# **Chapter 2 Rangeland Ecoregions of Western North America**



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**Abstract** The grasslands, deserts, shrublands, savannas, woodlands, open forests, and alpine tundra of western North America where livestock grazed were collectively referred to as 'range' in the nineteenth century. Today these ecosystems are often referred to as rangelands. In the United States, rangelands comprise about 1/3rd of the total land area, mostly in the 17 western states. Large areas of rangeland also occur in Canada and Mexico. Rangelands provide numerous products, values, and ecosystem services including wildlife habitat, clean air, clean water, recreation, open space, scenic beauty, energy and mineral resources, carbon sequestration, and livestock forage. This chapter describes rangeland ecoregions in western North America.

**Keywords** Rangeland regions · Grasslands · Savannas · Cool deserts · Sagebrush · Hot deserts · Piñon-juniper woodlands · Oak woodlands · Aspen parkland · Ponderosa pine savanna · Mountain rangelands · Alpine tundra

# 2.1 Introduction

It is unclear when the word range was first used to describe land in the western United States but reports from explorers, ranchers, and scientists in the mid to late 1800s referred to lands where livestock grazed as range. Confusingly, the word has also

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been used to describe the season of use (winter range) and the species of animal using the land (cattle or deer range; Chap. 30). Today, range or rangeland is not thought of as a kind of use but as a kind of land where grasses, forbs, shrubs, sedges, and rushes dominate and the land is valued and managed for wildlife habitat, clean air, clean water, recreation, open space, scenic beauty, energy and mineral resources, carbon sequestration as well as livestock forage (Box 1978; Havstad et al. 2009). Because the word range was used to describe lands throughout the western US, the idea that it referred to various kinds of vegetation developed early. Grasslands, deserts, shrublands, savannas, woodlands, some forests, meadows, and tundra ecosystems are all considered rangeland. Collectively rangelands form the most extensive land type on Earth and make up about 1/3rd (308 million ha) of the land area of the US. Most North American rangeland occurs in the 17 western states and adjacent areas in Canada and Mexico (Havstad et al. 2009).

Rangelands provide important habitat for many birds, herpetofauna, mammals, and insects (e.g., Chaps. 8-26). Sustaining rangeland wildlife requires sustaining rangeland vegetation suitable for wildlife. However, it is important for rangeland habitat managers to reconcile that it is impossible to maximize habitat quality for all wildlife at the same time. Any change in rangeland plant community structure or plant species composition simultaneously favors some wildlife species and disfavors others (Maser and Thomas 1983; Mosley and Brewer 2006). Consequently, habitat management commonly seeks to achieve two goals: (1) provide sufficient variability in vegetation conditions across the landscape to sustain a diverse wildlife community, and (2) make limiting habitat factors for desired wildlife species less limiting (Maser and Thomas 1983; Mosley and Brewer 2006). Changes in rangeland vegetation are dictated by the intensity and frequency of both natural and anthropogenic disturbances, and their interactions. Natural disturbances may include drought, flooding, wildfire, and grazing or browsing by wildlife. Anthropogenic-related disturbances may include chemical or mechanical habitat treatments, prescribed burning, artificial revegetation, and livestock grazing or browsing, which are discussed throughout this book.

Differences in amount, kind, and season of precipitation are the primary factors contributing to the development and distribution of the 25 rangeland ecoregions described in this chapter (Table 2.1; Stephenson 1990). Seven ecoregions occur east of the Rocky Mountains and Sierra Madre Oriental Mountains on the relatively flat landscapes of the Great Plains and Gulf Coastal Plain, while 18 ecoregions occur in the valleys, foothills, and mountains westward from the Rocky Mountains.

The eastern ecoregions, dominated by perennial grasslands and savannas, receive  $\geq 70\%$  of their annual precipitation between April and September from storms that originate in the Gulf of Mexico. Warm-season (C4) grasses dominate all but the most northern of these ecoregions. Cool-season (C3) plants dominate the western ecoregions, with most areas receiving  $\geq 50\%$  of their annual precipitation between October and April from storms originating in the Pacific Ocean. Many western ecoregions receive 50–70% of their annual precipitation as snow, and plants grow rapidly following snowmelt in spring. Sagebrush shrublands, piñon-juniper woodlands, oak woodlands, and montane ecosystems are the most extensive rangeland types in the

East of the rocky mountains	West of the rocky mountains		
	Winter precipitation	Summer precipitation	
Great Plains Prairie	Winter rain	Chihuahuan Desert	
Grasslands	California Annual Grassland	Sonoran Desert	
Tallgrass Prairie	California Oak Woodland	Mojave Desert	
Shortgrass Prairie	California Chaparral	Interior Chaparral	
Northern Mixed-Grass Prairie		Southwestern Oak Woodland	
Southern Mixed-Grass Prairie			
Savannas and Parklands	Winter snow		
Aspen Parkland	Salt Desert Shrub		
Edwards Plateau	Sagebrush Steppe		
Tamaulipan Thornscrub	Great Basin Sagebrush		
	Piñon-Juniper Woodland		
	Mountain Brush		
	Montane Grassland		
	Montane Sagebrush Steppe		
	Ponderosa Pine Savanna		
	Montane and Subalpine		
	Meadow		
	Alpine Tundra		

Table 2.1 Major rangeland ecoregions of western North America

Ecoregions are listed in the order they are presented in text

western ecoregions. West of the Sierra Nevada Mountains, annual grasses and forbs are major components of the vegetation and grow throughout the winter. These areas receive  $\geq 80\%$  of their annual precipitation as rain between October and April.

Ecoregions in the southwestern US and northern Mexico receive most of their precipitation from July to October during the North American monsoon. These ecoregions also have hotter air temperatures than areas located farther north, and C4 grasses, shrubs, and succulents (plants with CAM photosynthesis) are common.

Classification of rangelands into ecoregions helps us to understand ecological relationships at a large-scale level but is not sufficient for rangeland management. For management purposes, an ecological site system, including state-and-transition models (described in Chap. 5), has been developed for most rangelands in the US (Caudle et al. 2013). Within a rangeland ecoregion, an ecological site is a distinctive kind of land with specific soil and physical (primarily climate and topography) characteristics that differ from other kinds of land in its ability to produce a distinctive kind and amount of vegetation and its ability to respond similarly to management actions and natural disturbances. The state-and-transition model for a site identifies: (1) multiple stable vegetation states, (2) plant communities that can exist within a state, (3) pathways that indicate changes such as a fire and recovery from fire that can occur between plant communities, (4) reversible transitions between states, (5) thresholds or ecological constraints such as soil erosion that change soil water holding capacity, and (6) irreversible transitions that occur when thresholds are crossed (Fig. 2.1; see Chap. 5). Discussion included in an ecological site description and its state-andtransition model provide guidance to rangeland managers on which interventions



**Fig. 2.1** Conceptual state and transition model incorporating the concepts of multiple stable state, communities within states, community pathways between communities within states, reversible transitions, thresholds, and irreversible transitions (modified from Stringham et al. 2003)

(e.g., grazing, prescribed fire, mechanical treatments, herbicides, etc.) are likely to be successful. Opportunities for management intervention are severely limited or lost when a threshold has been crossed and a rangeland plant community transitions into a different state (Stringham et al. 2003; Briske et al. 2005).

Climate, soils, and topographic position mediate vegetation dynamics and define the ecological potential of rangeland vegetation at a broader ecoregion-scale. Rangeland ecoregions provide ecological sideboards that constrain rangeland habitat management options. In this chapter we highlight the physiognomy and ecology of 25 major rangeland ecoregions in western North America (Table 2.1). Each ecoregion provides critical habitat for wildlife. Common plant names are presented here, matched with their scientific names in Table 2.2.

## 2.2 Rangelands East of the Rocky Mountains

The Great Plains and the Gulf Coastal Plain extend from the Rocky Mountains and Sierra Madre Oriental Mountains toward the Mississippi River and from the Gulf of Mexico and northeastern Mexico to southern Canada. Dominant vegetation in the Great Plains and Gulf Coast Prairie was grassland before much of it was converted to cropland agriculture. North and south of the grasslands lies savannas where grasses and woody plants coexist. Aspen parkland savanna lies north while the Edwards Plateau and the Tamaulipan thornscrub savannas are located south of the grasslands (Fig. 2.2). Warm-season (C4) grasses dominate the rangeland ecoregions east of the Rocky Mountains except the northern mixed-grass prairie where cool-season (C3) grasses become codominant. Cool-season grasses dominate the aspen parkland (Sims and Risser 2000).



Fig. 2.2 Rangeland ecoregions in the eastern half of western North America

# 2.2.1 Great Plains Prairie Grasslands

Across the Great Plains elevations range from 1200–1500 m along the Rocky Mountain foothills to 200–400 m along a line running from central Texas to southcentral Manitoba. The Gulf Coast Prairie occurs as a narrow strip of land along the southern coast of Texas (Fig. 2.2). Topography of the Great Plains is described as rolling plains although scattered mountains such as the Black Hills occur in the region. The Gulf Coast Prairie with elevations ranging from sea level to 50 m has little topographic relief. Temperature, precipitation, and evapotranspiration decrease from south to north while precipitation effectiveness increases. Precipitation also decreases from east to west. Based on these differing climatic conditions the prairie is divided into tallgrass, northern-mixed grass, southern mixed-grass, and shortgrass prairies (Sims and Risser 2000; Anderson 2006).

Today ~65% of the prairie grasslands is used for cropland or another non-range use (Comer et al. 2018). The greatest loss of rangeland is in the tallgrass and northern mixed-grass prairies. Despite the amount of land that has been converted, the Great Plains prairie grasslands support  $\approx$ 50% of the US beef cow herd (Klemm and Briske 2021) and 75% of the beef cattle in Canada (Wang et al. 2017). Most of the livestock operations in the Great Plains graze less than 100 animals and produce both livestock and crops (Mitchell 2000).

