The Humid Temperate Ecoregions

6

6.1 200 Humid Temperate Domain

Both tropical and polar air masses govern the climate of the humid temperate domain, located in the mid-latitudes (30°–60°) on all the continents. The mid-latitudes are subject to **cyclones**; much of the precipitation in this belt comes from rising moist air along fronts within those cyclones. Pronounced seasons are the rule, with strong annual cycles of temperature and precipitation. The seasonal fluctuation of solar energy and temperature is greater than the diurnal (see Fig. 4.2, p. 29). The climates of the mid-latitudes have a distinctive winter season, which tropical climates do not. The lower temperatures of the winter season are due to two factors: reduced solar radiation and the inflow of cold air streams.

In the tropics (see Chap. 8), the different environments are distinguished on the basis of seasonal moisture pattern. There are regions with a high frequency of precipitation and regions with strong seasonal contrasts. Although the tropics are subject to one annual periodicity, most humid temperate regions are subject to two major annual cycles, one of solar energy and another of moisture.

In the temperate latitudes, probably the most important aspect of the hydrologic cycle is the periodic freezing of lakes, streams, and soil moisture. This freezing stops the flow of water runoff. At the same time, it decreases the water supply available to the plants, producing drought. Most streams will reflect the winter season in the flow pattern. When the spring thaw occurs, flooding may occur if there are large amounts of snow in the watershed and melting takes place rapidly. Removal of headwater forests leads to increased flooding.

Many of the same process of soil development which operate in tropical forest lands are active here, but go on more slowly, owing to lower temperatures and less extreme humidity. Humus accumulates, too, for the slower decay of organic litter on the forest floor, when mixed with the soil layers, imparts a brownish color.

Three zonal soil types are recognized in the regions of this group (Fig. 6.1). The red and yellow lateritic soils of the humid tropical group extend poleward into the warmer parts of the humid temperate lands, and are known as **yellow forest soils** (Ultisols). Farther poleward, however, humus accumulation is sufficiently rapid so that soil color is darkened. With the aid of earthworms, the organic matter is mixed with the upper soil layers to form the **brown forest soils** (Alfisols). The podzols (Spodosols) lie on the northern borders of this group, extending into the polar group. In the profiles of the podzol, the absence of earthworms is indicated by the concentration of humus at the surface, and the light, ashy color of the soil below (the name podzol is derived from a Russian word meaning ashes). The depth of these profiles decreases as the length of the frozen period of winter increases. None of these soils are fertile.

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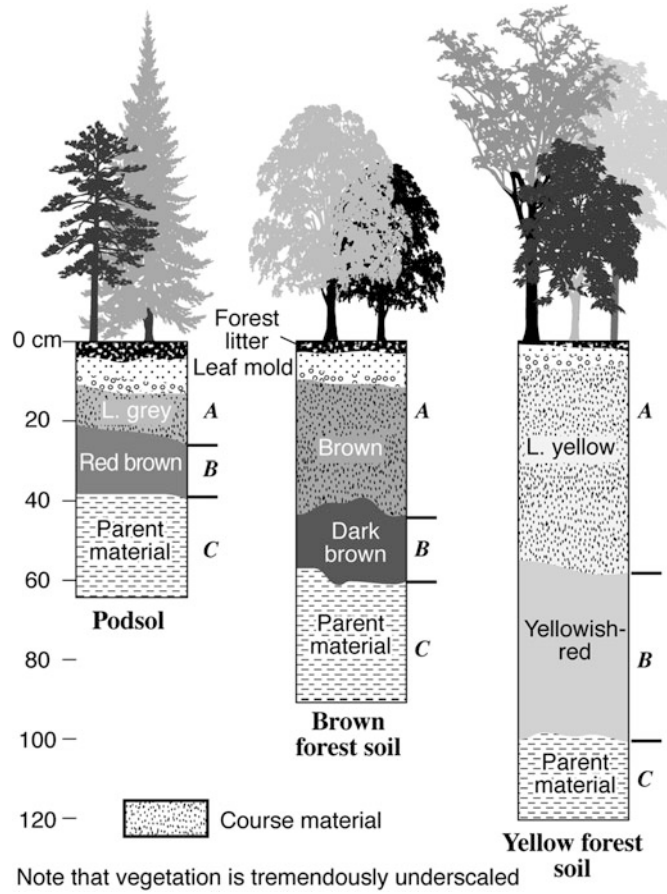

Fig. 6.1 Generalized mature soil profiles developed under mid-latitude forests. After Jenny (1941) in James (1959) p. 197

The regions of the humid temperate domain occur within climatic conditions where there is a winter cold season when plant growth ceases, and rain in summer is sufficient to support forest vegetation of broadleaf deciduous and needleleaf evergreen trees. On the equatorward side of these regions where this group borders the tropical regions, the differences in the forest are not sharply contrasted. Gradually the species that cannot survive frost drop out. On the poleward side of these regions in the Northern Hemisphere, there is a relatively sharp line of demarcation. The boreal forest occurs where there are severe winters and only short, cool summers. Here the spruce, fir, and larch are the more widespread conifers. Toward the continental interiors, on the dry side of these regions, grasslands usually border the forests.

