BIOMES

The biodiversity we see around us occurs partly because the earth has many different combinations of environmental conditions that support the amazing range of organisms around us. We can understand the range of environment types more easily if we classify them into a few broad groups. **Biomes** can be considered life zones, environments with similar climatic, topographic, and soil conditions, and roughly comparable biological communities. Most biomes are identified by the dominant plants of their communities (for example, grassland or deciduous forest). There can be considerable variation in the individual species that make up biological communities at two similar sites. But recognizing biome categories gives us insights about the general kinds of plants and animals that we might expect to find there and how they may be adapted to their particular environment.

Climates and Biomes

Temperature and precipitation are among the most important determinants in biome distribution. If we know the general temperature range and precipitation level, we can predict what kind of biological community is likely to develop on a particular site if that site is free of disturbance for a sufficient time (fig. 5.2). Biome distribution also is influenced by the prevailing landforms of an area. Mountains, in particular, exert major influences on biological communities.

Figure 5.3 shows the distribution of major terrestrial biomes around the world. Many variations exist within each biome type; these could be seen on more local maps. Note, however, that many biomes occupy characteristic ranges of latitude: tundra occurs only in cold regions near the poles, while tropical forests occur only within the tropics—near the equator.

Often, it is the *relationship* between temperature and precipitation that controls biome distribution and conditions. The reason for this is evapotranspiration, or the combination of moisture loss by evaporation and by plant transpiration—water taken up by plant roots and released to the atmosphere as part of plants' respiration and cooling mechanisms. In hot places, available moisture dissipates quickly through both evaporation and transpiration. In cool environments, evapotranspiration proceeds slowly, allowing moisture to accumulate.

This relationship is displayed using climagraphs, or climate diagrams (fig. 5.4). A climagraph shows temperature on the left axis and precipitation on the right for each month of the year. The difference between temperature and precipitation is what makes climagraphs interesting. In figure 5.4, yellow areas show months in which evapotranspiration is greater than available precipitation: if rain falls, it is used or evaporated quickly. Blue areas show

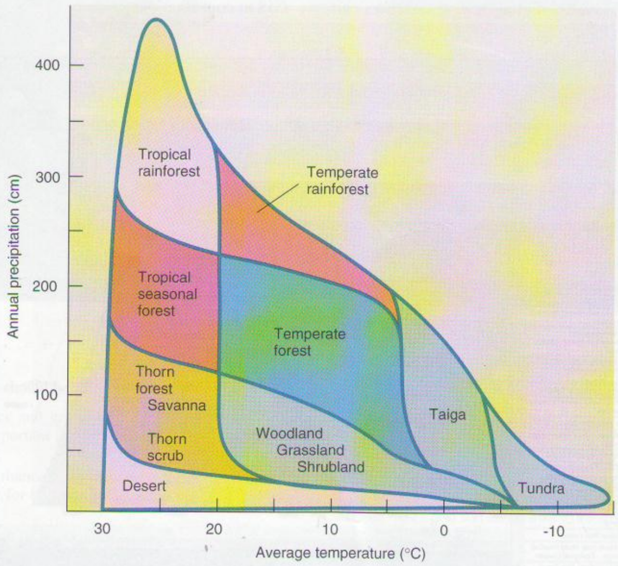

FIGURE 5.2 *Biomes most likely to occur in the absence of human disturbance or other disruptions, according to average annual temperature and precipitation.* Note: *This diagram does not consider soil type, topography, wind speed, or other important environmental factors. Still, it is a useful general guideline for biome location.*

