The Dry Ecoregions

7

7.1 300 Dry Domain

The essential feature of a dry climate is that annual losses of water through evaporation at the Earth's surface exceed annual water gains from precipitation. Due to the resulting water deficiency, no permanent streams originate in dry-climate zones. Because evaporation, which depends chiefly on temperature, varies greatly from one part of the Earth to another, no specific value for precipitation can be used as the boundary for all dry climates. For example, 610 mm of annual precipitation produces a humid climate and forest cover in cool northwestern Europe, but the same amount in the hot tropics produces semiarid conditions.

The tropical dry climates occupy the air masses in the subtropical high-pressure cells centered over the tropics of Cancer and Capricorn, both north and south of the equator, in the zone between 20° and 30°. This subsiding air mass is stable and dry. Dry land regions can be found on the western sides of all the continents. The dry lands also extend inland from the western sides of the continents, bending poleward in each hemisphere. The general regularity of the global pattern of dry climates is a reflection of the regular arrangement of certain climatic and water features. Fig. 4.6 (p. 31) shows that cold water baths parts of the west coasts of all the continents. Because evaporation is much less from cold water than warm water, the rainfall is much less here than continental margins bathed by warm water. The presence of dry lands along the east coast of South America in Patagonia is associated with a wide expanse of cold water of the South Atlantic Ocean (Falkland Island Current). In North America the dry lands cannot extend so far toward the east as they do in Asia because of the movement of moist maritime air from the Gulf of Mexico up to the Mississippi Valley, and the lack of such air moving across the Himalayas, in Asia.

We commonly recognize two divisions of dry climates: the arid *desert* (*BW*) and the semiarid *steppe* (*BS*). Generally, the steppe is a transitional belt surrounding the desert and separating it from the humid climates beyond. The boundary between arid and semiarid climates is arbitrary, but commonly defined as one-half of the amount of precipitation separating steppe from humid climates. These climates are displayed in Fig. 7.1 and mapped in Fig. 7.2.

Of all the climatic groups, dry climates are the most extensive; they occupy a fourth or more of the Earth's land surface (see Fig. 4.7, p. 32).

In these climates, many plants and animals have adapted to live with minimal rain, drying winds, and high temperatures.

7.2 310 Tropical/Subtropical Steppe Division

Tropical steppes occur along the less arid margins of the tropical deserts on both the north

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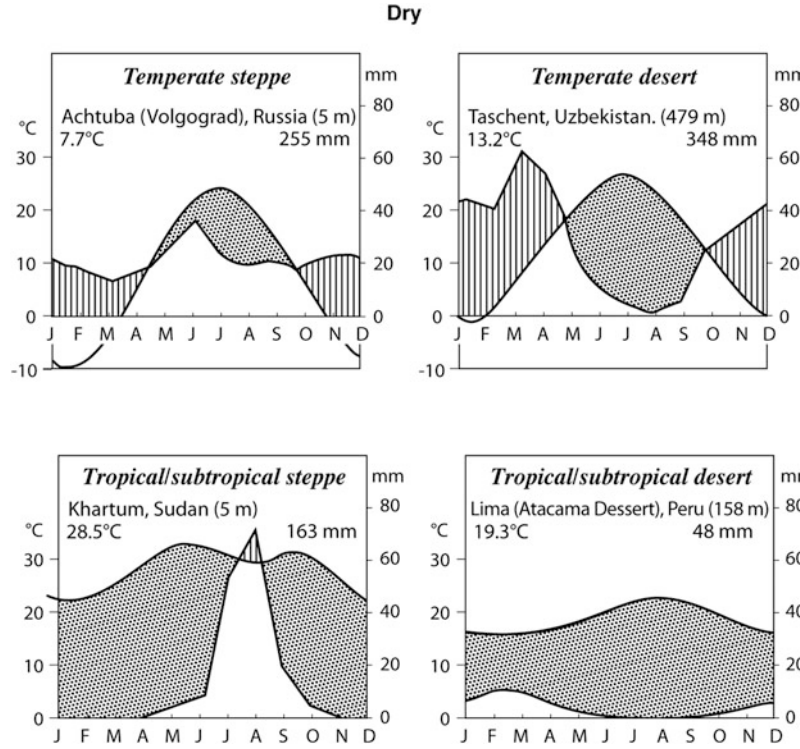