Animals in these climates need to survive cold winters and seasonal variations in their food supply. Some vary their diet. Many birds and mammals migrate to warmer climates. Most amphibians and reptiles, as well as some large mammals, hibernate or become dormant.

The variable importance of winter frost determines six divisions: *warm continental*, *hot continental*, *subtropical*, *marine*, *prairie*, and *mediterranean*. Figure 6.2 shows the distribution of these divisions. Climate diagrams for these divisions are presented in Fig. 6.3.

6.2 210 Warm Continental Division

South of the eastern area of the subarctic climate, between latitudes 40° and 55°N and from the

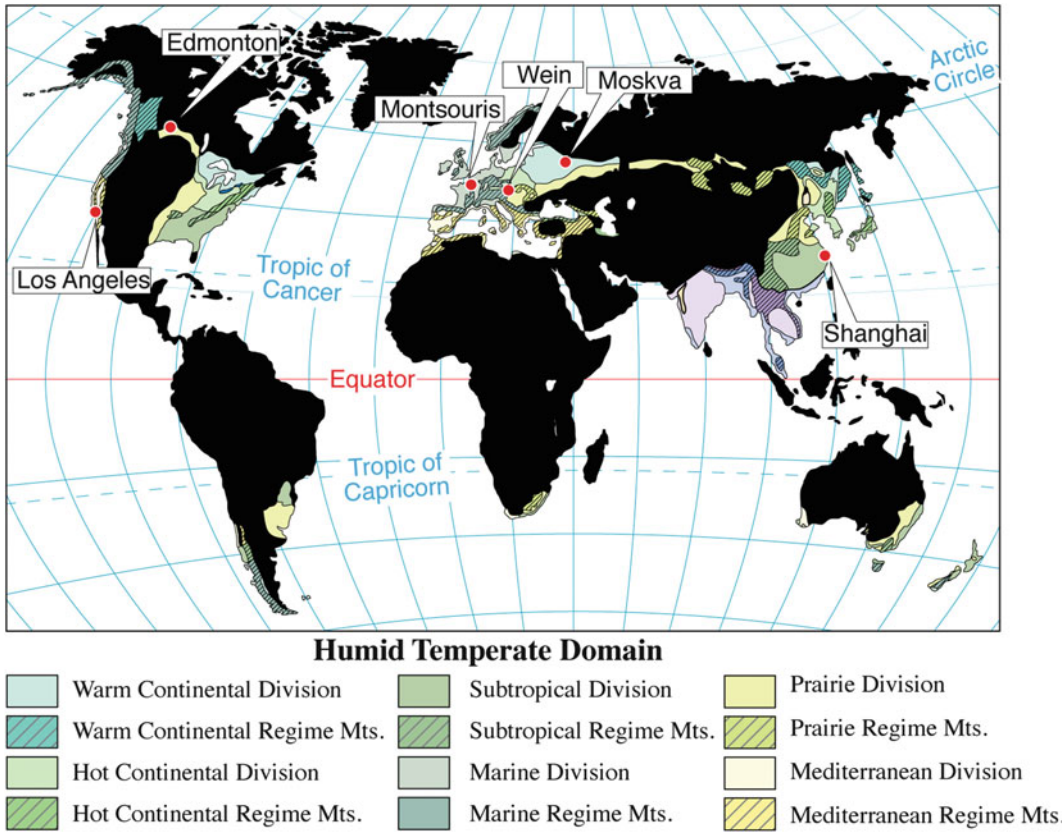

Fig. 6.2 Divisions of the continental humid temperate domain

continental interior to the east coast, lies the humid, warm-summer, continental climate. Located squarely between the source regions of polar continental air masses to the north, and maritime or continental tropical air masses to the south, it is subject to strong seasonal contrasts in temperature as air masses push back and forth across the continent.

This climate occurs only in the Northern Hemisphere. It applies to the northeastern United States and southeastern Canada, southeastern Siberia, and northern Japan. Very similar climatic conditions also hold for eastern Europe across the Baltic countries and Russia as far as the Urals.

The Köppen-Trewartha system designates this area as *Dcb*, a cold, snowy, winter climate with a warm summer (see Fig. 6.3, climate diagram for Moskva, Russia). This climate has 4–7 months when temperatures exceed 10 °C, with no dry season. The average temperature during the coldest month is below 0 °C. The warm summer signified by the letter *b* has an average temperature during its warmest month that never exceeds 22 °C. Precipitation is ample all year, but substantially greater during the summer. In eastern Asia, a monsoon effect is strongly accentuated in summer.