#### 2.2.1.1 Tallgrass Prairie

The tallgrass prairie occurs in the eastern Great Plains, extending from central Texas into Manitoba (Fig. 2.2). Annual precipitation averages 500–1000 mm with most falling during the summer (Anderson 2006). Approximately 90% of annual herbaceous production is completed each year by 1 September (Stephenson et al. 2019; Smart et al. 2021). Tallgrass prairie flora is dominated by four warm-season grasses (Samson and Knopf 1994; Griffith et al. 2004). Big bluestem, Indiangrass, and switchgrass grow in the more moist areas while little bluestem dominates drier sites. Green needlegrass and porcupine grass are important cool-season grasses that grow in the northern third of the tallgrass prairie. Grasses produce the larger amount of biomass, but the number of forb species exceeds the number of grass species. Kentucky bluegrass and smooth bromegrass are non-native cool-season grasses that have invaded the northern part of the tallgrass prairie. Caucasian bluestem and yellow bluestem (collectively "Old World bluestems") are non-native warm-season grasses that have invaded in the south. Sericea lespedeza, a forb originally introduced from Asia for erosion control, is invading the tallgrass prairie from Texas to Nebraska. Woody plants such as blackjack oak, post oak, and especially eastern red cedar are expanding throughout the tallgrass prairie (Lauenroth et al. 1999; DeKeyser et al. 2013). About 86% of the tallgrass prairie has been converted to cropland (Comer et al. 2018). Large areas where tallgrass prairie remain are where soils are not suitable for cultivation (e.g., the Flint Hills in Kansas; Anderson 2006).

#### 2.2.1.2 Shortgrass Prairie

The shortgrass prairie occurs on the flat-to-rolling dry plains of western Kansas and Oklahoma, eastern Colorado and New Mexico, and the High Plains of Texas (Fig. 2.2). Precipitation averages 300–500 mm (Lauenroth 2008). About 62% of the shortgrass prairie has been converted to cropland or other uses (Comer et al. 2018). The largest areas of land conversion are in the High Plains of Texas, eastern Colorado, and western Oklahoma and Kansas where irrigation water from the Ogallala aquifer is available (Lauenroth 2008).

Blue grama and buffalograss are the dominant grasses in the shortgrass prairie. Sideoats grama, galleta, threeawns, tobosagrass, and sand dropseed are other prominent warm-season grasses. Needle and thread, New Mexico feathergrass, prairie june-grass, western wheatgrass, and sun sedge are conspicuous cool-season plants (Lauenroth 2008). Semi- or subshrubs (herbaceous stems but woody at the base) such as broom snakeweed and prairie sagewort grow throughout the shortgrass prairie. Forbs can be abundant during wet years but seldom comprise large proportions of shortgrass prairie plant communities. Prickly pear cactus is common on dry sites. Honey mesquite and various species of juniper have increased on shortgrass prairie rangelands in Texas and New Mexico to such an extent that many areas are now savannas (Sims and Risser 2000; Lauenroth 2008). Sand shinnery oak, a native, low-growing deciduous shrub forms dense thickets on sandy soil sites in the southern High Plains of Texas, New Mexico, and Oklahoma (Peterson and Boyd 1998; Haukos 2011).

#### 2.2.1.3 Northern Mixed-Grass Prairie

The northern mixed-grass prairie is found in Alberta, Montana, North Dakota, Saskatchewan, South Dakota, and Wyoming. The boundaries are the Rocky Mountains on the west, shortgrass prairie and the Nebraska sandhills on the south, tallgrass prairie on the east, and aspen parkland on the north (Fig. 2.2). Northern mixed-grass prairie has the most diverse flora among the Great Plains grasslands (Barker and Whitman 1988; Lavin and Siebert 2011), with plant species that also exist in the tallgrass and shortgrass prairies and in the cool deserts located farther west. Large expanses of northern mixed-grass prairie remain, except in Manitoba where most rangeland has been converted to cropland (Coupland 1992). Annual precipitation averages 350–500 mm and peaks in April–June with 90% of annual herbaceous production completed each year by 1 July (Vermeire et al. 2009; Smart et al. 2021).

The most abundant cool-season grasses include bluebunch wheatgrass, bottlebrush squirreltail, green needlegrass, Idaho fescue, needle and thread, porcupine grass, prairie junegrass, Sandberg bluegrass, slender wheatgrass, and western wheatgrass. Big bluestem, blue grama, little bluestem, and sideoats grama are prevalent warm-season grasses in the eastern portion of the northern mixed-grass prairie. Shrubs such as shrubby prairie rose, silver buffaloberry, and snowberry grow in low-lying areas where snow accumulates. Other notable shrubs include plains silver sagebrush, Wyoming big sagebrush, and yellow rabbitbrush. Numerous native forbs occur in northern mixed-grass prairie but rarely comprise large proportions of the plant communities. Cheatgrass, crested wheatgrass, field brome, Kentucky bluegrass, medusahead, smooth bromegrass, and ventenata are non-native grasses that have invaded much of this ecoregion (DeKeyser et al. 2013). Non-native invasive forbs such as knapweeds, leafy spurge, and yellow toadflax also are widely distributed within the northern mixed-grass prairie.

#### 2.2.1.4 Southern Mixed-Grass Prairie

Southern mixed-grass prairie receives 530–870 mm annual precipitation, and 90% of annual herbaceous production is completed each year by 1 September (Vermeire et al. 2009; Smart et al. 2021). Southern mixed-grass prairie is bordered by northern mixed-grass prairie to the north, the Edwards Plateau to the south, tallgrass prairie to the east, and shortgrass prairie to the west (Fig. 2.2). Warmer temperatures, greater mid- to late summer precipitation, a longer growing season, and dominance by warmseason grasses distinguish southern mixed-grass prairie from northern mixed-grass prairie. Approximately 70% of the southern mixed-grass prairie in Texas has been converted to cropland (Comer et al. 2018).

Important warm-season grasses include sideoats grama, little bluestem, bristlegrass, dropseeds, silver bluestem, threeawns, and white tridens. Important coolseason grasses are Texas wintergrass in the southern part of this ecoregion, with needle and thread and western wheatgrass prevalent in the northern part. Big bluestem, Indiangrass, and switchgrass grow on moist sites throughout this ecoregion (Lauenroth et al. 1999; Sims and Risser 2000).

The southern mixed-grass prairie was dominated by grasses prior to European settlement, although escarpments and canyons were dominated by woody species including honey mesquite, eastern red cedar, lotebush, and redberry juniper. Post-settlement fire suppression enabled woody plants to expand into the grassland with honey mesquite and redberry juniper invading in New Mexico and Texas and eastern red cedar in the northern part of this ecoregion in Oklahoma and Kansas. Blue grama occurs throughout this ecoregion and becomes more abundant with increased grazing pressure and severe drought, as do buffalograss, red grama, and threeawns (Wright and Bailey 1980; Griffith et al. 2004).

### 2.2.2 Savannas and Parklands

Savannas and parklands occur where woody and herbaceous plants are co-dominant and woody canopy is sufficiently open to allow growth of grasses and other herbaceous species. Low-intensity ground fires maintain the codominance and openness of the savanna by reducing but not eliminating woody plant cover. Woody plants that are capable of regrowing from root buds located below ground are favored (Fowler and Beckage 2020). With fire suppression, woody plants increase in density and open savannas become closed woodlands or forests (Archer et al. 1988; Staver et al. 2011). Three savannas occur east of the Rocky Mountains and Sierra Madre Oriental Mountains: aspen parkland north of the northern mixed-grass prairie, Edwards Plateau south of the southern mixed-grass prairie, and Tamaulipan thornscrub in southern Texas and northeastern Mexico (Fig. 2.2).

#### 2.2.2.1 Aspen Parkland

Aspen parkland occurs as a mosaic of aspen groves and interspersed grassland from North Dakota, across Saskatchewan, to south-central Alberta (Strong and Leggat 1992; Padbury et al. 1998; Fig. 2.2). Aspen parkland is a transition zone, bounded to the north and east by boreal forest, to the south by northern mixed-grass prairie, and to the west by Rocky Mountain foothills. Annual precipitation averages 400-500 mm with 80+% occurring from late spring to early summer. The topography is mostly level to undulating, with aspen groves growing on moist north-facing slopes and depressions, and grassland occupying the drier hilltops and south-facing slopes. Balsam poplar often co-dominates with aspen in the wettest areas. Moderated air temperatures and longer frost-free periods beneath aspen grove canopies generate abundant and diverse understory vegetation (Powell and Bork 2007). Understory shrubs include chokecherry, serviceberry, snowberry, and wild rose. Noteworthy understory herbaceous species include bluegrasses, sedge, and western meadowrue. In the interspersed grassland, plains rough fescue dominates. Subdominant grasses include porcupine grass, prairie junegrass, and slender wheatgrass, and grassland forbs include geranium, goldenrod, and western varrow. Before European settlement, fire prevented aspen from encroaching into the grassland. Post-settlement fire suppression has enabled aspen to expand (Bailey and Wroe 1974; Anderson and Bailey 1980). Heavy livestock grazing pressure has reduced or eliminated plains rough fescue in many locations, and non-native orchardgrass and smooth bromegrass have become widespread. Much of the aspen parkland ecoregion (> 80%) has been converted to highly productive cropland (Comer et al. 2018).

#### 2.2.2.2 Edwards Plateau

The Edwards Plateau ecoregion is in central Texas, south of the shortgrass prairie and southern mixed-grass prairie, west of the tallgrass prairie, and east of the Chihuahuan Desert (Fig. 2.2). The eastern portion of the Edwards Plateau has weathered into low, rounded hills and valleys known locally as "The Hill Country" (Jordan 1978). Topography in the western portion of the Edwards Plateau is flat to gently rolling, dissected by steep-sloped canyons. Mean annual precipitation varies west to east, from 480 to 790 mm. Most soils are shallow and rocky. Woody plant density increases and understory plants decrease in the absence of fire or other disturbance (Fuhlendorf and Smeins 1997; Griffith et al. 2004).