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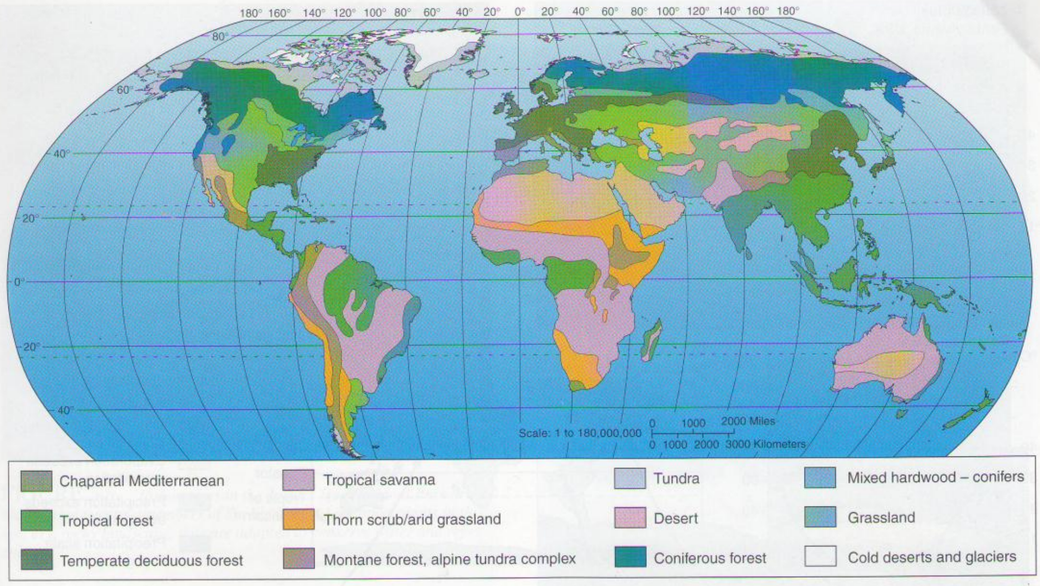

FIGURE 5.3 *Major world biomes. Compare this map to figure 5.2 for general climate conditions.*

months with a net excess of precipitation: water accumulates in the soil, and rivers and lakes may become full.

Compare January and February (marked J and F on the horizontal axes) in Taiyuan, China, and Yuma, Arizona. Both places receive only slight moisture, but Taiyuan is cold, while Yuma is about 15ºC. Yuma has a net deficit of moisture, colder Taiyuan has a net surplus. You can find similar contrast in April in Tiksi, Russia, and San Diego, USA. Later in the spring, Taiyuan receives more moisture, but rising temperatures increase evapotranspiration. A moisture deficit results for April and May.

Seasonal changes are also evident in a climagraph. Bombay, India, has extreme water deficits in winter, but in summer there is a huge surplus of moisture, which recharges wells and groundwater, fills rivers, and supports plant growth well into the next winter's dry season. Yuma, Arizona, on the other hand, has moisture deficits year-round. There, only specially adapted plants and animals can survive the continuous dry conditions.

Which of the graphs in figure 5.4 most resembles the place where you live? How do seasonal changes affect growing conditions and life-forms in your biome?

As you read the biome descriptions in this chapter and look at the biome photos, think about how water availability, heat, or freezing temperatures might influence the types of organisms that occur in each area.

Deserts

Deserts are dry, with precipitation that is both infrequent and unpredictable from year to year. With little moisture to absorb and store heat, daily and seasonal temperatures can fluctuate widely. Deserts with less than 2.5 cm (1 in) of measurable precipitation support almost no vegetation. Deserts with 2.5 to 5 cm (1 to 2 in) annual precipitation have sparse vegetation (less than 10 percent of the ground is covered), and plants in this harsh climate need a variety of specializations to conserve water and protect tissues from predation. Seasonal leaf production, water-storage tissues, and thick epidermal layers help reduce water loss. Spines and thorns discourage predators while also providing shade (fig. 5.5). Many desert animals avoid the drying sun by feeding at night, and most acquire water from the seeds and vegetation they eat.

Warm, dry, high-pressure atmospheric conditions (see chapter 9) create broad bands of deserts around the world at about 30° north and south latitude. This band includes deserts in the American Southwest, North and South Africa, China, and Australia. The coastal deserts of South America and Africa are among the driest regions in the world. Because vegetation grows so slowly in deserts, recovery after human disturbance or overgrazing can take centuries.