Mixed boreal and deciduous forest grows throughout the colder northern parts of the humid continental climate zone (Fig. 6.4), and is therefore transitional between the boreal forest to the north and the deciduous forest to the south. In eastern North America, part of it consists of mixed stands of a few coniferous species (mainly pine) and few deciduous species (mainly birch, maple, and beech). The rest is a macromosaic of pure deciduous forest in favorable habitats, with good soil and pure coniferous forest in less favorable habitats with poor soils. Here soils are

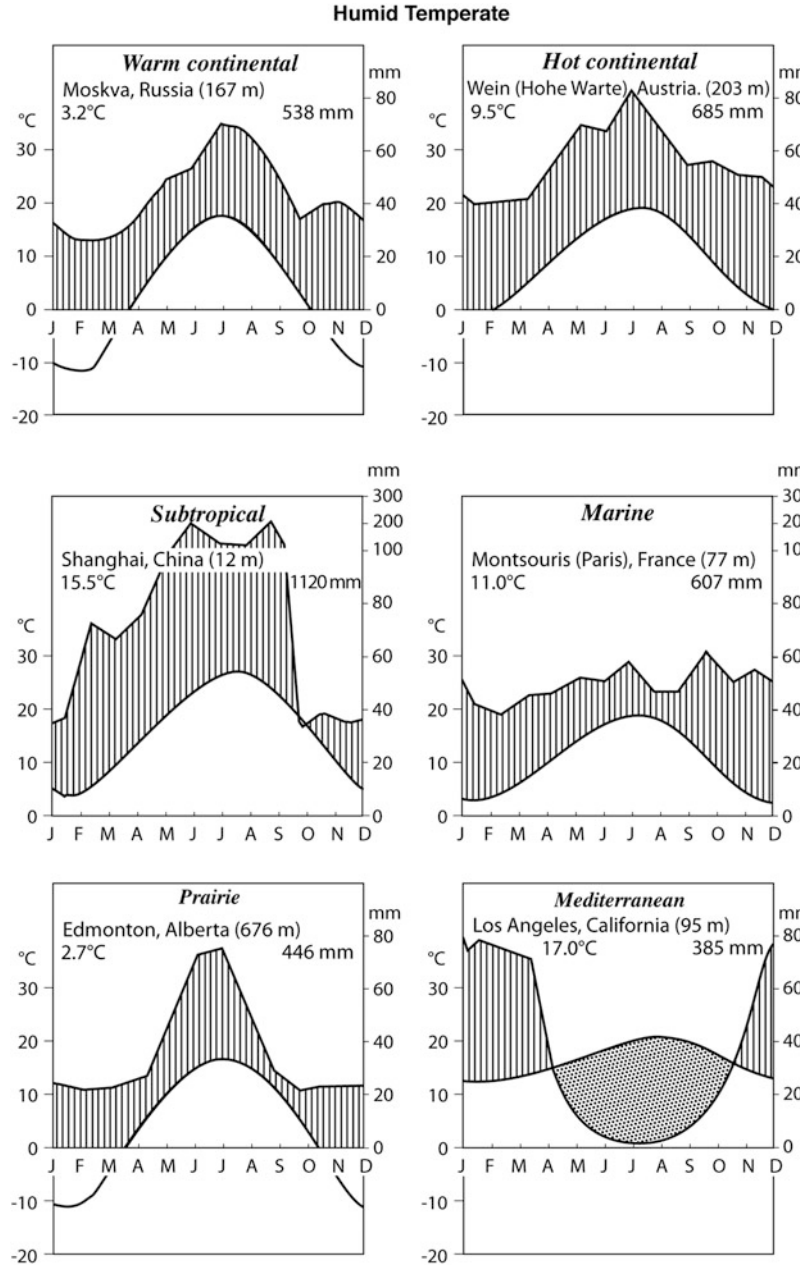

Fig. 6.3 Climate diagrams from the various divisions of the humid temperate domain: mixed deciduous–coniferous forest regions (continental with cold winters and warm summers) and deciduous forest region (more moderate), broadleaf evergreen forest region (very rainy with hot summers), oceanic broadleaf forest region (rainy with warm summers), prairie region (cold winter with warm summer), and sclerophyllous regions of California (dry summer). Redrawn from Walter et al. (1975)

podzols (Spodosols). Such soils have a low supply of bases and a horizon in which organic matter and iron and aluminum have accumulated. They are strongly leached, but have an upper layer of humus. Cool temperatures inhibit bacterial activity that would destroy this organic matter in tropical regions. Deficient in calcium, potassium, and magnesium, soils are generally acidic. Thus, they are poorly suited to crop production, even though adequate rainfall is generally assured. Conifers thrive here.

Because of the availability of soil water through a warm-summer growing season, this environment has an enormous potential for food production. North America and Europe support dairy farming on a large scale. A combination of

Fig. 6.4 Broadleaf deciduous and needleleaf evergreen forest as it appears in the Lake States region of north central United States. Photograph by Robert G. Bailey

Fig. 6.5 A stand of mature sugar maples in the Allegheny National Forest, Pennsylvania. Photograph by B.W. Muir, U.S. Forest Service

acid soils and unfavorable glacial terrain in the form of bogs and lakes, rocky hills, and stony soils has deterred crop farming in many parts.

6.3 220 Hot Continental Division

South of the warm continental climate lies another division in the humid tropical domain, one with a humid, hot-summer continental climate. It has the same characteristics as the warm continental except that it is more moderate and has hot summers and cool winters (see Fig. 6.3, climate diagram for Wien, Austria). The boundary between the two is the isotherm of 22 °C for the warmest month. In the warmer sections of the humid temperate domain, the frost-free or growing season continues for 5–6 months, and in the colder sections only 3–5 months. Snow cover is deeper and lasts longer in the northerly areas.

This climate is located in central and eastern parts of United States, northern China (including Manchuria), Korea, northern Japan, and central and eastern Europe.