Vegetation in the Edwards Plateau ecoregion is a mix of woodland and savanna. Ashe juniper co-dominates with Texas live oak in eastern portions of the Edwards Plateau. Prominent savanna grasses in the eastern Edwards Plateau include big bluestem, blue grama, Indiangrass, little bluestem, sideoats grama, silver bluestem, and switchgrass. These grasses decrease in abundance as tree canopy increases, enabling hairy grama, curlymesquite, Texas wintergrass, and threeawns to gain dominance. In the western part of the Edwards Plateau, Ashe juniper co-dominates with honey mesquite. Savanna grasses in the western Edwards Plateau include black grama, blue grama, dropseeds, little bluestem, lovegrasses, and sideoats grama. With increased herbivory and increased woody plant cover, buffalograss, curlymesquite, Texas grama, Texas wintergrass, and threeawns increase (Fuhlendorf and Smeins 1997; Griffith et al. 2004).

#### 2.2.2.3 Tamaulipan Thornscrub

Tamaulipan thornscrub occurs south of the Edwards Plateau and includes the South Texas Plain in southern Texas and adjacent areas in northeastern Mexico (Fig. 2.2). Plant species diversity is high in Tamaulipan thornscrub due to its location at the confluence of subtropical, desert, and coastal ecoregions. Elevations range from near sea level to 800 m, and annual precipitation averages 600-750 mm. Small trees and shrubs, many with thorns or spines, dominate the vegetation including algerita, Berlandier's wolfberry, blackbrush acacia, catclaw acacia, guajillo acacia, lotebush, prickly pear cactus, spiny hackberry, and Texas persimmon. Associated grasses include bristlegrass, cane bluestem, lovegrasses, multiflowered false rhodesgrass, pink pappusgrass, sideoats grama, silver bluestem, and thin paspalum. Tobosagrass grows on heavy clay soils. Grasses on drier sites include buffalograss, curlymesquite, hooded windmillgrass, red grama, Texas grama, and threeawns (Archer et al. 1988; Griffith et al. 2004). Several introduced perennial grasses have become invasive, including bermudagrass, buffelgrass, Lehmann lovegrass, and yellow bluestem (Wied et al. 2020). Tanglehead is a native perennial grass that also has become invasive (Bielfelt and Litt 2016; Wester et al. 2018).

### 2.3 Rangelands West of the Rocky Mountains

This region extends from southern British Columbia and southwestern Alberta to northern Mexico. The eastern boundary is the eastern slopes of the Rocky Mountains, Arizona-New Mexico Mountains, and the Sierra Madre Oriental Mountains. The western boundary is the Pacific Ocean (Fig. 2.3). Large areas in California, Washington, and Idaho have been converted to cropland, but when compared with the Great Plains the western rangelands are relatively intact.

Unlike the Great Plains where there is little topographic relief, the region westward from the Rocky Mountains is dominated by valleys and mountains.



Fig. 2.3 Rangeland ecoregions in the western half of western North America

Precipitation increases, temperatures decrease, and vegetation changes as elevation increases. Deserts, shrublands, and grasslands dominate the valleys. Sagebrush, chaparral, piñon-juniper, and oak woodlands dominate the mid-elevations, and montane meadows, shrublands, and savannas dominate the upper elevations. Alpine tundra is found on the highest mountains.

# 2.3.1 Rangeland Regions Receiving Precipitation as Winter Rain

Mediterranean climates are characterized as having warm wet winters and hot dry summers. In North America, Mediterranean rangelands are found in the Great Central Valley of California and surrounding foothills (Fig. 2.3). Ecoregions considered here are California annual grasslands, oak woodlands, and chaparral. Annual grasses and forbs dominate the annual grasslands, where topography is flat to rolling with elevation ranging from 15 to 150 m. Oak savannas-woodlands occur on rolling to steeply sloping hills with annual grasses and forbs dominating the understory and open meadows. Chaparral occurs on rocky slopes. Precipitation in the Central Valley annual grasslands ranges from 150 to 400 mm. In the oak woodlands and chaparral, annual precipitation varies from 200 to 815 mm, increasing with elevation and from south to north. Annual precipitation is highly variable but approximately 80+% of the precipitation in all three ecoregions occurs from October to April. Severe droughts are common (Barbour and Minnich 2000; Rundel et al. 2016).

#### 2.3.1.1 California Annual Grassland

The California annual grassland ecoregion is centered near the Great Central Valley (Fig. 2.3). Topography is flat to rolling with elevation ranging from 15 to 150 m. Nonnative annual grasses and forbs from Spain and other Mediterranean regions dominate California annual grassland. Prior to Spanish settlement in 1769, this grassland was dominated by native perennial grasses including California oatgrass, nodding needlegrass, purple needlegrass, wheatgrasses, and wildryes (Burcham 1957). Non-native annual grasses were widespread by the early 1800s (Wagner 1989). Heavy livestock grazing pressure and severe drought contributed to the conversion from native perennials to non-native annuals (Burcham 1957). A change in precipitation pattern exacerbated drought and grazing effects. Peak precipitation shifted from summer to winter, which favored the non-native annual grasses and disfavored native bunchgrasses (Axelrod 1973; Raven and Axelrod 1978). Hundreds of non-native annual grass and forb species grow in this ecoregion today, but only a few are widespread (Baker 1989). Ripgut brome, soft chess, slender wild oat, and wild oats are the dominant annual grasses. Associated annual forbs include burclover, filaree, and longbeak stork's bill. Medusahead, a non-native annual grass, is a significant problem (Nafus and Davies 2014).

### 2.3.1.2 California Oak Woodland

California oak woodland occupies a transition zone between California annual grassland and montane forest at the upper margins. Blue oak, coast live oak, and valley oak are the most widespread oak species. In blue oak woodland and savanna, blue oak associates with California foothill pine, coast live oak, and valley oak. In valley oak woodland and savanna, valley oak associates with coast live oak, blue oak, California black oak, walnut, and California sycamore. In coast live oak woodland and savanna, coast live oak associates with blue oak. The same annual grasses and forbs that grow in the lower elevation annual grasslands grow in open stands of the oak woodlands. Conspicuous understory shrubs include black sage, ceanothus, manzanita, and narrowleaf goldenbush (Bartolome 1987; Allen-Diaz et al. 2007). A major threat to California oak woodland is the plant disease known as sudden oak death which is caused by the non-native, fungus-like, soil-borne pathogen *Phytophthora ramorum* (Rizzo et al. 2002).

#### 2.3.1.3 California Chaparral

California chaparral is widespread throughout the state of California. More than 1000 plant species inhabit California chaparral. Herbaceous species comprise about 75% of the species, but plant communities are dominated by 1.5–4-m tall closely spaced shrubs that have thick, leathery, evergreen leaves (Rundel 2018). Ceanothus, chamise, and manzanita commonly inhabit drier sites. Buckthorn, scrub oak, and sumac occupy wetter sites (Keeley 2000). The thick, leathery leaves of chaparral plants increases their drought resistance, but their leaves also contain flammable resins and oils. Pre-European settlement fire return interval is estimated to have been 30–90 years depending on stand density and location. Due to human interference the return interval has decreased to 5–10 years. Both historical and current fires are high-severity, stand-replacing fires. Annual grasses and forbs proliferate soon after fire, but shrubs recover within 10 years because chaparral shrubs resprout following top-kill by fire or other disturbance, and seed dormancy is broken by heat or chemicals in smoke (Mooney and Miller 1985; Keeley et al. 2012).

# 2.3.2 Rangeland Regions Receiving Precipitation as Winter Snow

Most precipitation falls as snow during the winter in the Colorado Plateau, Columbia Plateau, Great Basin, Wyoming Basins, and at higher elevations in all western mountain ranges from Canada to Mexico. Temperatures are cool and snow accumulates throughout the winter. Soil water is generally at its maximum following spring snowmelt, allowing rapid growth of plants (West and Young 2000). In the valleys and lower foothills of these rangelands, salt desert shrublands and sagebrush shrublands have been described as cold deserts, but they are only cold in the winter (West 1983b; West and Young 2000). Summers in these regions are hot although temperatures decrease as elevation increases. Invasive annual grasses have increased the fire

frequency and severity in salt desert shrub, sagebrush steppe, and Great Basin sagebrush ecoregions (West and Young 2000). Rangeland ecoregions in the following sections are arranged from lower to higher elevations.

#### 2.3.2.1 Salt Desert Shrub

Salt desert shrub occurs in the Colorado Plateau, Great Basin, and Wyoming Basins (Fig. 2.3) on sites where soils are alkaline, saline or both (West 1983a; Blaisdell and Holmgren 1984). This vegetation type also occurs on similar sites in the northern mixed-grass prairie. Annual precipitation averages 130-330 mm. Shadscale and winterfat are important shrubs throughout this ecoregion. Gardner's saltbush cooccurs with shadscale and winterfat in the Wyoming Basins, whereas shadscale and winterfat associate with mat saltbush and valley saltbush in the Colorado Plateau. Greasewood occurs in areas with a seasonally high-water table (West and Young 2000; Duniway et al. 2018). Bottlebrush squirreltail, Indian ricegrass, needle and thread, and Sandberg bluegrass are the dominant native cool-season grasses. Warmseason grasses are more prevalent in the southern part of this ecoregion and include blue grama, galleta, purple threeawn, and sand dropseed. Buckwheat, desert prince'splume, and scarlet globemallow are important native forbs. The salt desert shrub ecoregion has been invaded by cheatgrass, bur buttercup, halogeton, and Russian thistle. Wildfire is infrequent but areas dominated by cheatgrass can burn during years of above-average precipitation (Blaisdell and Holmgren 1984; Duniway et al. 2018).

