropical, temperate, and polar (tundra).
- B. Savannas are tropical grasslands with scattered trees and enormous herds of hoofed animals. A savanna usually has warm temperatures year-round, two long dry seasons with much rain the rest of the year.
 1. Large herds of grazing and browsing animals feed here.
 2. There are a number of different niches in the savanna.
 3. Competition for plant materials has been minimized due to specialized eating habits
 4. Human attempts to raise cattle on savannas, and the use of trees for firewood, have converted savanna to desert.
- C. Temperate grasslands with cold winters and hot and dry summers have deep and fertile soils that make them widely used for growing crops and grazing cattle. They are widely distributed in North and South America, Europe, and Asia. Rain falls unevenly throughout the year.
 1. Organic matter accumulates, producing fertile soil, as aboveground plant parts die each year.
 2. Soil held in place by network of intertwined root.
 3. Natural grasses are adapted to fire.
 4. North American grasslands are tall-grass prairies and short-grass prairies.
 5. Evaporation is rapid, winds blow most of the time and fires occur in summer and fall.
 6. Humans have used these lands to raise cattle and crops. They are often flat areas, easily plowed.
 7. Plowing makes soil vulnerable to erosion and blowing.
- D. Polar grasslands are covered with ice and snow except during a brief summer. Polar grasslands, or arctic tundra are treeless, cold plains. Long, dark winters and low precipitation are the norm.

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1. Under the snow there is a thick, spongy mat of low-growing vegetation (grasses, mosses, dwarf woody shrubs)
 2. Most growth occurs within 6-8 weeks of summer during the long hours of daylight.
 3. Permafrost is a permanently frozen layer of soil when water freezes.
 4. Tundra is waterlogged during summer, with hordes of insects.
 5. Migratory birds nest and breed in bogs and ponds during summer.
 6. Animals are mostly small herbivores such as lemmings, hares, voles that burrow underground to evade the cold.
 7. Predators include lynx, weasel, snowy owl and arctic fox.
 8. Global warming is causing some parts of the permafrost in parts of Alaska to melt.
 9. Decomposition is slow, soil is poor in organic matter and minerals
 10. Human activities such as oil drilling, mining have scarred the landscape, which is very slow to recover.
 11. Another type of tundra, alpine tundra, occurs above tree line, but below permanent snow line. This area gets more sunlight than arctic tundra and has no permafrost. Vegetation is similar to that in arctic tundra.
- E. Chaparral has a moderate climate but its dense thickets of spiny shrubs are subject to periodic fire. Chaparral or temperate shrubland is found in coastal areas that border deserts.
1. The winter rainy season is longer than in desert, fog during spring/fall reduces evaporation.
 2. Low-growing, evergreen shrubs with occasional trees is vegetation type.
 3. Fires move swiftly when started in these areas. Chaparral adapted to occasional fires.
 4. Humans like the climate of this biome, but risk losing homes to fire.
 5. Floods/mudslides occur after fires at times.

Forest Biomes

- A. Forests have enough precipitation to support stands of trees and are found in tropical, temperate, and polar regions. The three main types of forest-tropical, temperate, and boreal (polar)-result from combinations of the precipitation level and the various average temperatures.
- B. Tropical rain forests have heavy rainfall on most days and a rich diversity of species occupying a variety of specialized niches in distinct layers. Tropical rain forests are near the equator, and have hot humid conditions.
1. Dominant plants are broadleaf evergreens with shallow roots.
 2. A dense canopy blocks most sunlight from reaching lower levels.
 3. Vines often drape individual trees.
 4. Epiphytes such as orchids and bromeliads are found on trunks and branches. They get nutrients from falling materials and water from humid air.
 5. There is great biological diversity found in many specialized niches within the forest.
 6. Most animal life is found in the sunny canopy layer of the forest.
 7. Ecologists build special structures to study canopy ecosystems.
 8. Tropical forests cover about 2% of the land surface, but are habitats for about half the terrestrial species of earth.
 9. Very little litter is on the forest floor because of rapid recycling of dead materials. Most nutrients are stored in trees, vines and other plants.
 10. The acidic soil makes these areas poor places to grow crops or graze cattle.
 11. So far at least 40% of these forests have been destroyed or disturbed by human activities, and ecologists are calling for strong conservation measures.
 12. Tropical dry forests are found in tropical areas with warm temperatures year round and wet and dry seasons.
- C. Temperate deciduous forests grow in areas with moderate average temperatures, abundant rainfall and long, warm summers. Most of the trees in these forests survive winter by dropping their leaves, which decay and produce nutrient-rich soil.
1. Broadleaf, deciduous trees dominate this biome. Leaves drop in fall, trees become dormant, and new leaves grow in spring.
 2. These areas have fewer species of trees.
 3. More sunlight penetrates the canopy so there is richer diversity of ground level plant life.
 4. A thick layer of leaf litter is usual due to fairly slow decomposition. It is a source of nutrients