In the Köppen-Trewartha system, areas in this division are classified as *Dca* (*a* signifies hot summer). We include in the hot continental division the northern part of Köppen's *Cf* (subtropical) climate region in the eastern United States. Köppen used as the boundary between the *C*-*D* climates the isotherm of −3 °C for the coldest month. Thus, for example, in the United States, Köppen places New Haven, Connecticut, and Cleveland, Ohio, in the same climatic region as New Orleans, Louisiana, and Tampa, Florida, despite obvious contrasts in January mean temperatures, soil groups, and natural vegetation between these northern and southern zones. Trewartha (1968) redefined the boundary between *C* and *D* climates as the isotherm of 0 °C of the coldest month, thereby pushing the climate boundary south to a line extending roughly from St. Louis to New York City. Trewartha's boundary is adopted here to distinguish between humid continental and humid subtropical climates.

Natural vegetation in this climate is winter deciduous forest, dominated by tall broadleaf trees that provide a continuous dense canopy in summer, but shed their leaves completely in the winter (Fig. 6.5). Lower layers of small trees and shrubs are weakly developed. In spring, a luxuriant ground cover of herbs quickly develops, but is greatly reduced after trees reach full foliage and shade the ground. Common trees in eastern United States, eastern Europe, and eastern Asia are oak, beech, birch, hickory, walnut, maple, basswood, elm, ash, tulip, sweet chestnut, and hornbeam. Hemlock, a needleleaf evergreen tree, may also be present.

Soils are chiefly **red-yellow podzols** (Ultisols), and **gray-brown podzols** (Alfisols),

rich in humus and moderately leached with a distinct, light-colored zone under the upper dark layer. The red-yellow podzols (Ultisols) have a low supply of bases and a horizon of accumulated clay. Where topography is favorable, diversified farming and dairying are the most successful agricultural practice. Because the gray-brown podzols (Alfisols) are soils of high base status, they proved highly productive for farming after the forests were cleared.

Most of the native forest has been cleared. The forest is preserved throughout the mountainous terrain of the Appalachians Mountains and the woodlots throughout the farmed belt. Much of this forest consists of second- or third-growth tree stands. Many farms in the forested area were abandoned and have since been covered by successional forest. The original animal life was abundant with deer, bear, panthers, squirrels, and wild turkeys. Large mammals became scarce during the peak of agricultural use, but populations have increased with return of the forest environment.

In China and Korea, the effects of prolonged deforestation are evident everywhere. Throughout central Europe, large areas have been under field crops and pastures for centuries, while at the same time forests have been cultivated. Cereals grown extensively in North America and Europe include corn and wheat. In north China, wheat is the principal crop. Rice is the dominant crop in both south Korea and Japan. Soybeans are intensively cultivated in the midwestern United States and in northern China and Manchuria, but very little in Europe.

6.4 230 Subtropical Division

The humid subtropical climate, marked by high humidity (especially in summer) and the absence of really cold winters, prevails on the eastern sides of the five continents in lower middle latitudes, and is influenced by trade and monsoon winds. These areas include the southeastern United States, southern China, Taiwan (Formosa), southernmost Japan, Uruguay and adjoining parts of Brazil and Argentina, the eastern coast of Australia, and the North Island of New Zealand.

In the Köppen-Trewartha system, this area lies within the *Cf* climate, described as temperate and rainy with hot summers (see Fig. 6.3, climate diagram for Shanghai, China). The *Cf* has no dry season; even the driest summer month receives at least 30 mm of rain. The average temperature of the warmest month is warmer than 22 °C. Rainfall is ample all year, but is markedly greater during summer. Rivers and streams flow copiously through much of the year. Thunderstorms, whether of thermal, squall-line, or cold-front origin, are especially frequent in summer. Tropical cyclones and hurricanes strike the coastal area occasionally, always bringing heavy rains and flooding. Winter fronts bring precipitation, some in the form of snow. Temperatures are moderately wide in range, comparable to those in tropical deserts, but without the extreme heat of a desert summer.

Soils of the moister, warmer parts of the humid subtropical regions are strongly leached red-yellow podzols (Ultisols) related to those of the humid tropical and equatorial climates. Rich in oxides of both iron and aluminum, these soils are poor in many of the plant nutrients essential for successful agricultural production. They are susceptible to severe erosion and gullying when exposed to forest removal and intensive cultivation.

Forest is the natural vegetation throughout most areas of this division. Along the outer coastal plain of the United States and in a large part of southern China and the south island of Japan, the native broadleaf forest was of the evergreen type. This forest consists of trees such as the evergreen oak, and trees of the laurel and magnolia families. Near its northern limits, vegetation of this region grades into broadleaf deciduous forest. Another type of rainforest is found in southeastern Australia and Tasmania and consists of many species of eucalyptus, which may reach heights of 100 m (Fig. 6.6). The rainforest flora found in New Zealand consists of large tree ferns, large conifers such

Fig. 6.6 Eucalyptus forest in southeastern Australia. Photograph by Forests Commission of Victoria; from the American Geographical Society Library, University of Wisconsin-Milwaukee Libraries

as the kauri tree, podocarp trees, and small-leaved southern beeches.