#### 2.3.2.2 Sagebrush Steppe

The sagebrush steppe occurs in the Columbia Plateau and Wyoming Basins (Fig. 2.3; West and Young 2000). Wyoming big sagebrush is typically dominant, with basin big sagebrush dominant in deeper, well-drained soils. Associated shrubs include horsebrush, rubber rabbitbrush, winterfat, and yellow rabbitbrush. Herbaceous understories are dominated by bluebunch wheatgrass, bottlebrush squirreltail, Columbia needlegrass, Idaho fescue, Indian ricegrass, needle and thread, Sandberg bluegrass, slender wheatgrass, and Thurber needlegrass (Miller and Eddleman 2000; West and Young 2000). Because of fire suppression, western juniper has invaded areas of sagebrush steppe (Miller et al. 2005, 2019). This ecoregion also has been invaded by non-native annual grasses including cheatgrass, medusahead, and ventenata (Davies et al. 2011; Jones et al. 2020).

#### 2.3.2.3 Great Basin Sagebrush

Sagebrush-dominated rangeland at low-to-mid elevations in the Great Basin and Colorado Plateau comprises the Great Basin sagebrush ecoregion (Fig. 2.3; West

and Young 2000). Wyoming big sagebrush and basin big sagebrush are the dominant shrubs. Rubber rabbitbrush and yellow rabbitbrush often co-occur and can dominate after fire. Broom snakeweed, horsebrush, and winterfat also are important shrubs. On sites with sandy loam or sandy soils, blackbrush, fourwing saltbush, Mormon tea, and sand sagebrush co-occur with Wyoming big sagebrush. Antelope bitterbrush grows with Wyoming big sagebrush on rocky soils adjacent to higher elevation piñonjuniper woodland (West 1983c; West and Young 2000). Basin wildrye, bluebunch wheatgrass, bottlebrush squirreltail, muttongrass, prairie junegrass, and Sandberg bluegrass are notable grasses. In the southern third of this ecoregion, associated warm-season grasses include blue grama, galleta, purple threeawn, and sand dropseed (West 1983c; West and Young 2000). Important forbs are blue flax, globemallow, and western varrow (West and Young 2000; Leger and Baughman 2015). Utah juniper has invaded areas of Great Basin sagebrush (Miller et al. 2008, 2019). Numerous non-native invasive plant species have invaded the Great Basin sagebrush ecoregion, including cheatgrass, medusahead, halogeton, bur buttercup, Russian thistle, mustards, and pepperweed (Pyke et al. 2016; Boyd et al. 2021).

#### 2.3.2.4 Piñon-Juniper Woodland

Piñon-juniper woodlands occupy mid-elevation foothills in the Apache Highlands, Arizona-New Mexico Mountains, Colorado Plateau, Columbia Plateau, Great Basin, and Wyoming Basins (Fig. 2.3; Adams 2018). Annual precipitation averages 300– 600 mm across this expansive and diverse ecoregion. Approximately 50–60% of the precipitation falls during the winter in the Columbia Plateau, Great Basin, and Wyoming Basins while 60+% falls during the summer in the southern regions. Varied species of juniper and piñon dominate together or alone, depending upon climate, soils, and topography (West 1999). Western juniper dominates alone in the Columbia Plateau. Utah juniper dominates alone in Wyoming, but co-occurs with singleleaf piñon in the Great Basin, and with two-needle piñon in the Colorado Plateau. Alligator juniper and oneseed juniper associate with two-needle piñon in the Arizona and New Mexico Mountains. Redberry juniper grows with Mexican piñon in the Arizona Highlands and mountain foothills in northern Mexico. In Northern Rocky Mountain foothills, Rocky Mountain juniper dominates alone or co-dominates with limber pine (Adams 2018).

Where juniper and piñon co-occur, juniper is more drought resistant, the first to expand into new areas, and usually more abundant at lower elevations. Piñons dominate or co-dominate more mesic and higher elevation sites (Romme et al. 2009; Miller et al. 2019). Piñon-juniper physiognomy in the Colorado Plateau, Arizona-New Mexico Mountains, and Apache Highlands is usually a persistent woodland with high tree densities, whereas the woodland is typically more savanna-like in the Columbia Plateau, Great Basin, Rocky Mountain foothills, and Wyoming Basins.

Juniper and piñon woodland has increased in area and tree density during the past 150 years, while understory grass, forb, and shrub cover has decreased (Burkhardt and Tisdale 1969; Romme et al. 2009). Within the Columbia Plateau, Great Basin,

and Wyoming Basins, prominent understory shrubs include antelope bitterbrush, black sagebrush, curl-leaf mountain mahogany, low sagebrush, Mormon tea, most subspecies of big sagebrush, rubber rabbitbrush, and yellow rabbitbrush. Grasses include bluebunch wheatgrass, Idaho fescue, Indian ricegrass, prairie junegrass, needle and thread, Sandberg bluegrass, and bottlebrush squirreltail. In the Colorado Plateau, blue grama and galleta also characterize piñon-juniper woodlands (West 1983c; Miller et al. 2019). Further south in Arizona, New Mexico, and Mexico, understory grasses include Arizona cottontop, black grama, blue grama, hairy grama, muhly, Rothrock grama, sideoats grama, slender grama, and threeawns. Understory shrubs include desert ceanothus, manzanita, Mexican cliffrose, shrub live oak, and true mountain-mahogany (Gottfried and Severson 1993; Floyd et al. 2004).

#### 2.3.2.5 Mountain Brush

Mountain brush occurs above piñon-juniper woodlands and below coniferous forests at elevations between 1500 and 2500 m. The largest areas of mountain brush occur in Colorado and Utah on the western slopes of the Rocky Mountains (Fig. 2.3; Vankat 2013a). Annual precipitation ranges from 380 to 560 mm. Gambel oak, the most widespread plant in this ecoregion, reproduces from rhizomes or resprouts from its root crown following top-kill by fire or other disturbance (Harper et al. 1985; Tiedemann et al. 1987). Growth of this species varies from dense shrub stands with sparse understory, to open plant communities with Gambel oak growing in clumps (mottes) and shrubs and herbaceous plants growing in the interspaces. Sometimes individual mottes cover several hectares. Other shrubs include antelope bitterbrush, bigtooth maple, chokecherry, mountain big sagebrush, mountain snowberry, and serviceberry. Grasses include bluebunch wheatgrass, Idaho fescue, muhly, muttongrass, needlegrass, slender wheatgrass, Thurber fescue, and western wheatgrass. Important forbs are balsamroot, beardtongue, blue flax, geranium, lupine, mule's ear wyethia, and western yarrow. Bulbous bluegrass, cheatgrass, knapweeds, thistle, and yellow toadflax are notable invasive plants in mountain brush (Vankat 2013a; Kaufmann et al. 2016).

#### 2.3.2.6 Montane Grassland

Montane grassland occurs on mountain and foothill slopes of the Rocky Mountains, eastern Cascade Mountains, and Sierra Nevada Mountains (Fig. 2.3). This ecoregion extends westward from the Cypress Hills in southwestern Saskatchewan to southern Alberta and British Columbia; south to include northeastern Oregon, southeastern Washington, and northern Nevada; eastward to include Idaho, Colorado, and Wyoming; and north to include central and western Montana (Mueggler and Stewart 1980). Annual precipitation averages 400–650 mm. Vegetation is dominated by cool-season perennial bunchgrasses including bluebunch wheatgrass, Idaho fescue, and slender wheatgrass. These grasses co-occur with foothills rough fescue in western Montana and southern British Columbia. Native forbs such as geranium, lupine, and western yarrow are common (Brewer et al. 2007; Thrift et al. 2013). In southern Alberta, Parry oatgrass replaces bluebunch wheatgrass in association with Idaho fescue and foothills rough fescue (Looman 1969). Heavy grazing pressure weakens bluebunch wheatgrass, foothills rough fescue, and Idaho fescue. In turn, Parry oatgrass, purple threeawn, and timber oatgrass increase along with invasive grasses and forbs. Non-native invasive grasses include cheatgrass, Kentucky blue-grass, medusahead, smooth bromegrass, timothy, and ventenata. Non-native invasive forbs include leafy spurge, spotted knapweed, and sulphur cinquefoil.

#### 2.3.2.7 Montane Sagebrush Steppe

Montane sagebrush steppe occurs on mountain and foothill slopes of the Rocky Mountains (Fig. 2.3) at elevations of 1050–3050 m. This ecoregion occurs in Alberta, British Columbia, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. Annual precipitation averages 250-700 mm. Montane sagebrush steppe generally has a longer summer growing season and warmer winters than montane grassland. The shrub layer in montane sagebrush steppe is usually dominated by mountain big sagebrush, mountain silver sagebrush, or snowfield sagebrush. Threetip sagebrush dominates or co-dominates some sites, and horsebrush and antelope bitterbrush are frequent associates. Cool-season perennial bunchgrasses such as bluebunch wheatgrass, foothills rough fescue, or Idaho fescue usually dominate the herbaceous layer. Foothills rough fescue and Idaho fescue are better adapted to mesic sites, and bluebunch wheatgrass better-suited to drier sites. Other common grasses include Columbia needlegrass, mountain brome, prairie junegrass, Sandberg bluegrass, and slender wheatgrass. Forbs are more abundant in montane sagebrush steppe than in lower elevation sagebrush steppe. Agoseris, buckwheat, balsamroot, cinquefoil, fleabane, hawksbeard, Indian paintbrush, lupine, and western yarrow are conspicuous forbs (Mueggler and Stewart 1980).