Fig 7.1 Climate diagrams of steppe and desert stations: *Above*: central Asia, with some rain at all seasons, and winter rain. *Below*: with summer rain (northern Africa), and with rain that may fall at any season (Atacama Desert). Redrawn from Walter et al. (1975)

and south, and in places on the east as well. On the equatorward side of the deserts it is transitional to the wet-dry tropical climate. Locally, altitude causes a semiarid steppe climate on plateaus and high plains that would otherwise be desert. Steppes on the poleward fringes of the tropical deserts grade into the Mediterranean climate in many places. In the United States, they are cut off from the Mediterranean climate by coastal mountains which allow the tropical deserts to extend farther north. Other important steppes of this type are the interior of the Kalahari Desert of South Africa, the dry eastern piedmont of the Andes, and northeastern Brazil.

Trewartha (1968) classified the climate of tropical/subtropical steppes as *BSh*, indicating a hot, semiarid climate where potential evaporation exceeds precipitation, and where all months have temperatures above 0 °C (see Fig. 7.1, climate diagram for Khartum, Sudan). Average rainfall is from 25 to 76 cm annually.

Steppes typically are grassland of short grasses and other herbs, with locally developed shrub and woodland. In the United States, pinyon-juniper woodland grows on the Colorado Plateau, for example. To the east, in New Mexico and Texas, the grasslands grade into savannah woodland or semi-deserts composed of xerophytic shrub and trees, and the climate becomes nearly arid-subtropical. Cactus plants are present in some places.

In the tropics, semi-desert is associated with this climate. A particularly important occurrence is the thorntree savanna of Africa, characterized by thorny trees and shrubs that shed their leaves for the long dry season. Another important area of this type is found in the Kalahari Desert of southern Africa, the home of the Bushmen. In the semi-desert zone of the African Sahel, the climate is associated with the acacia-desert grass savannah where the stunted trees stand far apart and the short desert grasses cover most of the