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- for plant growth.
5. Large predator species such as bear, wolves, wildcats, and mountain lions have been killed; deer and smaller mammals are now often the dominant species.
 6. Large tracts of temperate forest have been cleared, planted in a single species of tree (tree plantations).
 7. Bird species migrate to and from these areas to breed and feed. They are declining due to loss of habitat.
 8. On a worldwide basis, this biome has been disturbed by human activity more than any other terrestrial biome as a result of establishing settlements, industrialization, and urbanization.
- D. Evergreen coniferous forests or boreal forests are located in areas just south of arctic tundra around the northern sub-arctic regions of the earth. These forests consist mostly of cone-bearing evergreen trees that keep their needles year-round to help the trees survive long cold winters.
1. Long, dry, extremely cold winters with 6-8 hours sunlight are the norm. Summers are short with 19 hours of daily sunlight.
 2. Dominant trees are coniferous (cone-bearing) spruce, hemlock, fir, cedar and pine.
 3. There is low plant diversity.
 4. Decomposition is slow because of low temperatures, waxy narrow leaves and high soil acidity. Soil is nutrient poor.
 5. Year-round residents include bears, wolves, moose, lynx and many burrowing rodent species.
 6. Acidic bogs form in summer.
 7. During summer birds feed on the many insects.
- E. Coastal areas support huge cone-bearing evergreen trees such as redwoods and Douglas fir in a cool and moist environment. Coastal coniferous forests or temperate rain forests are located along the western coast of Canada to northern California. Cool temperatures, abundant rain and dense fog are the norm.
1. Most trees are evergreen with much moss as epiphytes and ground cover.
 2. There is a dense canopy with little light reaching the forest floor.
 3. The winters are mild and summers are cool.

Mountain Biomes

- A. Mountains are high-elevation forested islands of biodiversity and often have snow-covered peaks that reflect solar radiation and gradually release water to lower-elevation streams and ecosystems. Mountains are places with dramatic changes in altitude, climate, soil and vegetation within very short distances.
1. They are prone to erosion when vegetation is removed by natural disturbances, or human activities.
 2. Mountains have important ecological roles such as habitats for endemic species, biodiversity, and sanctuaries for animal species driven from other habitats.
 3. They help regulate earth’s climate, snow peaks reflect much of solar radiation into space. The glacier ice affects sea levels as glaciers increase or decrease in mass.
 4. Mountains play a major role in the hydrologic cycle.
 5. Mountain biomes are coming under pressure from human activities.

Human Impacts on Terrestrial Biomes

- A. Human activities have damaged or disturbed to some extent more than half of the world’s terrestrial ecosystems.
- B. Humans have had a number of specific harmful effects on the world’s deserts, grassland, forests, and mountains.

Summary

1. Key factors that determine the earth’s weather are short-term atmospheric conditions such as temperature, pressure, moisture content, sunshine, cloud cover, precipitation, wind direction and wind speed.

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2. Climate is a region’s long-term atmospheric conditions over decades. The two main factors in determining climate are average temperature and average precipitation.
3. The average climate—annual precipitation and temperature—determines terrestrial regions with characteristic types of natural ecological communities. According to these two factors, biomes form.
4. The major types of desert biomes are hot, medium, and cold. Human activities have created large desert cities, destroyed soil through urban development and off-road vehicles, salinized the soil through irrigation, depleted underground water supplies, disturbed land and polluted, stored toxic and radioactive wastes and located arrays of solar cells and solar collectors.
5. The three major types of grasslands are tropical or savannas, temperate grasslands, and polar grassland/tundra. The savannas have been destroyed by grazing cattle which destroys vegetation and kills grass through fecal droppings. The temperate grasslands have been used to grow crops and graze animals. As a result, the grasslands have disappeared. The arctic tundra has been compromised by oil drilling, mines and military bases.
6. The three main types of forest biomes are tropical, temperate, and polar/boreal. Human activities have destroyed much of the native trees; grazing has compromised the vegetation and eliminated food sources for native animals. And the deforestation has changed the tropical forest’s ecosystem, leading to death of plants and animals. The temperate forest has a fewer number of broadleaf trees and rich forest soil; but fires, logging, and hunting have undermined this type of forest. The evergreen firs of the polar forest support a variety of wildlife. But oil drilling and oil spills have compromised the water, the wildlife and the vegetation in the arctic.
7. Mountain and arctic biomes play important ecological roles; they help regulate climate and effect sea levels. Mountain biome degradation arises from timber and mining extraction, from hydroelectric dams and reservoirs, from air pollution, increased tourism, and radiation from ozone depletion.

Objectives

1. Distinguish between weather and climate. Summarize how warm fronts, cold fronts, high-pressure air masses, and low-pressure air masses affect weather.
2. Describe at least five different factors that contribute to global air-circulation patterns.
3. Describe how ocean currents generally redistribute heat.
4. Define *greenhouse effect*. Name greenhouse gases. State the significance of the greenhouse effect.
5. Describe the general effects of the following microclimates: windward and leeward sides of a mountain, forests, cities.
6. Describe how climate affects the distribution of plant life on Earth. Draw connections between biomes and the following plants, which are particularly adapted for different biomes: succulent plants, broadleaf evergreen plants, broadleaf deciduous plants, coniferous evergreen plants.
7. Compare the climate and adaptations of plants and animals in deserts, grasslands, and forests. Describe the distinctive qualities of a chaparral ecosystem. Be sure to distinguish among the three major kinds of forests.
8. Compare the biodiversity and stratification in the three major kinds of forests.
9. Describe how a mountain ecosystem is like an "island of biodiversity."

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Key Terms (Terms are listed in the same font style as they appear in the text.)

alpine tundra (p. 115)
arctic tundra (p. 114)
average precipitation (p. 101)
average temperature (p. 101)
biomes (p. 106)
boreal forests (p. 120)
broadleaf deciduous trees (p. 119)
broadleaf evergreen plants (p. 117)
browsing (p. 111)
canopy (p. 118)
chaparral (p. 115)
climate (p. 101)
coastal coniferous forests (p. 121)
cold deserts (p. 108)
coniferous evergreen trees (p. 120)
convection (p. 103)
Coriolis effect (p. 102)
prairies (p. 108)
prevailing winds (p. 102)
savanna (p. 111)
short-grass prairies (p. 108)
southern pine forests (p. 121)
succulent plants (p. 108)
taigas (p. 120)
tall-grass prairies (p. 108)
temperate deciduous forests (p. 119)

desert (p. 108)
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