Historical records indicate that fires set by Native Americans and lightning occurred in the montane sagebrush steppe. However, evidence varies on how often fires occurred, with fire interval estimates ranging from 15 to 50 years or more (Welch and Criddle 2003; Moffet et al. 2015). Post-settlement fire suppression has increased sagebrush density and canopy cover, decreased herbaceous productivity, and decreased plant species diversity, especially forbs. Threetip sagebrush, snow-field sagebrush, and mountain silver sagebrush resprout after fire but mountain big sagebrush is easily killed by fire. However, after fire, mountain big sagebrush can reestablish readily from seed, which enables sagebrush to recover from fire much more quickly in montane sagebrush steppe than in lower elevation sagebrush areas in the Columbia Plateau, Colorado Plateau, Great Basin, and Wyoming Basins (Innes and Zouhar 2018).

#### 2.3.2.8 Ponderosa Pine Savanna

Ponderosa pine savanna occurs throughout the mountains of the western US and in northern mixed-grass prairie (Figs. 2.2 and 2.3; Franklin and Dyrness 1973; Peet 2000). In the Sierra Nevada Mountains, Jeffrey pine forms savannas similar to those of ponderosa pine in the Rocky Mountains. Ponderosa pine savanna generally occurs in drier environments and is the climax tree species. Annual precipitation in the ponderosa pine savanna ecoregion averages 280-760 mm. From north to south, winter precipitation decreases and summer precipitation increases. Older ponderosa pine trees have thick bark that helps them tolerate surface fires that historically occurred every 5–30 years. Without fire or other disturbance, tree density increases rapidly and park-like savannas can become "dog-hair thickets" (Covington et al. 1997). Increased tree canopy cover, coupled with increased duff on the soil surface, reduces understory productivity. In the southern portion of ponderosa pine savanna, Arizona fescue, pine dropseed, muhly, muttongrass, and New Mexico feathergrass are the most common understory perennial grasses. Black dropseed, blue grama, Kentucky bluegrass, and threeawns increase with increased grazing pressure (Milchunas 2006; Strahan et al. 2015). In northern ponderosa pine savanna, important grasses include bluebunch wheatgrass, Idaho fescue, little bluestem, pinegrass, sedge, sideoats grama, and Thurber fescue. Understory shrub associates in northern ponderosa pine savanna include antelope bitterbrush, Bolander silver sagebrush, chokecherry, low sagebrush, mountain big sagebrush, mountain silver sagebrush, serviceberry, and Wyoming big sagebrush (Skovlin et al. 1975; Graham and Jain 2005).

#### 2.3.2.9 Montane and Subalpine Meadow

Montane and subalpine meadows (hereafter mountain meadows) occur on nearly level, high-elevation, low-lying terrain in the Rocky Mountains, Cascade Mountains, and Sierra Nevada Mountains (Fig. 2.3; Franklin and Dyrness 1973; Barbour and Minnich 2000; Peet 2000). Soil substrates are alluvium, colluvium, or glacial outwash. Mountain meadows vary in size from one to several hundred hectares, adjoined in the montane zone by lodgepole pine or Douglas-fir forest. Subalpine meadows are commonly associated with subalpine fir or spruce forest.

Mountain meadow vegetation is a diverse mixture of grasses, sedges, rushes, and forbs. Shrubs are usually absent, although adjacent willow communities may occur along streams. Mountain big sagebrush, shrubby cinquefoil, or snowfield sagebrush may be present along drier meadow margins. Mean annual precipitation varies from 500 to 1250 mm. Mountain meadows are often categorized into three types based on soil moisture regime: wet meadows, moist meadows, and dry meadows (Hall 1973). Wet meadows remain wet at or near the soil surface throughout the growing season. Moist meadows have freely available water within the rooting zone throughout the growing season, but the soil surface is dry by late summer. Dry meadows are moist to wet in spring and early summer, but the soil surface is moderately to severely dry by

mid-summer. Elephanthead lousewort, rushes, sedges, and tall mountain shootingstar characterize wet meadows. Alpine timothy, cinquefoil, groundsel, sedge, and tufted hairgrass occur in moist meadows. Dry meadows are often dominated by bluejoint reedgrass, Idaho fescue, sedge, timber oatgrass, thickstem aster, and western yarrow (Ratliff 1985; Mosley et al. 1989).

Conifers have encroached into many mountain meadows during the past 150 years. No single causal agent is responsible. Jakubos and Romme (1993) suggest that warmer and wetter conditions from the late 1800s to mid-twentieth Century aided conifer expansion, particularly into dry meadows. Pocket gopher (Family Geomyoidae) activity and grazing by wild and domestic ungulates can also promote conifer seedling establishment by reducing vegetative cover and exposing bare mineral soil. Heavy cattle and sheep grazing in the late 1800s and early 1900s prevented many seedlings from surviving, but reduced stocking rates and fire suppression beginning in the 1920s allowed surviving seedlings to grow into trees (Ratliff 1985; Taylor 1990). Conifer expansion also is affected by weather. In mesic and wet meadows where soil moisture inhibits conifers in most years, drought decreases soil moisture and herbaceous competition, thereby benefiting tree seedling establishment (Butler 1986). In dry meadows, conifer recruitment benefits when wet years immediately follow years with favorable conifer seed production (Dyer and Moffett 1999).

#### 2.3.2.10 Alpine Tundra

Alpine tundra occurs from Canada to Mexico on snowcapped peaks, cliffs, rocky slopes, plateaus, and in glaciated valleys. Annual precipitation ranges from 750 mm at 55 degrees north latitude in west-central Alberta (elevation 500 m; Janz and Storr 1977) to 2250 mm at 25 degrees north latitude in central Mexico (elevation 3800 m; Beaman and Andersen 1966; Ramírez-Amezcua et al. 2016). Plant growth is limited because of the cold temperatures, short growing seasons, and winds associated with high elevations. Annual plants are rare. Trees can only survive where they are sheltered by rock formations or snow cover. Where trees do occur they have a stunted, twisted growth form referred to as Krumholtz. Forbs, grasses, and shrubs avoid desiccation and damage from cold and wind by growing close to the ground and maintaining little living plant material aboveground during winter (Billings 2000; Litaor et al. 2008).

Alpine bluegrass, alpine fescue, Cusick's bluegrass, and purple reedgrass are often abundant. Other common plant species include cinquefoil, Lewis' flax, mountain sorrel, rush, sedge, Townsend daisy, whitlowgrass, and woodrush. Alpine avens is common in alpine tundra of the Rocky Mountains but does not occur in the Sierra Nevada Mountains (Fowler et al. 2014; Rundel 2011).

# 2.3.3 Rangeland Regions Receiving Precipitation as Summer Rain

Low-elevation rangelands occurring from southern Nevada and eastern California to western Texas and northern Mexico are termed warm deserts because they are warmer and drier than the cold deserts to the north (i.e., salt desert shrub, Great Basin sagebrush, and lower elevation sagebrush steppe). Three warm deserts are recognized—Chihuahuan, Mojave, and Sonoran—due to differences in topography, climate, and vegetation. The harsh environment of the warm deserts is largely due to their location near the 30th parallel north where descending air creates hot and dry conditions. The warm deserts are also in rain shadows of surrounding mountains (MacMahon 2000).

Mean annual precipitation varies from 80 mm at low elevations of the Mojave Desert and Sonoran Desert to 380 mm in the eastern portion of the Chihuahuan Desert where elevation is greater. Summer monsoon precipitation is important in all three deserts but the proportion of summer to winter precipitation varies among the three warm deserts. The Mojave Desert receives 65–75% of its annual precipitation during winter. The Arizona and California portions of the Sonoran Desert have a bimodal precipitation pattern, receiving 50–60% of annual precipitation during winter. A greater proportion of total precipitation is greater in the eastern Sonoran Desert due to increased elevation and orographic lifting which results in more summer thunderstorms. In the Chihuahuan Desert, peak precipitation occurs during summer (Adams and Comrie 1997; Sheppard et al. 2002).

Soils throughout the three warm deserts are shallow and alkaline, with subsoil petrocalcic layers often present (Duniway et al. 2007; Stefanov and Green 2013). Creosotebush is one of the few plant species that is widely distributed in all three warm deserts, growing on soils that are coarse, well-drained, alkaline, non-saline and often underlain by a petrocalcic layer. Creosotebush most commonly associates with tarbush in the Chihuahuan Desert, with triangle bursage in the eastern Sonoran Desert, and with burrobush in the Mojave Desert and western part of the Sonoran Desert (MacMahon 2000; Schafer et al. 2012).

#### 2.3.3.1 Chihuahuan Desert

The Chihuahuan Desert occupies southern New Mexico, southwestern Texas, and northern Mexico between the Sierra Madre Oriental and Occidental Mountains (Fig. 2.3). Both desert scrub and desert grassland occur in the Chihuahuan Desert. Desert scrub varies from low-diversity, creosotebush-dominated plant communities on gently sloping plains, to more diverse shrub communities on upland rocky bajadas (i.e., alluvial fans that extend from mountain foothills). Important desert scrub plants include honey mesquite, tarbush, ocotillo, crown of thorns, agave, Spanish-bayonet, and many cacti of varied genera (Brown 1982a; Alvarez et al. 2011).

Desert grasslands are widespread throughout the Chihuahuan Desert, occurring on flat lowlands where soils are more developed and annual precipitation is greater than desert scrub areas. Grama grasses are prevalent, with black grama dominant on sandy loam uplands. Alkali sacaton and tobosagrass dominate areas with clay soils. Dropseeds and threeawns are widespread (Brown 1982b). Creosotebush, honey mesquite, tarbush, and yuccas increased in density in Chihuahuan Desert grassland after large numbers of domestic livestock were introduced into the ecoregion in the late 1800s (Gibbens et al. 1992). Fire suppression also enabled woody plants to increase (Drewa and Havstad 2001), resulting in less herbaceous cover and more soil erosion (Dinerstein et al. 2000).

