Chapter 9: Ecology
Lesson 9.2: Terrestrial and Aquatic Biomes

What may be the most biologically diverse type of ecosystem? These are wetland marshes in Delaware. Notice the abundance of vegetation mixed with the water. And of course, where there are plants, there are animals. Wetlands are considered the most biologically diverse of all ecosystems. Plant life found in wetlands includes mangrove, water lilies, cattails, black spruce, cypress, and many others. Animal life includes many different amphibians, reptiles, birds, insects, and mammals.

Lesson Objectives
- Define biome.
- Identify the factors that define terrestrial biomes.
- Identify and describe the different terrestrial biomes found on Earth.
- Determine how climate affects terrestrial biomes.
- Give an overview of aquatic biomes.
- Identify the factors that define aquatic biomes.
- Identify and describe the different aquatic biomes found on Earth.
- Determine how climate affects aquatic biomes.

Vocabulary
- aphyotic zone
- aquatic biome
- climate
- coral
- coral reef
- estuary
- freshwater biome
- growing season
- headwaters
- humidity
- hydrothermal vent
- intertidal zone
- marine biome
- photic zone
- phytoplankton
- terrestrial biome
- wetland
- zooplankton

Introduction
If you look at the two pictures in Figure 9.3, you will see very few similarities. The picture on the left shows a desert in Africa. The picture on the right shows a rainforest in Australia. The desert doesn’t have any visible plants, whereas the rainforest is densely packed with trees. What explains these differences?

Figure 9.3 On the left is a picture of the Sahara Desert in northern Africa; and on the right is a picture of a rainforest in northeastern Australia. Two very different biomes are pictured here. Both are found at roughly the same distance from the equator.

The two pictures in Figure 9.3 represent two different biomes. A biome is a group of similar ecosystems with the same general abiotic factors and primary producers. Biomes may be terrestrial or aquatic.
What Are Biomes?

A biome is an area with similar populations of organisms. This can easily be seen with a community of plants and animals. Remember that a community is all of the populations of different species that live in the same area and interact with one another. Different biomes, such as a rainforest (Figure 9.4) or a desert, obviously have different communities of plants and animals.

The differences in the biomes are due to differences in the abiotic factors, especially climate. Climate is the typical weather in an area over a long period of time. The climate includes the amount of rainfall and the average temperature in the region.

![Figure 9.4](image)

Tropical rainforests like the one in Hawaii pictured above have plants that are very different from those found in deserts.

There are into two major groups of biomes:
1. Terrestrial biomes, which are land-based, such as deserts and forests.
2. Aquatic biomes, which are water-based, such as ponds and lakes.

The abiotic factors, such as the amount of rainfall and the temperature, are going to influence other abiotic factors, such as the quality of the soil. This, in turn, is going to influence the plants that migrate into the ecosystem and thrive in that biome. Recall that migration is the movement of an organism into or out of a population. The types of plants that live in a biome are going to attract a certain type of animal to that habitat. It is the interaction of the abiotic and biotic factors that describe a biome and ecosystem. It is the abiotic factors that determine the biotic factors of an ecosystem, and together these define the biome.

Terrestrial Biomes

A terrestrial biome is an area of land with a similar climate that includes similar communities of plants and animals. Different terrestrial biomes are usually defined in terms of their plants, such as trees, shrubs, and grasses.

Factors such as latitude, humidity, and elevation affect biome type:
- Latitude means how far a biome is from the equator.
- Humidity is the amount of water in the air. Air with a high concentration of water will be called humid.
- Elevation measures how high land is above sea level. It gets colder as you go higher above sea level, which is why you see snow-capped mountains.
Terrestrial biomes include grasslands, forests, deserts, and tundra.

- Grasslands are characterized as lands dominated by grasses rather than large shrubs or trees and include the savanna and temperate grasslands.
- Forests are dominated by trees and other woody vegetation and are classified based on their latitude. Forests include tropical, temperate, and boreal forests (taiga).
- Deserts cover about one fifth of the Earth’s surface and occur where rainfall is less than 50 cm (about 20 inches) each year.
- Tundra is the coldest of all the biomes. The tundra is characterized for its frost-molded landscapes, extremely low temperatures, little precipitation, poor nutrients, and short growing seasons. There are two main types of tundra, Arctic and Alpine tundras.
- Terrestrial biomes (Figure 9.5) lying within the Arctic and Antarctic Circles do not have very much plant or animal life.