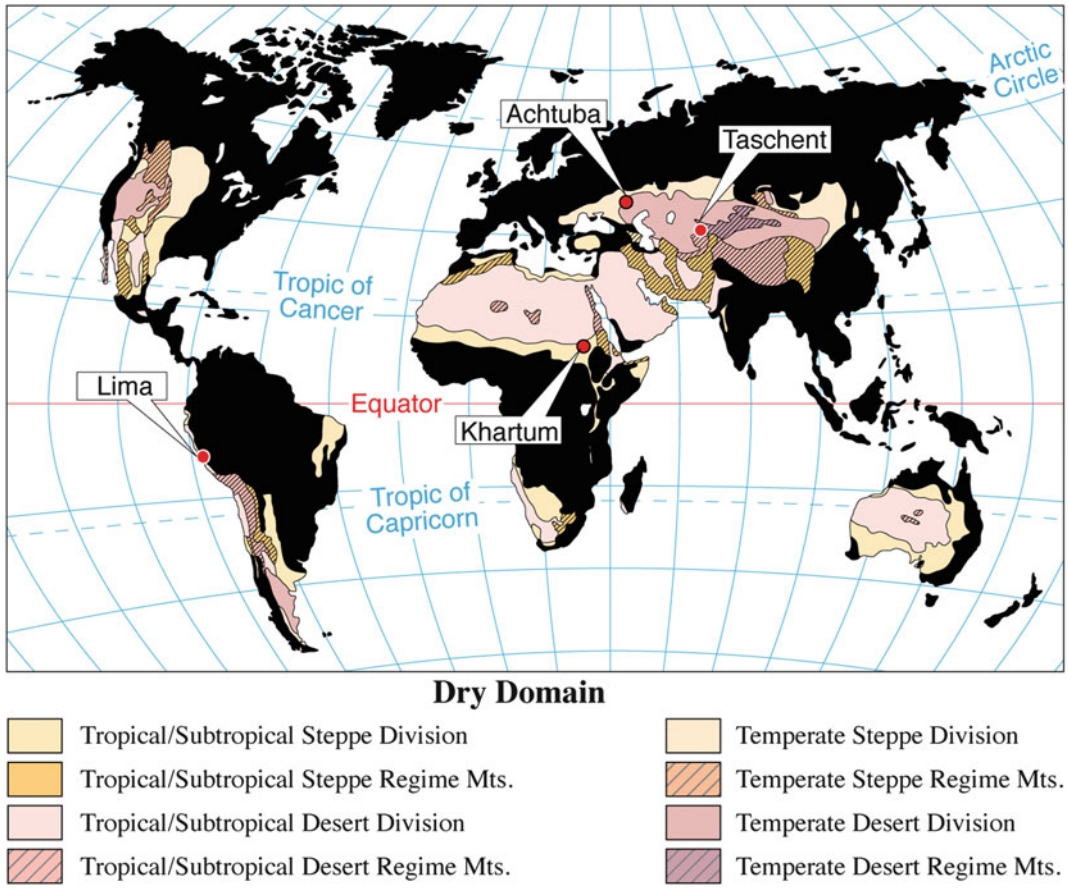

Fig 7.2 Divisions of the continental dry domain

surface. In northwestern Brazil, there is an area once covered with thorny, scrubby deciduous trees known as *caatinga*. Where brush is thicker and mixed with trees it forms the scrub woodland of the Chaco in Argentina. Scrub woodland also forms a fringe around the desert in Australia (Fig. 7.3).

Chestnut-brown soils and sierozems (Mollisols, Aridisols) are associated with these tropical, semi-arid climates.

In Africa, nomadic herding is one of the main forms of agrarian uses, which is linked to the alternation of the dry and rainy seasons. During the dry season the herders move into high-altitude regions, which are generally wetter, and during the rainy season they move down to the lowlands again. In the deserts and semi-deserts, the herds consist of camels, sheep, and goats, while in the thorn savannas, cattle predominate.

Like the temperate steppe we describe below, rainfall in these regions can be expected to vary greatly and is subject to periods of drought interspersed with periods of ample rainfall. In several West African nations within the Sahelian zone, recent droughts have depleted grasses for grazing and devastated the annual grain crop. Some five million cattle perished and many thousands of people died of starvation and disease. Periodic droughts in the past are well documented. In places, the land surface has been changed into desert through a process called **desertification**. Desertification in the African steppes can be attributed to greatly increased numbers of humans and their cattle.

Fig 7.3 Mulga scrub, a subtropical semi-desert, near Oudabunna Sta., western Australia. Photograph by R.A. Gould. Image #335754, American Museum of Natural History, Library

Fig 7.4 The incised channel of the Rio Puerco, New Mexico, northwest of Albuquerque. It carries water only a few days each year. Photograph by Lev Ropes, Guru Graphics

7.3 320 Tropical/Subtropical Desert Division

The continental desert climates are south of the Arizona-New Mexico Mountains in the United States. They are not only extremely arid but also have extremely high air and soil temperatures. Direct solar radiation is very high, as is outgoing radiation at night, causing extreme variations between day and night temperatures, and a rare nocturnal frost. Annual precipitation is less than 200 mm, and less than 100 mm in extreme deserts (see Fig. 7.1, climate diagram for Lima, Peru). These areas have climates that Trewartha (1968) calls *BWh*.

The vast desert belt extending across North Africa (Sahara Desert), Arabia, and Iran to Pakistan (Thar Desert) is of this type. Other important deserts in this belt are the Sonoran Desert of the southwestern United States and northern Mexico and the Great Australian Desert.