#### 2.3.3.2 Sonoran Desert

The Sonoran Desert occurs in southwestern Arizona, southeastern California, and in northern Mexico (Fig. 2.3). Vegetation on upper bajadas includes saguaro cactus, paloverde, ocotillo, desert ironwood, barrel-shaped cactus, prickly pear cactus, cholla cactus, creosotebush, and triangle bursage. Western honey mesquite occupies drier sites whereas honey mesquite grows on the most favorable upland sites. Velvet mesquite occupies riparian areas. Arizona cottontop and grama grasses (e.g., black grama, blue grama, Rothrock grama, sideoats grama, and slender grama) are abundant on lower slopes (MacMahon 2000; Medeiros and Drezner 2012). Broad, flat valleys are dominated by creosotebush, brittlebush, and burrobush. In Mexico, saguaro cactus is replaced with Mexican giant cardón. Invasive annual cool-season grasses such as Arabian schismus, Mediterranean grass, and red brome have invaded the Sonoran Desert (Evens et al. 2007; Steers and Allen 2012). Buffelgrass and Lehmann lovegrass, both non-native perennial grasses, also have become invasive (Van Devender et al. 1997; Brenner 2010).

#### 2.3.3.3 Mojave Desert

The Mojave Desert is located in southern Nevada, southeastern California, northeastern Arizona, and southwestern Utah (Fig. 2.3). In addition to creosotebush, important plant communities in the Mojave Desert are characterized by blackbrush, burrobush, or Joshua tree. Blackbrush communities in the northern portion of the Mojave Desert are the transition zone to the Great Basin, occupying upland terraces, ridges, open plains, and alluvial slopes (Bowns 1973; Brooks and Matchett 2003). Joshua trees are most abundant in the southern portion of the Mojave Desert. Burrobush-dominated communities, in association with creosotebush, Mojave buckwheat, and Mormon tea, are prevalent in eastern portions of the Mojave Desert. Big galleta, bush muhly, desert needlegrass, galleta, and Indian ricegrass are noteworthy native perennial grasses in the Mojave Desert (Rasmuson et al. 1994; Sirchia et al. 2018). Arabian schismus, cheatgrass, Mediterranean grass, and red brome are nonnative annual grasses that have invaded the Mojave Desert. Filaree, a non-native cool-season forb, also has invaded much of the Mojave Desert (Brooks and Matchett 2003; Underwood et al. 2019).

#### 2.3.3.4 Interior Chaparral

Interior chaparral occurs almost entirely in central Arizona in the foothills bordering the Sonoran Desert on the north and the Mojave Desert on the east (Fig. 2.3). Average annual precipitation ranges from 380 to 640 mm (Cable 1975; Carmichael et al. 1978) with about half occurring during the summer. Shrub live oak comprises 25–80% of the total shrub cover on most sites. Associated shrubs include buckthorn, desert ceanothus, fragrant sumac, and manzanita (Pase and Brown 1982; Vankat 2013b). Important grasses, now largely confined to rocky, protected sites because of historical livestock grazing practices, include blue grama, black grama, cane bluestem, deergrass, and threeawns. Forbs are not abundant except for brief periods after fire. Nonnative grasses, including buffelgrass, Lehmann lovegrass, red brome, and weeping lovegrass have invaded interior chaparral (Carmichael et al. 1978; Vankat 2013b).

#### 2.3.3.5 Southwestern Oak Woodland

The northern portion of southwestern oak woodland is located in the Apache Highlands of southeastern Arizona, southwestern New Mexico and northern Mexico, bounded by the Sonoran Desert to the west and the Chihuahuan Desert to the east (Fig. 2.3; McPherson 1992). The southern portion of the ecoregion is located in the Sierra Madre Occidental Mountains of Mexico (Fig. 2.3), where southwestern oak woodland forms expansive savannas. Precipitation is distributed evenly between early spring and mid-to-late summer, averaging 350–600 mm annually. Emory oak is widespread in oak woodland in Arizona and New Mexico. In northern Mexico, Emory oak associates with Arizona white oak, Mexican blue oak, and several species of juniper. Further south in Mexico, Emory oak associates with Chihuahuan oak. Herbaceous understories are dominated by warm-season perennial grasses, including blue grama, hairy grama, sideoats grama, slender grama, bullgrass, common wolfstail, green sprangletop, and threeawns. Annual forbs emerge briefly each year coincident with early spring rains and again with summer rains. Non-native plants are rarely present in this ecoregion (McClaran and McPherson 1999; Ffolliott et al. 2008).

### Appendix

See Table 2.2.

Common name	Scientific name	Growth form	Longevity	Origin	Comment
Agave	Agave spp.	Succulent	Perennial	Native	
Agoseris or false dandelion	Agoseris spp.	Forb	Perennial	Native	
Algerita	Mahonia trifoliolata	Shrub	Perennial	Native	
Alligator juniper	Juniperus deppeana	Shrub/tree	Perennial	Native	
Alkali sacaton	Sporobolus airoides	Grass/C4	Perennial	Native	
Alpine avens	Geum rossii	Forb	Perennial	Native	
Subalpine big sagebrush	Artemisia spiciformis	Shrub	Perennial	Native	
Alpine bluegrass	Poa alpina	Grass/C3	Perennial	Native	
Alpine fescue	Festuca brachyphylla	Grass/C3	Perennial	Native	
Alpine timothy	Phleum alpinum	Grass/C3	Perennial	Native	
Antelope bitterbrush	Purshia tridentata	Shrub	Perennial	Native	
Arabian schismus	Schismus arabicus	Grass/C3	Annual	Introduced	Invasive
Arizona cottontop	Digitaria californica	Grass/C4	Perennial	Native	
Arizona fescue	Festuca arizonica	Grass/C3	Perennial	Native	
Arizona white oak	Quercus arizonica	Tree	Perennial	Native	
Ashe juniper	Juniperus ashei	Shrub	Perennial	Native	Invasive
Aspen	Populus tremuloides	Tree	Perennial	Native	
Balsam poplar	Populus balsamifera	Tree	Perennial	Native	
Balsamroot	Balsamorhiza spp.	Forb	Perennial	Native	
Barrel-shaped cactus	Ferocactus spp.	Succulent	Perennial	Native	
Basin big sagebrush	Artemisia tridentata ssp. tridentata	Shrub	Perennial	Native	
Basin wildrye	Leymus cinereus	Grass/C3	Perennial	Native	
Beardtongue or penstemon	Penstemon spp.	Forb	Perennial	Native	
Berlandier's wolfberry	Lycium berlandieri	Shrub	Perennial	Native	
Bermudagrass	Cynodon dactylon	Grass/C4	Perennial	Introduced	Seeded/ Invasive
Big bluestem	Andropogon gerardii	Grass/C4	Perennial	Native	
Big galleta	Hilaria rigida	Grass/C4	Perennial	Native	
Big sagebrush	Artemisia tridentata	Shrub	Perennial	Native	
Bigtooth maple	Acer grandidentatum	Shrub/tree	Perennial	Native	

 Table 2.2
 Common and scientific names of plants referenced in this chapter, rangeland ecoregions of western North America

	·)				
Common name	Scientific name	Growth form	Longevity	Origin	Comment
Blackbrush (Mojave)	Coleogyne ramosissima	Shrub	Perennial	Native	
Blackbrush acacia (Tamaulipan Thornscrub)	Vachellia rigidula = Acacia rigidula	Shrub	Perennial	Native	
Black dropseed	Sporobolus interruptus	Grass/C4	Perennial	Native	
Black grama	Bouteloua eriopoda	Grass/C4	Perennial	Native	
Blackjack oak	Quercus marilandica	Shrub/tree	Perennial	Native	Invader
Black sage	Salvia mellifera	Shrub	Perennial	Native	
Black sagebrush	Artemisia nova	Shrub	Perennial	Native	
Bluebunch wheatgrass	Pseudoroegneria spicata	Grass/C3	Perennial	Native	
Blue flax	Linum perenne	Forb	Perennial	Native	
Blue grama	Bouteloua gracilis	Grass/C4	Perennial	Native	
Bluegrasses	Poa spp.	Grass/C3	Perennial	Native	
Bluejoint reedgrass	Calamagrostis canadensis	Grass/C3	Perennial	Native	
Blue oak	Quercus douglasii	Tree	Perennial	Native	
Bolander silver sagebrush	Artemisia cana ssp. bolanderi	Shrub	Perennial	Native	
Bottlebrush squirreltail	Elymus elymoides	Grass/C3	Perennial	Native	
Bristlegrass	Seteria spp.	Grass/C4	Perennial	Native	
Brittlebush	Encelia farinose	Shrub	Perennial	Native	
Broom snakeweed	Gutierrezia sarothrae	Semi-shrub	Perennial	Native	Invader
Buckthorn	Rhamnus spp.	Shrub	Perennial	Native	
Buckwheat	Eriogonum spp.	Forb	Perennial	Native	
Buffalograss	Bouteloua dactyloides = Buchloe dactyloides	Grass/C4	Perennial	Native	
Buffelgrass	Cenchrus ciliaris = Pennisetum ciliare	Grass/C4	Perennial	Introduced	Seeded/ Invasive
Bulbous bluegrass	Poa bulbosa	Grass/C3	Perennial	Introduced	Seeded/ Invasive
Bullgrass	Muhlenbergia emersleyi	Grass/C4	Perennial	Native	

 Table 2.2 (continued)