Figure 9.5 One of the terrestrial biomes, taiga, is an evergreen forest of the subarctic, covering extensive areas of northern North America and Eurasia. This taiga is along the Denali Highway in Alaska.

Biomes with the highest amount of biodiversity, that is the most variation in plant and animal life, are near the equator (Figure 9.6).

Survey of Terrestrial Biomes

Terrestrial biomes are classified by the climate and their biodiversity, especially the types of primary producers. The world map in Figure 9.7 shows where 13 major terrestrial biomes are found.

Figure 9.7 This map shows the locations of Earth’s 13 major terrestrial biomes.
The table below summarizes the basic features of 10 of the 13 major terrestrial biomes. As you read about each biome, think about how its biodiversity and types of plants and animals relate to its climate. For example, why do you think there are no amphibians or reptiles in tundra biomes? (Hint: Amphibians and reptiles cannot maintain a constant body temperature. Instead, they have about the same temperature as their surroundings.)

**Table 9.3** Summary of ten of the major terrestrial biomes characteristics.

<table>
<thead>
<tr>
<th>Biome</th>
<th>Precipitation</th>
<th>Temperature</th>
<th>Soil</th>
<th>Diversity</th>
<th>Trees</th>
<th>Grasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Rain Forest</td>
<td>high</td>
<td>hot</td>
<td>poor</td>
<td>high</td>
<td>dense</td>
<td>sparse</td>
</tr>
<tr>
<td>Tropical Dry Forest</td>
<td>variable</td>
<td>mild</td>
<td>rich</td>
<td>moderate</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Tropical Savanna</td>
<td>variable</td>
<td>mild</td>
<td>clay</td>
<td>moderate</td>
<td>sparse</td>
<td>dense</td>
</tr>
<tr>
<td>Desert</td>
<td>low</td>
<td>variable</td>
<td>poor</td>
<td>moderate</td>
<td>sparse</td>
<td>sparse</td>
</tr>
<tr>
<td>Temperate Grassland</td>
<td>moderate</td>
<td>summer hot</td>
<td>rich</td>
<td>moderate</td>
<td>absent</td>
<td>dense</td>
</tr>
<tr>
<td>Temperate woodland and Shrubland</td>
<td>summer low, winter moderate</td>
<td>summer hot</td>
<td>poor</td>
<td>low</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Temperate Forest</td>
<td>moderate</td>
<td>summer moderate, winter cold</td>
<td>rich</td>
<td>high</td>
<td>dense</td>
<td>sparse</td>
</tr>
<tr>
<td>Northwestern Coniferous Forest</td>
<td>high</td>
<td>summer mild, winter cold</td>
<td>rocky, acidic</td>
<td>low</td>
<td>dense</td>
<td>sparse</td>
</tr>
<tr>
<td>Boreal Forest</td>
<td>moderate</td>
<td>summer mild, winter cool</td>
<td>poor, acidic</td>
<td>moderate</td>
<td>dense</td>
<td>sparse</td>
</tr>
<tr>
<td>Tundra</td>
<td>low</td>
<td>summer mild, winter cold</td>
<td>poor</td>
<td>low</td>
<td>absent</td>
<td>medium</td>
</tr>
</tbody>
</table>

**Terrestrial Biomes and Climate**

Climate is the average weather in an area over a long period of time. Weather refers to the conditions of the atmosphere from day to day. Climate is generally described in terms of temperature and moisture. Temperature falls from the equator to the poles. Therefore, major temperature zones are based on latitude. They include tropical, temperate, and arctic zones (see Figure 9.8). However, other factors besides latitude may also influence temperature. For example, land near the ocean may have cooler summers and warmer winters than land farther inland. This is because water gains and loses heat more slowly than does land, and the water temperature influences the temperature on the coast. Temperature also falls from lower to higher altitudes. That’s why tropical zone mountain tops may be capped with snow.

**Figure 9.8** Temperature zones are based on latitude. What temperature zone do you live in?
In terms of moisture, climates can be classified as arid (dry), semi-arid, humid (wet), or semi-humid. The amount of moisture depends on both precipitation and evaporation. Precipitation increases moisture. Evaporation decreases moisture.