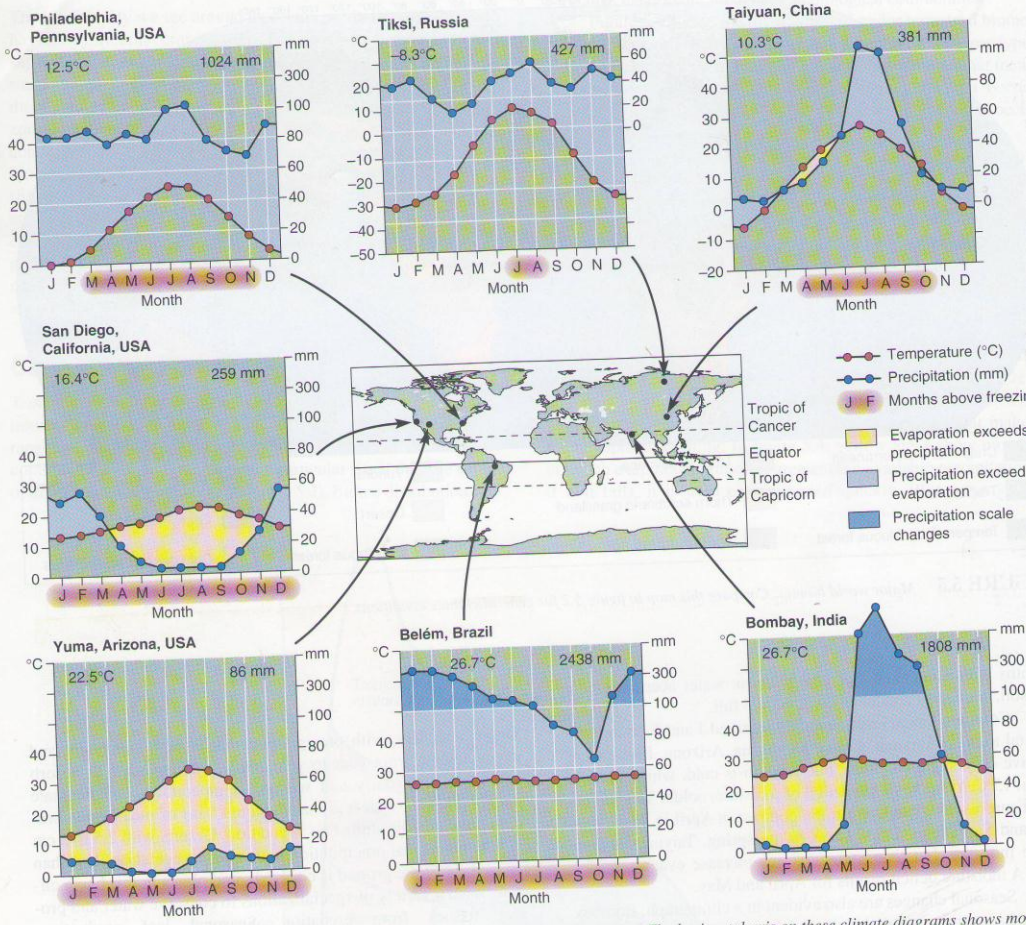

FIGURE 5.4 *Moisture availability depends on temperature as well as precipitation. The horizontal axis on these climate diagrams shows mo of the year; vertical axes show temperature* (left side) *and precipitation* (right). *The number of dry months* (shaded yellow) *and wetter months* (blue *varies with geographic location. Mean annual temperature (°C) and precipitation (mm) are shown at the top of each graph.*

Grasslands: Prairies and Savannas

The moderately dry continental climates of the Great Plains of central North America, the broad Russian steppes, the African veldt, and the South American pampas support **grasslands,** rich biological communities of grasses, seasonal flowering plants, and open savannas (grasslands with scattered trees) (fig. 5.6). Seasonal cycles of temperature and precipitation contribute to abundant vegetative growth that both protects and enriches the soils of prairies and plains, making them among the richest farmlar the world—where there is enough water to support crops. In parts of the world, including parts of the American Great F grasslands have been artificially created or maintained by people using fire. In addition to keeping grasslands open an logically diverse, occasional fires improve grazing (and hu and ease of travel.