Important climatic differences exist between interior and coastal deserts at the same latitude. Cold ocean currents upwelling from great depths lie offshore along the west coasts. The cold ocean current absorbs heat from the overlying air. Fog is a persistent feature and extends inland for short distances. Deserts here are cool and have low annual range of temperatures. The Atacama Desert of Chile and the Namib Desert of coastal southwest Africa are notable examples of these cool, foggy deserts.

Because desert rainfall is unreliable, river channels and the beds of smaller streams are dry most of the time (Fig. 7.4). However, a sudden and intense downpour can cause local, brief flooding that transports large amounts of sediment. Major river channels, called **wadis** (or **arroyos** in the southwestern United States), often end in flat-floored basins having no outlet (Fig. 7.5). Here clay and silt are deposited and accumulate, along with layers of soluble salts. Shallow salt lakes occupy some of these basins. Where the lakes are temporary, they are known as **playas**. In various low places in the hot desert, ground water can be reached by digging or drilling a well. Where such water supplies are available, they are often used to irrigate agricultural plots, creating an oasis (Fig. 7.6).

Dry-desert vegetation characterizes the region. Widely dispersed xerophytic plants provide negligible ground cover. In dry periods, visible vegetation is limited to small hard-leaved or spiny shrubs, cacti, or hard grasses. Many species of small annuals may be present, but they appear only after the rare, but heavy rains have saturated the soil.

In a variety of ways, the biota of the deserts have adapted to drought, a situation made worse by drying winds and high temperatures.

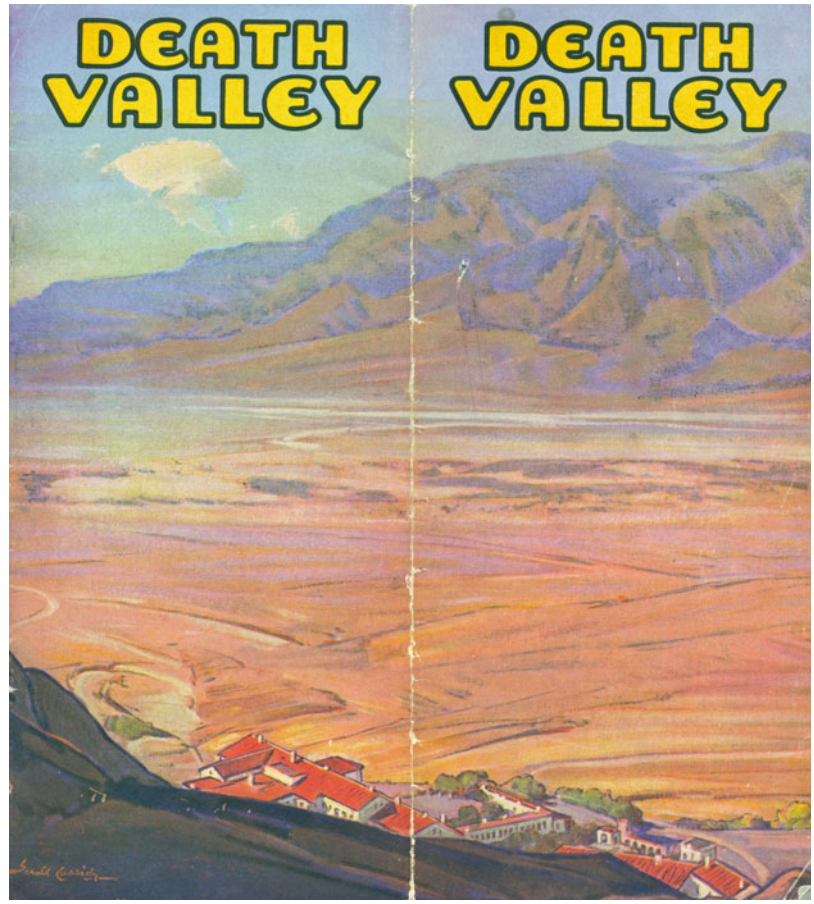

Fig 7.5 Death Valley's Badwater Basin in California is the point of the lowest elevation in North America at 282 ft (86 m) below sea level. With no outlet, it accumulated runoff and sediment from the surrounding mountains. During the Pleistocene ice age, Death Valley was filled with a huge lake. Vintage travel brochure by Death Valley Hotel Company; cover illustration by Gerald Cassidy, c. 1930. Author's collection