Common name	Scientific name	Growth form	Longevity	Origin	Comment
Burclover	Medicago polymorpha	Forb	Annual	Introduced	Invasive
Bur buttercup	Ceratocephala testiculata	Forb	Annual	Introduced	Invasive
Burrobush or white bursage	Ambrosia dumosa	Shrub	Perennial	Native	
Bush muhly	Muhlenbergia porteri	Grass/C4	Perennial	Native	
California black oak	Quercus kelloggii	Tree	Perennial	Native	
California foothill pine	Pinus sabiniana	Tree	Perennial	Native	
California oatgrass	Danthonia californica	Grass/C3	Perennial	Native	
California sycamore	Platanus racemosa	Tree	Perennial	Native	
Cane bluestem	Bothriochloa barbinodis	Grass/C4	Perennial	Native	
Catclaw acacia	Senegalia greggii = Acacia greggii	Shrub	Perennial	Native	
Caucasian bluestem	Bothriochloa bladhii	Grass/C4	Perennial	Introduced	Seeded/ Invasive
Ceanothus	Ceanothus spp.	Shrub	Perennial	Native	
Chamise	Adenostoma fasciculatum	Shrub	Perennial	Native	
Cheatgrass	Bromus tectorum	Grass/C3	Annual	Introduced	Invasive
Chihuahuan oak	Quercus chihuahuensis	Tree	Perennial	Native	
Chokecherry	Prunus virginiana	Shrub	Perennial	Native	
Cholla cactus	Cylindropuntia spp.	Succulent	Perennial	Native	
Cinquefoil	Potentilla spp.	Forb	Perennial	Native	
Coast live oak	Quercus agrifolia	Tree	Perennial	Native	
Columbia needlegrass	Achnatherum nelsonii	Grass/C3	Perennial	Native	
Common wolfstail	Lycurus phleoides	Grass/C4	Perennial	Native	
Creosotebush	Larrea tridentata	Shrub	Perennial	Native	
Crested wheatgrass	Agropyron cristatum	Grass/C3	Perennial	Introduced	Seeded/ Invasive
Crown of thorns	Koeberlinia spinosa	Shrub	Perennial	Native	
Curl-leaf mountain-mahogany	Cercocarpus ledifolius	Shrub	Perennial	Native	

 Table 2.2 (continued)

	-)				
Common name	Scientific name	Growth form	Longevity	Origin	Comment
Curlymesquite	Hilaria belangeri	Grass/C4	Perennial	Native	
Cusick's bluegrass	Poa cusickii ssp. epilis	Grass/C3	Perennial	Native	
Deergrass	Muhlenbergia rigens	Grass/C4	Perennial	Native	
Desert ceanothus	Ceanothus greggii	Shrub	Perennial	Native	
Desert ironwood	Olneya tesota	Shrub/tree	Perennial	Native	
Desert needlegrass	Pappostipa speciosa = Achnatherum speciosum	Grass/C3	Perennial	Native	
Desert prince's-plume	Stanleya pinnata	Forb	Perennial	Native	
Douglas-fir	Pseudotsuga menziesii	Tree	Perennial	Native	
Dropseeds	Sporobolus spp.	Grass/C4	Perennial	Native	
Eastern red cedar	Juniperus virginiana	Shrub/tree	Perennial	Native	Invasive
Elephanthead lousewort	Pedicularis groenlandica	Forb	Perennial	Native	
Emory oak	Quercus emoryi	Tree	Perennial	Native	
Field brome	Bromus arvensis	Grass/C3	Annual	Introduced	Invasive
Filaree or redstem stork's bill	Erodium cicutarium	Forb	Annual	Introduced	Invasive
Fleabane	Erigeron spp.	Forb	Perennial	Native	
Foothills rough fescue	Festuca campestris	Grass/C3	Perennial	Native	
Fourwing saltbush	Atriplex canescens	Shrub	Perennial	Native	
Fragrant sumac or skunkbush sumac	Rhus aromatica	Shrub	Perennial	Native	
Galleta	Hilaria jamesii	Grass/C4	Perennial	Native	
Gambel oak	Quercus gambelii	Shrub/tree	Perennial	Native	
Gardner's saltbush	Atriplex gardneri var. gardneri	Shrub	Perennial	Native	
Geranium	Geranium spp.	Forb	Perennial	Native	
Globernallow	Sphaeralcea spp.	Forb	Perennial	Native	
Goldenrod	Solidago spp.	Forb	Perennial	Native	
Greasewood	Sarcobatus vermiculatus	Shrub	Perennial	Native	
Green needlegrass	Nassella viridula	Grass/C3	Perennial	Native	
Green sprangletop	Leptochloa dubia	Grass/C4	Perennial	Native	

 Table 2.2 (continued)

Common name	Scientific name	Growth form	Longevity	Origin	Comment
Groundsel or butterweed	Senecio spp.	Forb	Perennial	Native	
Guajillo acacia	Senegalia berlandieri = Acacia berlandieri	Shrub	Perennial	Native	
Hairy grama	Bouteloua hirsuta	Grass/C4	Perennial	Native	
Halogeton	Halogeton glomeratus	Forb	Annual	Introduced	Invasive
Hawksbeard	Crepis spp.	Forb			
Honey mesquite	Prosopis glandulosa var. glandulosa	Shrub	Perennial	Native	Invasive
Hooded windmillgrass	Chloris cucullata	Grass/C4	Perennial	Native	
Horsebrush	Tetradymia spp.	Shrub	Perennial	Native	
Idaho fescue	Festuca idahoensis	Grass/C3	Perennial	Native	
Indiangrass	Sorghastrum nutans	Grass/C4	Perennial	Native	
Indian paintbrush	Castilleja spp.	Forb	Perennial	Native	
Indian ricegrass	Achnatherum hymenoides	Grass/C3	Perennial	Native	
Jeffrey pine	Pinus jeffreyi	Tree	Perennial	Native	
Joshua tree	Yucca brevifolia	Succulent	Perennial	Native	
Juniper	Juniperus spp.	Shrub/tree	Perennial	Native	
Kentucky bluegrass	Poa pratensis	Grass/C3	Perennial	Introduced	Invasive
Knapweeds	Centaurea spp.	Forb	Perennial	Introduced	Invasive
Leafy spurge	Euphorbia esula	Forb	Perennial	Introduced	Invasive
Lehmann lovegrass	Eragrostis lehmanniana	Grass/C4	Perennial	Introduced	Seeded/ Invasive
Lewis' flax	Linum lewisii	Forb	Perennial	Native	
Limber pine	Pinus flexilis	Tree	Perennial	Native	
Little bluestem	Schizachyrium scoparium	Grass/C4	Perennial	Native	
Lodgepole pine	Pinus contorta	Tree	Perennial	Native	
Longbeak stork's bill	Erodium botrys	Forb	Annual	Introduced	Invasive
Lotebush	Ziziphus obtusifolia	Shrub	Perennial	Native	
Lovegrasses	Eragrostis spp.	Grass/C4	Perennial/ Annual	Native/ Introduced	

Table 2.2	(continued)
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Common name	Scientific name	Growth form	Longevity	Origin	Comment
Low sagebrush	Artemisia arbuscula ssp. arbuscula	Shrub	Perennial	Native	
Lupine	Lupinus spp.	Forb	Perennial	Native	
Manzanita	Arctostaphylos spp.	Shrub	Perennial	Native	
Mat saltbush	Atriplex corrugata	Shrub	Perennial	Native	
Mediterranean grass	Schismus barbatus	Grass/C3	Annual	Introduced	Invasive
Medusahead	Taeniatherum caput-medusae	Grass/C3	Annual	Introduced	Invasive
Mexican blue oak	Quercus oblongifolia	Tree	Perennial	Native	
Mexican giant cardón	Pachycereus pringlei	Succulent	Perennial	Native	
Mexican cliffrose	Purshia mexicana	Shrub	Perennial	Native	
Mexican piñon	Pinus cembroides	Shrub/tree	Perennial	Native	
Mojave buckwheat	Eriogonum fasciculatum	Shrub	Perennial	Native	
Mormon tea	Ephedra spp.	Shrub	Perennial	Native	
Mountain big sagebrush	Artemisia tridentata ssp. vaseyana	Shrub	Perennial	Native	
Mountain brome	Bromus carinatus	Grass/C3	Perennial	Native	
Mountain silver sagebrush	Artemisia cana ssp. viscidula	Shrub	Perennial	Native	
Mountain snowberry	Symphoricarpos oreophilus	Shrub	Perennial	Native	
Mountain sorrel	Oxyria digyna	Forb	Perennial	Native	
Muhly	Muhlenbergia spp.	Grass/C4	Perennial	Native	
Mule's ear wyethia	Wyethia amplexicaulis	Forb	Perennial	Native	
Multiflowered false rhodesgrass	Trichloris pluriflora	Grass/C4	Perennial	Native	
Mustards	Brassica spp.	Forb	Perennial/ Annual	Native/ Introduced	May be invasive
Muttongrass	Poa fendleriana	Grass/C3	Perennial	Native	
Narrowleaf goldenbush	Ericameria linearifolia	Forb	Perennial	Native	
Needle and thread	Hesperostipa comata	Grass/C3	Perennial	Native	
Needlegrass	Achnatherum spp.	Grass/C3	Perennial	Native	
New Mexico feathergrass	Hesperostipa neomexicana	Grass/C3	Perennial	Native	

 Table 2.2 (continued)