**Figure 9.9** These diagrams show how precipitation is affected by the ocean and a mountain range.

**Climate and Plant Growth**

Plants are the major producers in terrestrial biomes. They have five basic needs: air, warmth, sunlight, water, and nutrients. How well these needs are met in a given location depends on the growing season and soil quality, both of which are determined mainly by climate.

- The growing season is the period of time each year when it is warm and wet enough for plants to grow. The growing season may last all year in a hot, wet climate but just a few months in a cooler or drier climate.
- Plants grow best in soil that contains plenty of nutrients and organic matter. Both are added to soil when plant litter and dead organisms decompose. Decomposition occurs too slowly in cold climates and too quickly in hot, wet climates for nutrients and organic matter to accumulate. Temperate climates usually have the best soil for plant growth.

**Climate and Biodiversity**

Because climate determines plant growth, it also influences the number and variety of other organisms in a terrestrial biome. Biodiversity generally increases from the poles to the equator. It is also usually greater in more humid climates. This is apparent from the desert and rainforest biomes pictured in **Figure 9.9** above.

**Climate and Adaptations**

Organisms evolve adaptations that help them survive in the climate of the biome where they live. For example, in biomes with arid climates, plants may have special tissues for storing water (see **Figure 9.10**). The desert animals pictured in **Figure 9.10** also have adaptations for a dry climate.

**Figure 9.10** The aloe plant on the far left stores water in its large, hollow leaves. The cactus plant on the far right stores water in its stout, barrel-shaped stems. The Gila monster’s fat tail is an adaptation to its dry climate. It serves as a storage depot for water. The kangaroo rat has very efficient kidneys. They produce concentrated urine, thus reducing the amount of water lost from the body.

In biomes with cold climates, plants may adapt by becoming dormant during the coldest part of the year. Dormancy is a state in which a plant slows down cellular activities and may shed its leaves. Animals also adapt to cold temperatures. One way is with insulation in the form of fur and fat.

**Figure 9.11** Thick fur and a layer of blubber keep polar bears warm in their Arctic ecosystem. Why do you think their fur is white? Why might it be an adaptation in an Arctic biome?
Aquatic Biomes

Terrestrial organisms are generally limited by temperature and moisture. Therefore, terrestrial biomes are defined in terms of these abiotic factors. Most aquatic organisms do not have to deal with extremes of temperature or moisture. Instead, their main limiting factors are the availability of sunlight and the concentration of dissolved oxygen and nutrients in the water. These factors vary from place to place in a body of water and are used to define aquatic biomes.

Aquatic biomes can be generally classified based on the amount of salt in the water. Freshwater biomes have less than 1% salt and are typical of ponds and lakes, streams and rivers, and wetlands. Marine biomes have more salt and are characteristic of the oceans, coral reefs, and estuaries.

The Aquatic Biomes

Water is the common link among the aquatic biomes and they make 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%. They include standing and running freshwater biomes. Standing freshwater biomes include ponds and lakes. Lakes are generally bigger and deeper than ponds. Some of the water in lakes is in the aphotic zone where there is too little sunlight for photosynthesis. Plankton and plants (such as the duckweed in Figure below) are the primary producers in standing freshwater biomes.

Ponds and Lakes

These regions range in size from just a few square meters to thousands of square kilometers. 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.

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.

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. At the start there are cool temperatures, clear water, and high oxygen levels. Freshwater fish such as trout and heterotrophs can be found there. Towards the middle of the stream diversity increases—numerous aquatic green plants and algae can be found. Toward the mouth of the river/stream, the water becomes murky from all the

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sediiments that it has picked up upstream. Less light creates 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**

A wetland is an area that is saturated with water or covered by water for at least one season of the year. The water may be freshwater or saltwater. Wetlands are extremely important biomes for several reasons:
- They store excess water from floods.
- They slow down runoff and help prevent erosion.
- They remove excess nutrients from runoff before it empties into rivers or lakes.
- They provide a unique habitat that certain communities of plants need to survive.
- They provide a safe, lush habitat for many species of animals, so they have high biodiversity.

**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.

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 a constant mixing of warm and cold water. Species include surface seaweeds, 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. 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. Species include seaweed, 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. Hydrothermal vents at mid-ocean ridges can also be found here.

**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 and tissues of animal polyp. Besides corals, the fauna include several species of microorganisms, invertebrates, fishes, sea urchins, octopuses, and sea stars.