Fig 7.6 An oasis in the Sahara Desert of Libya. Date palms are planted in a sea of dune sand. Photograph by G.H. Goudarzi, U.S. Geological Survey

Succulents resist drought by storing water inside their roots and stems, and protect themselves from evaporation by having a thick, waxy layer and no leaves. Their extensive surface root-system quickly absorbs water before it sinks into porous soil. Some desert plants, such as the creosote bush, can survive without water, while others evade drought by growing close to a constant source of water, such as an oasis. Other plants, such as mesquite and tamarisk, send down very deep roots that are able to tap into a year-round supply of moisture. Some annual plants avoid the drought by lying dormant during the period between rains. Perennials, such as ocotillo, become dormant between the rains. Once all moisture has evaporated from the soil, the plant drops its leaves and temporarily stops growing.

In the Mojave-Sonoran Deserts (American Desert) of the United States and Mexico, plants are often so large that some places have a near-woodland appearance (Fig. 7.7). They include the tree-like saguaro cactus, the prickly pear cactus, the ocotillo, creosote bush, and smoke tree.

Fig 7.7 Sonoran Desert near Tucson, Arizona. Photograph by Matthew G. Bailey

Fig 7.8 Barren mountains in the Peruvian littoral desert at Santa Valley, north of Lima. Photograph by Shippee-Johnson. Image #334565, American Museum of Natural History, Library

However, much of the desert of the southwestern United States is in fact scrub, thorn scrub, savannah, or steppe grassland. Parts of these regions have no visible plants. They are made up of shifting dune sand, almost sterile salt flats, or bare mountain slopes covered by a mantle of loose rock fragments (Fig. 7.8).

Over large areas of these deserts, the regolith has no soil. On the margins, however, where enough percolating water exists to moisten the upper layers of the regolith at more or less regular intervals, and where **xerophytes**, or xerophytic plants, are concentrated, a dry type of soil is formed; it is known as the **sierozem** (Aridisol). Humus is lacking and this soil is gray in color at the surface, becoming lighter in the subsoil (Fig. 7.9).

Fig 7.9 Creosote bush on light desert soil in southern Nevada. Photograph by Robert G. Bailey

The dominant pedogenic process is **salinization**, which produces areas of salt crust where only salt-loving plants (halophytes) can survive. Calcification is conspicuous on well-drained uplands, where encrustations and deposits of calcium carbonate (caliche) are common.

Because there is little water in the deserts, mechanical weathering, or physical disintegration of the bedrock, is more rapid than chemical weathering. When a rock, such as granite, is composed of minerals of different colors, each mineral expands and contracts at a different rate. Such rocks quickly crumble into coarse sand, which forms an abrasive agent when picked up by the wind (Fig. 7.10). The very rough and youthful appearance of the desert topography is largely the result of this process. There are three kinds of desert landform regions: the **erg**, or sandy desert (Fig. 7.11), the **hamada** deserts composed of rocky plateaus channeled by dry water courses (see Frontispiece), and basin-and-range deserts of basins surrounded by barren mountains.

Animals have adapted to the desert environment. Some very specialized forms, of which the classic example is the camel must have fresh water but are able to store considerable quantities. Other species, such as scorpions, are nocturnal, carrying on their life activities at night when it is cooler and less water is needed for temperature control. Snakes and tortoises retreat to burrows. Still others, such as kangaroo rats of the American desert, restrict their water needs to what water they can manufacture by metabolism. These animals usually have little evaporation

Fig 7.10 Granite hollowed out by windblown sand, Atacama Desert, Chile. Photograph by K. Segerstrom, U.S. Geological Survey

Fig 7.11 An erg landscape in the Gobi Desert, Mongolia. Taken during the Roy Chapman Andrews Third Asiatic Expedition, 1925. Photograph by J.B. Shackelford. Image #315830, American Museum of Natural History, Library

loss from the surface and extremely dry waste products.