Broadleaf evergreen forest may have a well-developed lower layer of vegetation that may include tree ferns, small palms, bamboos, shrubs, and herbaceous plants. Lianas and epiphytes are abundant.

Much of the southeastern United States today is covered by a second-growth forest consisting of a number of pine species. It grows on the sandy soils of the coastal plain, where it appears to be a specialized type dependent on fast-draining sandy soils and frequent fires for its preservation.

Today, large areas have been converted to agricultural croplands, particularly in China. Corn is a major crop in the southern United States. Cattle production and tree farming are the important uses of soils too sandy for field crops. Rice and tea are the most important crops in those parts of China and Japan with similar climate.

6.5 240 Marine Division

Situated chiefly on the continental west coasts and on islands of the higher middle latitudes between 40° and 60°N is a zone that receives abundant rainfall from maritime polar air masses, and has a narrow range of temperature because it borders on the ocean. These coasts and islands are bathed by warm ocean water, and the prevailing westerly winds bring abundant moisture to the land.

Trewartha (1968) classified the marine, west coast climate as *Do*—temperate and rainy, with warm summers. The average temperature of the warmest month is below 22 °C, but at least 4 months of the year have an average temperature of 10 °C. The average temperature during the coldest month of the year is above 0 °C. Precipitation is abundant throughout the year, but is markedly reduced during the summer (see Fig. 6.3, climate diagram for Montsouris [Paris], France). Although total rainfall is not great by tropical standards, the cooler air temperatures reduce evaporation and produce a damp, humid climate with much cloud cover. Mild winters and relatively cool summers are typical. Coastal mountain ranges influence precipitation markedly in these middle latitudes. The mountainous coasts of British Columbia and Alaska annually receive 1,530–2,040 mm of precipitation and more. Heavy precipitation greatly contributed to the development of fiords along the coast in Norway (Fig. 6.7), British Columbia, southern Chile, and the South Island of New Zealand. Heavy snows in the glacial period fed vigorous valley glaciers that descended to the seas, scouring deep troughs that reach below sea level at their lower ends. Farther back from the coast the annual rainfall decreases, even to less than 75 cm (London 60 cm; Paris 55 cm); but in the absence of any very high temperatures so little evaporation occurs that even this relatively small amount is highly effective and supports a luxuriant plant growth.

Needleleaf forest is the natural vegetation of the marine division. In the coastal ranges of the

Fig. 6.7 This Norwegian fiord has the steep rock walls of a deep glacial trough. Postcard by Eneret Mittet and Co. [Place of publication unknown, author's collection]

northwestern United States, it is the redwood zone. Farther north, this vegetation is succeeded by Douglas-fir, western red cedar (Fig. 6.8), and spruce which grow to enormous heights, forming some of the densest of all coniferous forest with some of the world's largest trees. Under the lower precipitation regime of Ireland, southern England, France, and the Low Countries, a broadleaf deciduous forest was the native vegetation. However, much of it disappeared many centuries ago under cultivation, so that only scattered forest plots or groves remain. Dominant tree species of this forest type in western Europe are oak and ash, with beech in the cooler, moister areas. In the Southern Hemisphere, the forests of Tasmania and New Zealand, and the mountainous coastal belt of southern Chile are of the **temperate rainforest** class.

The trees are covered with mosses, epiphytes, and ferns. They cover everything from living branches and leaves to rotting logs. Because of the cool climate, decomposition works slowly; log piles upon logs to form a moss and fern-covered jumble over the forest floor, which is deep in humus. This is very much unlike the tropical rainforest, where decomposers make short work of falling debris so that the forest floor has little humus and few fallen logs.

Because of recent Pleistocene glaciation, landforms of glacial erosion and deposition are little changed from their original shapes. Glacial troughs and fiords are striking landforms. Extensive lowlands of northwestern Europe consist of till plains, moraines, and outwash plains left by ice sheets. Mountain watersheds, when disturbed by logging, can experience severe erosion and high sediment yields, particularly from mass wasting.

Fig. 6.8 Damp, oceanic coniferous forest with western red cedar in Mt. Baker National Forest, Washington. Photograph by E. Lindsay, U.S. Forest Service

Soils of the marine regions bearing needleleaf forest are strongly leached, acidic brown forest soils (Alfisols). Due to the region's cool temperatures, bacterial activity is slower than in the warm tropics, so unconsumed vegetative

matter forms a heavy surface deposit. Organic acids from decomposing vegetation react with soil compounds, removing bases such as calcium, sodium, and potassium. Under the lower precipitation of the British Isles and western Europe, mid-latitude deciduous forests are underlain by gray-brown podzols (Alfisols).

Productivity is fairly high in these forests, but it chiefly goes into wood. Available forage is not high, so that the biomass of large animals is not great, although deer, elk, and mountain lions form part of the American marine ecosystem. In New Zealand, no mammals or reptiles existed in the original forest. The niches were filled by birds, such as the kiwi.