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Common name	Scientific name	Growth form	Longevity	Origin	Comment
Nodding needlegrass	Nassella cernua	Grass/C3	Perennial	Native	
Oak	Quercus spp.	Shrub/tree	Perennial	Native	
Ocotillo	Fouquieria splendens	Semi-succulent	Perennial	Native	
Oneseed juniper	Juniperus monosperma	Shrub/tree	Perennial	Native	
Orchardgrass	Dactylis glomerata	Grass/C3	Perennial	Introduced	Seeded/ invasive
Paloverde	Parkinsonia spp.	Shrub/tree	Perennial	Native	
Parry oatgrass	Danthonia parryi	Grass/C3	Perennial	Native	
Pepperweed	Lepidium spp.	Forb	Annual	Introduced	Invasive
Pine dropseed	Blepharoneuron tricholepis	Grass/C4	Perennial	Native	
Pinegrass	Calamagrostis rubescens	Grass/C3	Perennial	Native	
Pink pappusgrass	Pappophorum bicolor	Grass/C4	Perennial	Native	
Piñon pine	Pinus spp.	Shrub/tree	Perennial	Native	
Plains rough fescue	Festuca hallii	Grass/C3	Perennial	Native	
Plains silver sagebrush	Artemisia cana ssp. cana	Shrub	Perennial	Native	
Ponderosa pine	Pinus ponderosa	Tree	Perennial	Native	
Porcupine grass	Hesperostipa spartea	Grass/C3	Perennial	Native	
Post oak	Quercus stellata	Tree	Perennial	Native	Invasive
Prairie junegrass	Koeleria macrantha	Grass/C3	Perennial	Native	
Prairie sagewort	Artemisia frigida	Semi-shrub	Perennial	Native	
Prickly pear cactus	Opuntia spp.	Succulent	Perennial	Native	
Purple needlegrass	Nassella pulchra	Grass/C3	Perennial	Native	
Purple reedgrass	Calamagrostis purpurascens	Grass/C3	Perennial	Native	
Purple threeawn	Aristida purpurea	Grass/C4	Perennial	Native	
Redberry juniper (Arizona)	Juniperus coahuilensis	Shrub/tree	Perennial	Native	
Redberry juniper (Texas)	Juniperus pinchotii	Shrub/tree	Perennial	Native	Invasive
Red brome	Bromus rubens	Grass/C3	Annual	Introduced	Invasive
Red grama	Bouteloua trifida	Grass/C4	Perennial	Native	

 Table 2.2 (continued)

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Common name	Scientific name	Growth form	Longevity	Origin	Comment
Ripgut brome	Bromus diandrus	Grass/C3	Annual	Introduced	Invasive
Rocky Mountain juniper	Juniperus scopulorum	Shrub/tree	Perennial	Native	
Rothrock grama	Bouteloua rothrockii	Grass/C4	Perennial	Native	
Rubber rabbitbrush	Ericameria nauseosa	Shrub	Perennial	Native	Invasive
Rush	Juncus spp.	Grass-like	Perennial	Native	
Russian thistle	Salsola spp.	Forb	Annual	Introduced	Invasive
Saguaro cactus	Carnegiea gigantea	Succulent	Perennial	Native	
Sandberg bluegrass	Poa secunda	Grass/C3	Perennial	Native	
Sand dropseed	Sporobolus cryptandrus	Grass/C4	Perennial	Native	
Sand sagebrush	Artemisia filifolia	Shrub	Perennial	Native	
Sand shinnery oak	Quercus havardii	Shrub	Perennial	Native	
Scarlet globemallow	Sphaeralcea coccinea	Forb	Perennial	Native	
Scrub oak	Quercus berberidifolia	Shrub	Perennial	Native	
Sedge	Carex spp.	Grass-like	Perennial	Native	
Sericea lespedeza	Lespedeza cuneata	Forb	Perennial	Introduced	Seeded/ Invasive
Serviceberry	Amelanchier spp.	Shrub	Perennial	Native	
Shadscale	Atriplex confertifolia	Shrub	Perennial	Native	
Shrub live oak	Quercus turbinella	Shrub	Perennial	Native	
Shrubby cinquefoil	Dasiphora fruticosa	Shrub	Perennial	Native	
Shrubby prairie rose	Rosa arkansana	Shrub	Perennial	Native	
Sideoats grama	Bouteloua curtipendula	Grass/C4	Perennial	Native	
Silver bluestem	Bothriochloa laguroides	Grass/C4	Perennial	Native	
Silver buffaloberry	Shepherdia argentea	Shrub	Perennial	Native	
Singleleaf piñon	Pinus monophylla	Shrub/tree	Perennial	Native	
Slender grama	Bouteloua repens	Grass/C4	Perennial	Native	
Slender wheatgrass	Elymus trachycaulus	Grass/C3	Perennial	Native	
Slender wild oats	Avena barbata	Grass/C3	Annual	Introduced	
Smooth bromegrass	Bromus inermis	Grass/C3	Perennial	Introduced	Seeded/ Invasive
Snowberry	Symphoricarpos spp.	Shrub	Perennial	Native	

 Table 2.2 (continued)

Common name	Scientific name	Growth form	Longevity	Origin	Comment
Snowfield sagebrush	Artemisia spiciformis	Shrub	Perennial	Native	
Soft chess	Bromus hordeaceus	Grass/C3	Annual	Introduced	Invasive
Spanish-bayonet	Yucca harrimaniae	Succulent	Perennial	Native	
Spiny hackberry or granjeno	Celtis ehrenbergiana = C. pallida	Shrub/tree	Perennial	Native	
Spotted knapweed	Centaurea stoebe	Forb	Perennial	Introduced	Invasive
Spruce	Picea spp.	Tree	Perennial	Native	
Subalpine fir	Abies lasiocarpa	Tree	Perennial	Native	
Sulphur cinquefoil	Potentilla recta	Forb	Perennial	Introduced	Invasive
Sumac	Rhus spp.	Shrub	Perennial	Native	
Sun sedge	Carex inops ssp. heliophila	Grass-like	Perennial	Native	
Switchgrass	Panicum virgatum	Grass/C4	Perennial	Native	
Tall mountain shootingstar	Primula jeffreyi	Forb	Perennial	Native	
Tanglehead	Heteropogon contortus	Grass/C4	Perennial	Native	Invasive
Tarbush	Flourensia cernua	Shrub	Perennial	Native	
Texas grama	Bouteloua rigidiseta	Grass/C4	Perennial	Native	
Texas live oak	Quercus fusiformis	Tree	Perennial	Native	
Texas persimmon	Diospyros texana	Shrub/tree	Perennial	Native	
Texas wintergrass	Nassella leucotricha	Grass/C3	Perennial	Native	
Thickstem aster	Eurybia integrifolia	Forb	Perennial	Native	
Thin paspalum	Paspalum setaceum	Grass/C4	Perennial	Native	
Thistle	<i>Carduus</i> spp., <i>Centaurea</i> spp., and <i>Cirsium</i> spp.	Forb	Perennial	Native/ Introduced	Invasive
Threeawns	Aristida spp.	Grass/C4	Perennial	Native	
Threetip sagebrush	Artemisia tripartita	Shrub	Perennial	Native	
Thurber fescue	Festuca thurberi	Grass/C3	Perennial	Native	
Thurber needlegrass	Achnatherum thurberianum	Grass/C3	Perennial	Native	
Timber oatgrass	Danthonia intermedia	Grass/C3	Perennial	Native	
Timothy	Phleum pratense	Grass/C3	Perennial	Introduced	Seeded/ Invasive
Tobosagrass	Hilaria mutica	Grass/C4	Perennial	Native	

 Table 2.2 (continued)

Common name	Scientific name	Growth form	Longevity	Origin	Comment
Townsend daisy	Townsendia leptotes	Forb	Perennial	Native	
Triangle bursage	Ambrosia deltoidea	Shrub	Perennial	Native	
True mountain-mahogany	Cercocarpus montanus	Shrub	Perennial	Native	
Tufted hairgrass	Deschampsia cespitosa	Grass/C3	Perennial	Native	
Two-needle piñon	Pinus edulis	Shrub/tree	Perennial	Native	
Utah juniper	Juniperus osteosperma	Shrub/tree	Perennial	Native	Invasive
Valley oak	Quercus lobata	Tree	Perennial	Native	
Velvet mesquite	Prosopis velutina	Shrub/tree	Perennial	Native	
Ventenata	Ventenata dubia	Grass/C3	Annual	Introduced	Invasive
Walnut	Juglans spp.	Tree	Perennial	Native	
Weeping lovegrass	Eragrostis curvula	Grass/C4	Perennial	Introduced	Seeded/ Invasive
Western honey mesquite	Prosopis glandulosa var. torreyana	Shrub/tree	Perennial	Native	Invasive
Western meadowrue	Thalictrum occidentale	Forb	Perennial	Native	
Western juniper	Juniperus occidentalis	Shrub/tree	Perennial	Native	Invasive
Western yarrow	Achillea millefolium	Forb	Perennial	Native	
Western wheatgrass	Pascopyrum smithii	Grass/C3	Perennial	Native	
White tridens	Tridens albescens	Grass/C4	Perennial	Native	
Whitlowgrass	Draba spp.	Forb	Perennial	Native	
Wild oat	Avena fatua	Grass/C3	Annual	Introduced	
Willow	Salix spp.	Shrub/tree	Perennial	Native	
Winterfat	Krascheninnikovia lanata	Semi-shrub	Perennial	Native	
Wild rose	Rosa spp.	Shrub	Perennial	Native	
Wildryes and wheatgrasses	<i>Elymus</i> spp. and <i>Leymus</i> spp.	Grass/C3	Perennial	Native	
Woodrush	Luzula spp.	Grass-like	Perennial	Native	
Wyoming big sagebrush	Artemisia tridentata ssp. wyomingensis	Shrub	Perennial	Native	
Yellow bluestem (King Ranch bluestem)	Bothriochloa ischaemum	Grass/C4	Perennial	Introduced	Invasive

 Table 2.2 (continued)

Common name	Scientific name	Growth form	Longevity	Origin	Comment
Yellow rabbitbrush	Chrysothamnus viscidiflorus	Shrub	Perennial	Native	Invasive
Yellow toadflax	Linaria vulgaris	Forb	Perennial	Introduced	Invasive
Yucca	Yucca spp.	Succulent	Perennial	Native	

Table 2.2 (continued)

Source for common and scientific names is the Integrated Taxonomic Information System (ITIS; https://www.itis.gov, National Museum of Natural History 2023). Warm-season (C4) and cool-season (C3) photosynthetic pathways of grasses and CAM pathways for succulents are indicated under growth form. Longevity and origin information is from a variety of sources. The comment column is reserved to indicate plants that are generally considered invasive, although in some locations they may not be invasive. Seeded/invasive refers to plants that were purposely introduced to North America but have become invasive on some sites

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