The world's hot deserts have been productive. Wherever irrigation is possible, the yields of crops have been high. The crops include long-staple cotton, fruits (dates, oranges, lemons, grapefruit, limes), vegetables, grains, and alfalfa. However, such irrigation projects suffer from two undesirable side effects—salinization and waterlogging of the soil. If irrigation water is evaporated in the soil it leaves salts behind. When these are sodium salts, and they accumulate too rapidly, they form an impervious **alkali**. When drainage is not adequate to flush out the excess sodium salts, this alkali may render desert soil completely sterile.

Like the Arctic tundra, the processes of soil development and plant succession are highly vulnerable to change from human activities. A single passage of an army tank over desert soil can dramatically alter water infiltration, soil moisture, and heat distribution, and consequently biological productivity. For example, in the Mojave Desert, lichen crust on sandy soil destroyed in tracks left by tank traffic in World War II-vintage maneuvers has not recovered in 60 years.

7.4 330 Temperate Steppe Division

Temperate steppes are areas that have a semiarid continental climatic regime in which, despite maximum summer rainfall, evaporation usually exceeds precipitation. There is too little water to support a forest and too much to create a desert. Instead these regions are dominated by grasslands, which are called *shortgrass prairie* in the central United States (Columbia Plateau, Great Plains), *steppe* in Eurasia, *pampas* in South America, and *veldt* in Africa. With more moisture, the vegetation changes to savannas, which are grasslands with enough moisture to support sparse tree growth.

Trewartha (1968) classified the climate as *BSk*. The letter *k* signifies a cool climate with at least 1 month of average temperature below 0 °C. Winters are cold and dry; summers—warm to hot (see Fig. 7.1, climate diagram for Achtuba [Volograd], Russia). Drought periods are common in this climate. With the droughts come the dust storms that blow the fertile topsoil from vast areas of plowed land being used for dry farming (Fig. 7.12).

These regions are subject to periodic climatic shifts. Thus, the drought typical of arid zones may extend well outside the normal desert

Fig 7.12 A dust storm approaching in the steppe of eastern Colorado. Photograph by Soil Conservation Service

boundaries one year, and precipitation characteristic of wetter regions may make incursions into an arid zone in the next year (Fig. 7.13). These shifts in climate become critical in areas where agriculture is carried out at the margins of humidity. In semiarid areas like the Great Plains of the United States the settlers have been devastated, because these locations are sometimes desert, sometimes humid, and sometimes a hybrid of the two.

The vegetation is steppe, sometimes called shortgrass prairie, and semi-desert (Fig. 7.14). Typical steppe vegetation consists of numerous species of short grasses that usually grow in sparsely distributed bunches. Many species of grasses and other herbs occur. Buffalograss is the typical grass of the American steppe. Other typical plants are the sunflower and locoweed. Scattered shrubs and low trees sometimes grow in the steppe; all gradations of cover are present, from semi-desert to woodland. Because ground cover is generally sparse, much soil is exposed.

The semi-desert cover is xerophytic shrub vegetation accompanied by a poorly developed herbaceous layer. Trees are generally absent. An example of semi-desert cover is the sagebrush vegetation of the middle and southern Rocky Mountain region and the Colorado Plateau in the United States.

In this climatic regime, the dominant pedogenic process is calcification, with salinization on poorly drained sites. Soils contain an excess of precipitated calcium carbonate and are rich in bases. **Brown soils** (Mollisols) are typical (see Fig. 11.9, p. 108). The soils of the semi-desert shrub are sierozems (Aridisols), with little organic content, and (occasionally) clay horizons, and (in some places) accumulations of various salts. Humus content is small because the vegetation is so sparse.