The marine regions of western Europe and the British Isles have been intensively developed for centuries for such diverse use as crop farming, dairying, orchards, and forests. In North America, the mountainous terrain is not suitable for agricultural use, except in limited valley floors. Forests are the primary resource here and constitute the greatest structural and pulpwood timber resource on Earth. Douglas-fir, western cedar, and western hemlock are the principal lumber trees. The same mountainous terrain that limits agriculture is a producer of enormous water surpluses that run to the sea in rivers. These rivers support anadromous fisheries.

In spite of the heavy rainfall, periods of drought up to several weeks can occur, so that many areas in the northwestern United States and the western coast of New Zealand have been burned. In New Zealand, the introduction of many species of deer proved to be a serious mistake, since these forests evolved in the absence of grazing mammals. Deer and sheep have seriously overbrowsed these forests.

6.6 250 Prairie Division

The deciduous forests of the temperate zone are confined to climatic regions of an oceanic nature, where extremes of temperature are not sharp, and where rainfall is more or less evenly distributed throughout the year. Two chief kinds of grasslands thrive in the transition zone of the middle latitudes between the forests and the deserts. On the dry margins are the short-grass **steppes** (p. 75) and on the wet margins are the tall-grass **prairies**.

Fig. 6.9 Prairie parkland on the Central Lowland, in northwest Iowa. Photograph by Robert G. Bailey

Prairies are typically associated with continental, mid-latitude climates designated as *subhumid*. Precipitation in these climates ranges from 510 and 1,020 mm per year, and is almost entirely offset by evapotranspiration (see Fig. 6.3, climate diagram for Edmonton, Alberta). In summer, air and soil temperatures are high. Soil moisture in the uplands is inadequate for tree growth, and deeper sources of water are beyond the reach of tree roots. In North America, prairies form a broad belt extending from Texas northward to southern Alberta and Saskatchewan. Similar prairies occur in the humid *pampa* of Argentina, in Uruguay and southern Brazil, in the *puszta* of Hungary and on the northern side of Russian steppes, in South Africa, in Manchuria, and in Australia.

In a transitional belt on the wetter border of the division, forest and prairie mix in the so-called **forest-steppe** or **parkland**. It is not a homogeneous vegetation formation like the tropical savanna (Chap. 8), but rather a macromosaic of deciduous forest stands and prairie. Relief and soil texture determine the predominating vegetation. Forests are found on well-drained habitats, slightly raised ground, the sides of the river valleys, and porous soils, whereas the prairies occupy badly drained, flat sites with a relatively heavy soil (Fig. 6.9). In the western prairies of the United States, the grassland has been changed

with the introduction of trees. Forests were planted around the farmsteads and villages, so that today the buildings are all but hidden in foliage during the summer.

In Canada and northern United States the transition from grassland to boreal forest consists of a narrow belt of poplar and aspen deciduous forest. This belt is from 60 to 200 km wide.

The boundary between the prairie and the forest is not so clearly related to climatic or edaphic conditions. Prairies exist well within a climate humid enough for tree growth, and where trees are planted they grow if protected from competition with the roots of the grasses. In previous times, fires caused by lightning and the grazing of big-game herds encouraged the growth of the grasses in the treeless, wet prairies.

The prairie climate is not designated as a separate variety in the Köppen-Trewartha system. Geographers' recognition of the prairie climate (Thornthwaite 1931; Borchert 1950) has been incorporated into the system presented here. Prairies lie on the arid western side of the humid continental climate, extending into the subtropical climate at lower latitudes. Temperature characteristics correspond to those of the adjacent humid climates, forming the basis for two types of prairies: temperate and subtropical.

Tall grasses associated with subdominant broad-leaved herbs dominate prairie vegetation. The grasses of the Argentine Pampa are said to have once risen above the head of a man on horseback. Trees and shrubs are almost totally absent, but a few may grow as woodland patches in valleys and other depressions. Deeply rooted grasses form a continuous cover. They flower in spring and early summer, the forbs in late summer. In the tall-grass prairie of Iowa, for example, typical grasses are big bluestem and little bluestem; a typical forb is black-eyed Susan.

Because rain falls less in the grasslands than in forest, less leaching of the soil occurs. The pedogenic process associated with prairie vegetation is **calcification**, as carbonates accumulate in the lower layers. Soils of the prairies are prairie soils (Mollisols), which have black, friable, organic surface horizons and a high content of bases. Grass roots deeply penetrate these soils. Bases brought to the surface by plant growth are released on the surface and restored to the soil, perpetuating fertility. These soils are the most productive of the great soil groups.

These soils are not uniform and reflect the transitional nature of the climate. A succession of soil types, from the humid forest margins across the prairies and the steppes to the dry lands, conforms to the changes in moisture and vegetation cover (Fig. 6.10). On the rainy margins of the prairie, a deep soil is formed which is so abundantly supplied with organic material that is dark-colored even in the *B* horizon. This is the **black prairie soil** (Fig. 6.11). Near the dry margin, rainfall decreases to the point that minerals dissolved near the surface are carried down to the *B* horizon and no farther.