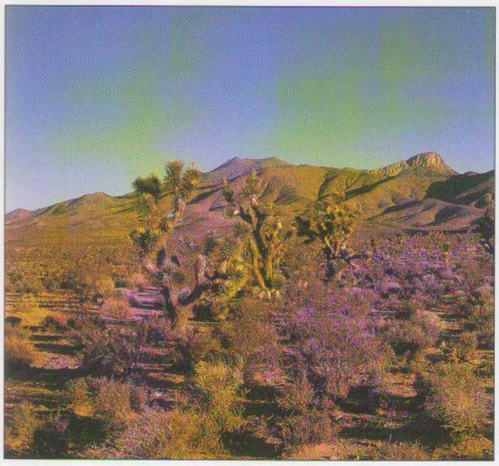

FIGURE 5.5 *Joshua trees in the Joshua Tree National Park are really large yuccas—members of the lily family. Like other plants in this hot, dry, rocky landscape, they are adapted to conserve water and repel enemies.*

Grasslands have few trees because inadequate rainfall, large daily and seasonal temperature ranges, and frequent grass fires kill woody seedlings. Exceptions are the narrow gallery forests that form corridors along rivers and streams through the grasslands.

Tundra

Climates in high mountain areas or at far northern or southern latitudes often are too harsh for trees. This treeless landscape, called **tundra,** has a very short growing season, cold, harsh winters, and the potential for frost any month of the year. Although water may be abundant on the tundra, for much of the year it is locked up in ice or snow and therefore unavailable to plants. Dominant tundra plants are dwarf shrubs, sedges, grasses, mosses, and lichens (fig. 5.7). Some larger animals are adapted to these conditions, including musk ox and caribou. Most animals migrate south or downhill in the winter. In summer, arctic tundra provides some of the most important bird breeding grounds in the world. (See related story, "Too Many Geese," at www.mhhe.com/apps.)

Tundra has low biological productivity, low diversity, and low resilience. Truck ruts and bulldozer tracks on the tundra landscapes of Alaska will probably take centuries to heal. Arctic tundra winters are long and dark. Only the top several centimeters of the soil thaw out in the summer, and the lower soil is permafrost. This permanently frozen layer prevents snowmelt water from being absorbed into the soil, so the surface soil is waterlogged during the summer. Try to imagine the difficulties that plants encounter in this kind of soil. Most of the year, the soil is

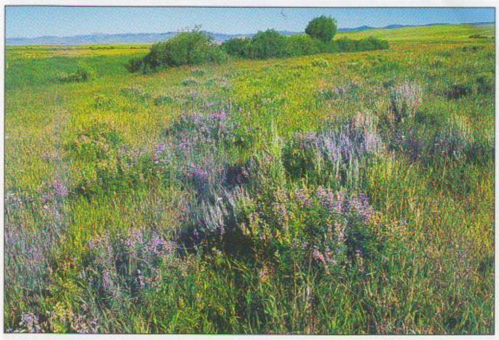

FIGURE 5.6 *A combination of dry climate, extreme temperatures, and periodic fires keeps grasslands, like this one in Montana, clear of trees except in protected coulees and streambeds.*

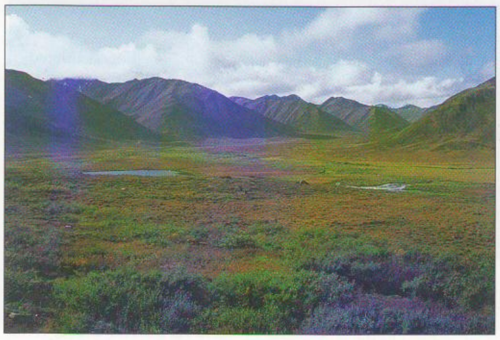

FIGURE 5.7 *Tundra ecosystems have short growing seasons and long, dark winters. Vegetation is mainly short and grows extremely slowly.*

completely frozen, and even during the brief growing season, the permafrost is an impenetrable barrier to deep root growth. In addition, the top layer of soil buckles and heaves in response to cycles of freezing and thawing, toppling plants and disrupting root systems.

Alpine (high mountain) tundra plants endure thin mountain air, strong ultraviolet radiation, hot daytime temperatures and often freezing nights, even in summer. Alpine soil is windswept and often gravelly or rocky.

Conifer Forests

Conifer (cone-bearing) trees dominate several distinctive biomes. The thin, needle-like leaves of conifers have small surface areas and thick, waxy coatings that help trees minimize moisture loss.