The grasslands are generally areas of plains and tablelands. Few perennial streams originate here, so that those streams which do exist have their source in other more humid areas. Crossing the grasslands, the streams lose their ability to carry sediment as volume and velocity decline. The result is considerable braiding of streams during the dry season.

The dominant animals of grasslands are the large herds of hoofed grazers, such as camels in Asia, American bison, pronghorn antelope in the United States, and several species of deer worldwide. In New Zealand and Australia, mammals are replaced by large grazing birds, such as the emu (Fig. 7.15). Much of the animal life in grasslands is found underground. Rodents—such as the prairie dog in America and hamsters of Eurasia—retreat underground to escape predators and the summer heat.

These steppes constitute the great sheep and cattle ranges of the world. The steppes of central Asia have for centuries supported nomadic populations. Wheat and, to a lesser extent, oats, rye, and barley, are dominant crops. The North American Great Plains, the Ukraine, and parts of north China are all within this region. Large areas of steppe have disappeared, replaced by farmlands (Fig. 7.16).

In the Occidental world, farmers cultivate poorer land, supporting themselves on large areas by using machinery. On the dry margins they have managed to survive by allowing the land to lie fallow for a year, so that enough moisture might be stored up to permit crop production the following year.

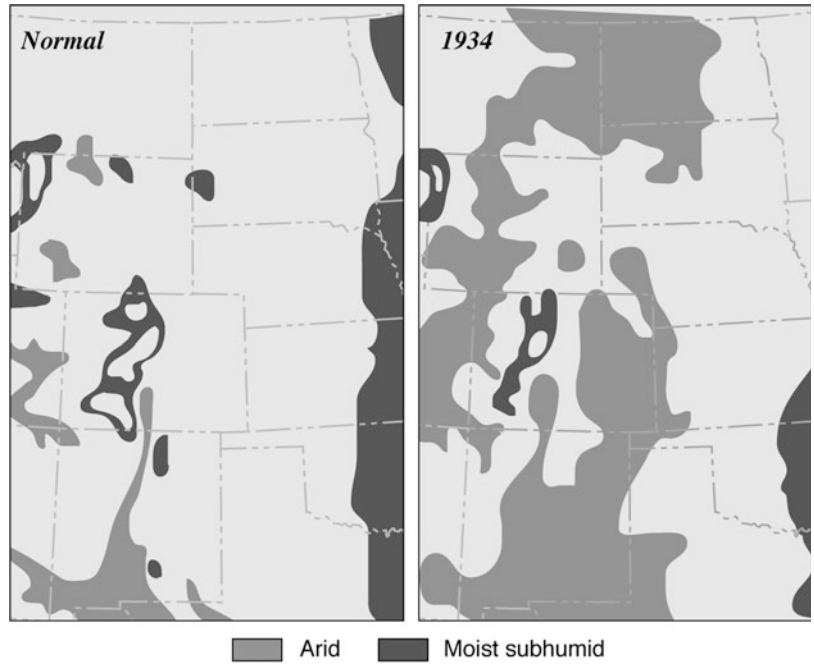

Fig 7.13 Climatic variations in the Great Plains of the United States during normal times and a drought in 1934. From Thornthwaite (1941), p. 182

Fig 7.14 Antelope herd in shortgrass prairie landscape in South Dakota. Photograph by R.S. Cole, Soil Conservation Service

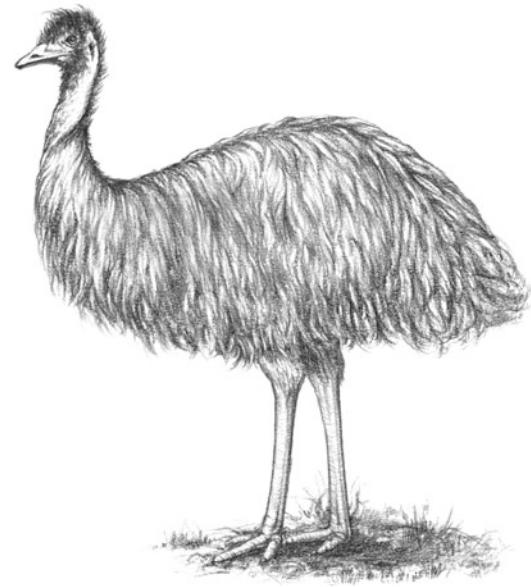

Fig 7.15 The Australian emu, one of the world's largest birds, has long, powerful legs to outrun predators. It can go without water for days and withstand extreme temperatures. Drawing by Susan Strawn