Two soil types share this process of having mineral accumulations, chiefly lime, in the *B* horizon. The first of these, occupying the dry margins of the prairies, is known as the **chernozem** (Mollisol). The color of the chernozem is even darker than the black prairie soil, and its fertility is increased by the decreased effectiveness of the leaching process. The dry boundary of the chernozem coincides with the prairie–steppe boundary, where, because the depth of the moist surface soil becomes less than about 60 cm, the tall grasses give way to the short grasses. The smaller supply of humus from the short grasses is reflected in a change from the black color of the chernozem to a chestnut-brown color; and the more active evaporation and shallower penetration of the rain water result in the formation of a continuous layer of lime salts much closer to the surface than in the chernozem. This is the **chestnut-brown soil** (Mollisol).

Most of the regions of this type are either plains or plateaus. The rainfall in the prairie is usually sufficient to support permanent streams, many of which are lined by **galeria forests**.

Most of the prairie has disappeared, replaced by some of the richest farmland in the world (Fig. 6.12). Some of the native animals of the region enjoyed either an elimination of their natural enemies or an increase in the supply of food, which made possible a sudden and large increase in their numbers.

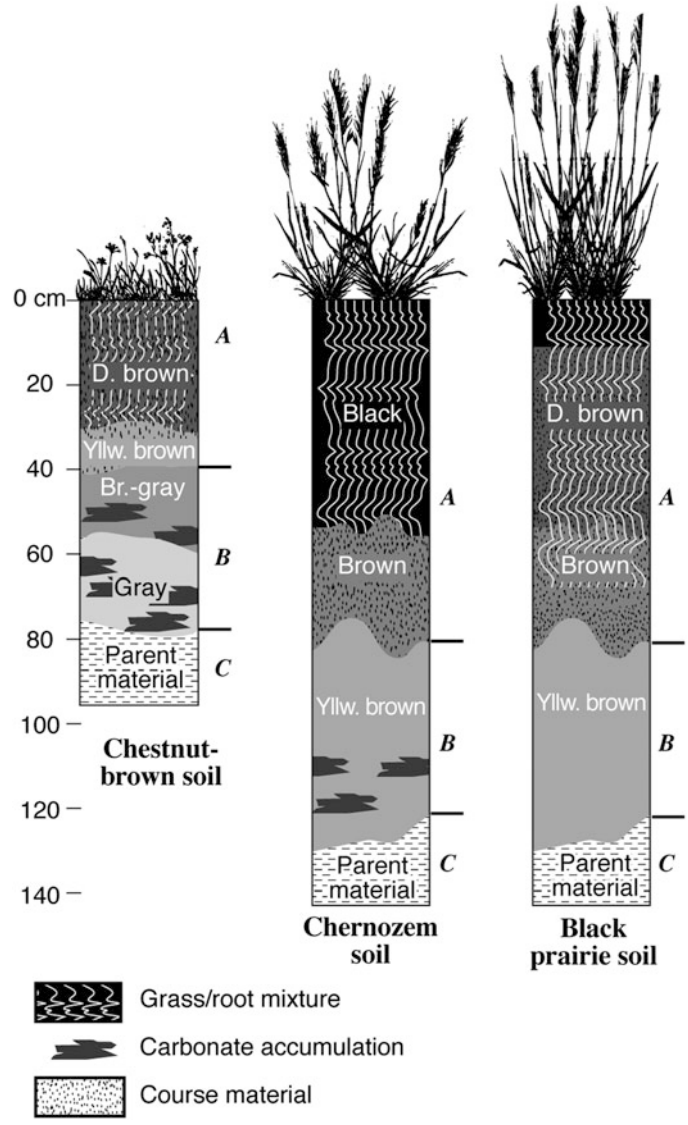

Fig. 6.10 Generalized mature soil profiles that develop under mid-latitude grassland. From Jenny (1941) in James (1959) p. 312

Fig. 6.11 Corn planted in prairie soil, Iowa. Photograph by Robert G. Bailey

The agricultural region that developed on the central plains of the United States as a result of the spread of farm settlement on to the prairie is known as the Corn Belt. Here the practice of feeding maize to hogs and cattle, and marketing the fattened animals is sustained by the vast areas of level land, and the remarkably sustained fertility of the soils. Although maize is the principal crop worldwide, this region is also ideally suited to other crops, such as wheat, particularly in Russia. On the other hand, soybeans are intensively cultivated in midwestern United States and in northern China and Manchuria.

Fig. 6.12 North American Corn Belt in a prairie region of South Dakota. Some patches of relict galeria forest follow the stream in the foreground. Photograph by John S. Shelton; from the University of Washington Libraries, Special Collections, John Shelton Collection, KC6162

6.7 260 Mediterranean Division

Situated on the western margins of the continents between latitudes 30° and 45°N is a zone subject to alternately wet and dry seasons, the transition zone between the dry west coast desert and the wet west coast. There are five such locations in the world. The largest borders the Mediterranean Sea. In North America the area included in this division lies primarily in California. Other areas are found in Chile, in South Africa around Capetown, and in Australia, where they are divided into a western area around Perth and an eastern area around Adelaide. They occupy only 2 % of the Earth's surface.

Trewartha (1968) classified the climate of these lands as *Cs*, signifying a temperate, rainy climate with dry, hot summers. The symbol *s* signifies a dry summer (see Fig. 6.3, climate diagram for Los Angeles, Calif.).

This climate is a product of subsidence associated with the subtropical high. In the summer the high moves poleward over these areas bringing essentially desert weather. In the winter the anticyclonic circulation moves equatorward allowing the westerlies to bring moisture into the area. These weather patterns often lead to summer wildfires (Fig. 6.13).