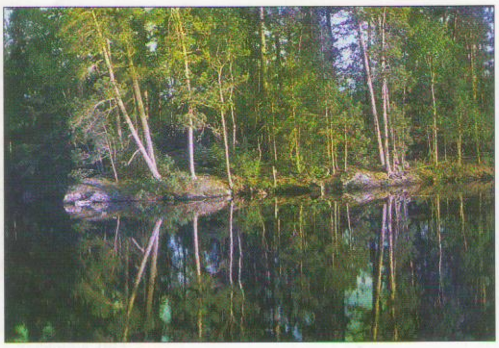

FIGURE 5.8 *Mixed conifer and deciduous forests like this one in northern Minnesota are characteristic of the Great Lakes Region. Although other species assemblages are found elsewhere, temperate cool forests around the world share many common characteristics.*

Consequently, conifers often occur where moisture is limited by sandy soil, low precipitation, or a short growing season. Although not as efficient in carrying out photosynthesis during summer months as the broad, soft leaves of deciduous trees, conifer needles and scales can survive harsh winters or extended droughts and do accomplish some photosynthesis, even under poor conditions. In many areas, frequent fires help keep the forest open and encourage seedling growth.

The **boreal forest,** or northern coniferous forest, stretches in a broad band of mixed coniferous and deciduous trees around the world between about 45° and 60° north latitude, depending on altitude and distance from coastlines or major rivers. Among the dominant conifers are pine, hemlock, spruce, cedar, and fir. Some

APPLICATION: Comparing Biome Climates

Look back at the climate graphs for Yuma, Arizona, a desert region, and Tiksi, Russia, a tundra region (fig. 5.4). How much colder is Tiksi than Yuma in January? In July? Which location has the greater range of temperature through the year? How much do the two locations differ in precipitation during their wettest months?

Compare the temperature and precipitation in these two places to those in the other biomes shown. How wet are the wettest locations? Which biomes have distinct dry seasons? How do rainfall and length of warm seasons explain vegetation conditions in these biomes?

Answers: Tiksi is about 42°C colder in January, 25°C colder in June; Tiksi has the greater range of temperature; there is about 40 mm difference in precipitation in August.

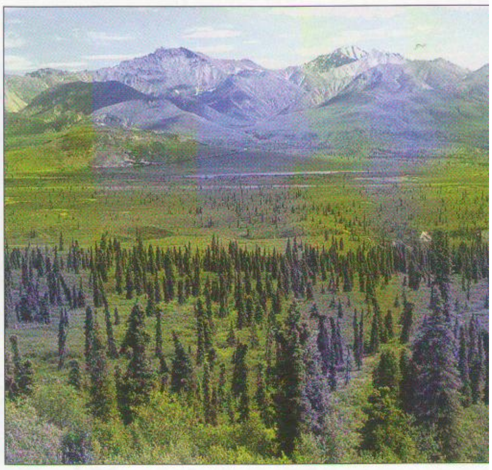

FIGURE 5.9 *In Alaska's Chugach Mountains, a sparse, black spruce forest grades into arctic tundra.*

small deciduous trees are also common, including birches, aspens and maples, while mosses and lichens form much of the groun cover. In this moist, cool biome, streams and wetlands abound—especially on recently glaciated landscapes. As a result, there ar many bogs, fens, and lakes (fig. 5.8). **Taiga,** a Russian word use for the northernmost edge of the boreal forest, is a species-poor often sparse forest of black spruce and sphagnum moss (pea moss). The taiga of Russia and North America forms a ragged bor der with the treeless arctic tundra (fig. 5.9).

Warm-climate pine forests occur at lower latitudes. In th United States, southern pine forests grow in a warm, moist climat on sandy soils. The undergrowth includes saw palmetto and vari ous thorny bushes.

Temperate rainforests, such as those in the Pacific North west, are also dominated by conifers. Here, mild temperatures an precipitation as high as 250 cm (100 in) per year support luxurian growth and huge trees, such as the California redwood, the larges tree in the world (fig. 5.10).

Broad-Leaved Deciduous and Evergreen Forests

Forests of broad-leaved trees occur throughout the world wher rainfall is plentiful. In temperate regions, the climate supports lus summer plant growth when water is plentiful. In winter, whe water is scarce or the ground is frozen, **deciduous** trees shed thei leaves to conserve water. Temperate deciduous forests contain ric and varied associations of many tree species, including oak maple, birch, beech, elm, ash, and other hardwoods. These ta