7.5 340 Temperate Desert Division

Temperate deserts are located in the interior of continents, although they merge with tropical deserts equatorward. They are found in North America in the Great Basin, from Arizona, northward into Washington. In Eurasia they are found embedded in the trans-Eurasian cordillera or lie on the flanks of these mountains. Most occur in the Turkestan and Gobi regions of central Asia. In the Southern Hemisphere, only South America

Fig 7.16 Plowing with steam tractor in the steppe of North Dakota during the early 1900s. Postcard by Bloom Bros., Minneapolis, author's collection

projects far enough into mid-latitudes to a have a temperate desert climate, and only on the east side of the Andes Mountains in Patagonia, Argentina.

These desert regions have low rainfall and strong temperature contrasts between summer and winter. In the intermountain region of the western United States, between the Pacific and Rocky Mountains, the temperate desert has characteristics of a sagebrush semi-desert, with a pronounced drought season and a short humid season. Most precipitation falls in the winter, despite a peak in May (see Fig. 7.1, climate diagram of Taschkent, Uzbekistan). Aridity increases markedly in the rain shadow of the Pacific mountain ranges. Even at intermediate elevations, winters are long and cold, with temperatures below 0 °C.

These desert areas have the highest percentage of possible sunshine of any of the mid-latitude climates. Because of low humidity, over 90 % of the sun's radiation reaches the ground. These deserts experience high daily temperature fluctuations. During the summer when the days are long and the sun high in the sky, temperatures will reach 50 °C. At sunset, heat is lost rapidly because of the lack of insulating clouds. The nighttime temperature can drop over 44 °C from the daytime high, with winter temperatures in Asia's Gobi Desert plummeting to −21 °C.

Fig 7.17 Temperate semi-desert in Wyoming. Postcard by Sanborn Souvenir Co., Denver, author's collection

Under the Köppen-Trewartha system, this is the true desert, *BWk*. The letter *k* signifies that at least 1 month has an average temperature below 0 °C. These deserts differ from those at lower latitude chiefly in their far greater annual temperature range and much lower winter temperatures. Unlike the dry climates of the tropics, middle-latitude dry climates receive a portion of their precipitation as snow.

Temperate deserts support the sparse xerophytic shrub vegetation typical of semi-deserts. One example is the sagebrush vegetation of the Great Basin (Fig. 7.17) and northern Colorado Plateau region of the United States. Recently, semi-desert shrub vegetation seems to have invaded wide areas of the western United States that were formerly steppe grasslands, due to

Fig 7.18 Desert vegetation and dissected alluvial fan of the Altai Mountains, Mongolia. Taken during the Roy Chapman Andrews Third Asiatic Expedition, 1925. Photograph by J.B. Shakelford. Image #322017, American Museum of Natural History, Library

overgrazing and trampling by livestock. Soils of the temperate desert are sierozems (Aridisols), low in humus and high in calcium carbonate. Poorly drained areas develop saline soils, and salt deposits cover dry lake beds.

Productivity is low due to drought and low temperatures. Growth is thus limited to a short period between winter cold and summer drought. Much of the small production goes into woody tissue. This is in contrast to the production of digestible foods in grasslands. Consequently, although there are herbivores in the desert, the weight in animals per unit area is small.

The surface features of these deserts consist of vast depressions surrounded by mountains or basin-and-range where flat-floored **bolsons** separate irregularly placed desert ranges. Alluvial fans surround the mountain ranges (Fig. 7.18). Water from the mountains is abundant and provides support for the large oasis communities at the base of the mountains and along the courses of exotic rivers.

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