**Hydrothermal Vents**

Hydrothermal vents are among the most unusual ecosystems on Earth since they are dependent on chemosynthetic organisms at the base of the food web. This ecosystem is entirely separate from the photosynthesis at the surface. Shrimp, clams, fish, and giant tube worms have been found in these extreme places. A video explaining hydrothermal vents with good footage is seen [here](#).
Figure 9.12 Giant tube worms found at hydrothermal vents get food from the chemosynthetic bacteria that live within them. The bacteria provide food; the worms provide shelter.

**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. Micro-flora like algae, and macro-flora, 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.

**Aquatic Biomes and Sunlight**

In large bodies of standing water, including the ocean and lakes, the water can be divided into zones based on the amount of sunlight it receives:

1. The photic zone extends to a maximum depth of 200 meters (656 feet) below the surface of the water. This is where enough sunlight penetrates for photosynthesis to occur. Algae and other photosynthetic organisms can make food and support food webs.
2. The aphotic zone is water deeper than 200 meters. This is where too little sunlight penetrates for photosynthesis to occur. As a result, food must be made by chemosynthesis or else drift down from the water above.

![Ocean Zones](image-url)

**Aquatic Biomes and Dissolved Substances**

Water in lakes and the ocean also varies in the amount of dissolved oxygen and nutrients it contains:

1. Water near the surface of lakes and the ocean usually has more dissolved oxygen than does deeper water. This is because surface water absorbs oxygen from the air above it.
2. Water near shore generally has more dissolved nutrients than water farther from shore. This is because most nutrients enter the water from land. They are carried by runoff, streams, and rivers that empty into a body of water.
3. Water near the bottom of lakes and the ocean may contain more nutrients than water closer to the surface. When aquatic organisms die, they sink to the bottom. Decomposers near the
bottom of the water break down the dead organisms and release their nutrients back into the water.

**Aquatic Organisms**

Aquatic organisms generally fall into three broad groups: plankton, nekton, and benthos. They vary in how they move and where they live.

1. **Plankton** are tiny aquatic organisms that cannot move on their own. They live in the photic zone. They include phytoplankton and zooplankton. Phytoplankton are bacteria and algae that use sunlight to make food. Zooplankton are tiny animals that feed on phytoplankton.

2. **Nekton** are aquatic animals that can move on their own by “swimming” through the water. They may live in the photic or aphotic zone. They feed on plankton or other nekton. Examples of nekton include fish and shrimp.

3. **Benthos** are aquatic organisms that crawl in sediments at the bottom of a body of water. Many are decomposers. Benthos include sponges, clams, and anglerfish like the one in Figure 9.14. How has this fish adapted to a life in the dark?

![Figure 9.14](image)

This anglerfish lives between 1000 and 4000 meters below sea level. No sunlight penetrates to this depth. The rod-like structure on its face has a glow-in-the-dark tip. It is covered with microorganisms that give off their own light. The fish wiggles the structure like a worm to attract prey. In the darkness, only the rod-like worm is visible.

**Lesson Summary**

- A biome is an area with similar climate that includes similar communities of plants and animals.
- Climate influences the types of plants and animals that inhabit a specific biome.
- Factors affecting biome type include latitude, humidity, and elevation.
- Terrestrial biomes are determined mainly by climate. Climate influences plant growth, biodiversity, and adaptations of land organisms. Terrestrial biomes include tundras, temperate forests and grasslands, chaparral, temperate and tropical deserts, and tropical forests and grasslands.
- Aquatic biomes are determined mainly by sunlight and concentrations of dissolved oxygen and nutrients in the water. Aquatic organisms are either plankton, nekton, or benthos. Marine biomes are found in the salt water of the ocean. Freshwater biomes include standing and running water biomes. Wetlands are extremely important biomes. They may have freshwater or salt water.
- In the ocean, phytoplankton photosynthesize as the main food source. They are eaten by zooplankton and other larger animals.
- The photic zone extends to a maximum depth of 200 meters, while the aphotic zone is deeper than 200 meters.
- Organisms that live in the deepest ocean have amazing adaptations to the exceptionally harsh conditions, such as unhinging jaws, backward-folding teeth, or a bioluminescent lure.
- A hydrothermal vent ecosystem has chemosynthesis as its food source. The ecosystem is independent of photosynthesis at the surface.
- Life in the intertidal is difficult, but there are many types of organisms there.
- There are few organisms that live in the deepest ocean. The ones that do have amazing adaptations to the exceptionally harsh conditions.