Fig. 6.13 Fire sweeping through California chaparral in summer. Photograph by Leonard F. DeBano, U.S. Forest Service

The combination of wet winters with dry summers is unique among climate types, and produces a distinctive natural vegetation of hard-leaved evergreen trees and shrubs called **sclerophyll**, scrub woodland. They reduce water loss with leaves which are small, thick, and stiff, with hard, leathery, and shiny surfaces. Various forms of sclerophyll woodland and scrub are also typical. Trees and shrubs must withstand the severe summer drought—two to four rainless months—and severe evaporation. Although in the different continents different species compose the woodland, the appearance of the

Fig. 6.14 Sclerophyll open woodland south of San Francisco, California. Most of the trees are oaks. Photograph by R.E. Wallace, U.S. Geological Survey

vegetation, resulting from its adaptation to the peculiarities of climate, is strikingly similar. The broadleaf evergreen woodlands of southern Europe, for example, are composed mostly of various kinds of oaks, whereas the similar forests of Australia are species of eucalpytus.

Because the winters are not cold enough, nor the summer droughts long enough to enforce a period of rest, there is no season when the leaves drop from the trees and growth ceases. In this way the mediterranean vegetation differs from selva (p. 84), which is evergreen but which has no seasonal rhythm. The woodland adapts itself to summer droughts. The trees are widely spaced and all plants have deep tap roots and a wide development of surface roots (Fig. 6.14). The evaporation from the plants is diminished by a thick bark and by the sclerophyllous leaves.

In many areas, the original cover of woodland has been radically altered, probably by humans. At present, large areas of this group are covered by a thick, low growth of bushes and shrubs, known as *maquis* in Europe, *chaparral* in California, and *mallee* in southern Australia. Extreme flammability characterizes the chaparral during the long, dry summer. This poses an ever present threat to suburban housing which has expanded into chaparral-covered hillsides in California.

This has raised a problem of resource management in the suburban areas around cities. When an attempt is made to keep fires from starting, the brush grows thicker and accumulates a layer of debris underneath. As a result, the brush fires are more destructive than they were when smaller fires occurred each year. Furthermore, when a large fire has completely burned the cover, the torrential winter rains that follow produce mud flows and floods. The soil may be swept completely away, leaving only the bare rock exposed at the surface, while bordering valleys are filled with mud. This situation is worsened in southern California where soil becomes water repellent following fire.

After a fire, many mediterranean shrubs resprout from root crowns. The seeds of some species need fire to germinate and may lay dormant for years until the next fire.

Soils of this mediterranean climate are not susceptible to simple classification. Soils typical of semiarid climates associated with grasslands are generally found. Severe and prolonged soil erosion following deforestation and overgrazing has left the mediterranean region with much exposed regolith and bedrock.

Animals survive fire by taking flight, or by retreating to underground burrows. Native mammals include deer, rabbits, and numerous rodents. In southern Europe and California, many of the native species have been replaced by large domestic grazers such as cows, sheep, and goats. Much of the birdlife is migratory, visiting mainly during the spring and fall. Resident birds tend to have short wings and long tails, an aid to maneuvering around shrubs.

The region is an important source of citrus fruits, grapes, and olives. In the mediterranean, cork from the bark of the cork oak is also important. In central and southern California citrus, grapes, avocadoes, nuts (almond, walnut), and deciduous fruits are extensively grown. Irrigated alluvial soils are also highly productive for vegetable crops such as carrots, lettuce, artichokes, strawberries, and forage crops (alfalfa).

This division lies closely hemmed in between high mountains and the sea. The surface features include small and isolated valley lowlands, bordered by hills and backed by high mountain ranges. The heavy rains in the highlands feed numerous torrential streams. The gravels and sands which they bring down with them to the lowlands are piled up in huge alluvial fans along the piedmonts. Delta plains grow where the rivers flow into the sea. Owing to the concentration of rain in the winter season, the regimen of these streams shows a maximum in that season. However, where the streams rise high enough in the mountains to reach the snow fields, the maximum flow comes during the melting period in the spring. The removal of forest from the mountains has seriously changed this regimen in many areas. The removal of the forest causes severe floods during the winter and spring, and during the summer these floods are followed by droughts, when the streams dry up. The original forest cover of most of the regions bordering the Mediterranean Sea has largely been removed, seriously affecting the habitability of the lowlands.

References

Borchert JF (1950) The climate of the central North American grassland. Ann Assoc Am Geogr 40:1–39

James PE (1959) A geography of man, 2nd edn. Ginn, Boston, 656 pp

Jenny H (1941) Factors of soil formation. McGraw-Hill, New York, 281 pp

Thornthwaite CW (1931) The climates of North America according to a new classification. Geogr Rev 21:633–655, with separate map at 1:20,000,000

Trewartha GT (1968) An introduction to climate, 4th edn. McGraw-Hill, New York, 408 pp

Walter H, Harnickell E, Mueller-Dombois D (1975) Climate-diagram maps of the individual continents and the ecological climatic regions of the earth. Springer-Verlag, Berlin, 36 pp, with 9 maps