The Western United States Rangelands: A Major Resource

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"Nearly every acre of range has other uses and values besides forage production—to protect watersheds, produce timber, give wildlife a home, and provide places for recreation. These are the 'other' values of range. Each is important; on some ranges, indeed, the demands of one or more may dominate or even exclude grazing. If grazing is properly managed, however, the various uses are usually compatible with the use of forage by livestock."—C.A. Connaughton, in Stefferud, Grass: The 1948 Yearbook of Agriculture, *p. 239*

A DYNAMIC LANDSCAPE

Kris Havstad and Debra Peters

Rangeland is a type of land found predominantly in arid and semiarid regions and managed as a natural ecosystem supporting vegetation of grasses, grasslike plants, forbs, or shrubs. This land type is characterized by four features: (i) it is limited by water and nutrients, primarily nitrogen, (ii) annual production is low and characterized by tremendous temporal and spatial variability, (iii) it is a landscape mosaic of communal, government (commonly referred to in the United States as "public lands"), and/or private ownership, and (iv) throughout their history of use, these lands have been uniquely coupled systems of both people and nature. Although precise determinations are lacking, approximately half of the world's land surface is typically classified as rangeland, with nearly one-fourth of the world's population, more than 1.5 billion, living on or immediately adjacent to this land type. Many of these people, over 600 million, are engaged in subsistence animal agriculture as pastoralists.

In the United States, rangelands comprise about 31% of the total land area, approximately 761 million acres (308 million ha), which occur mostly in the West. In the USDA's *Grass: 1948 Yearbook of Agriculture* (Stefferud, 1948), the chapter on rangelands ("The Range: A Major Resource") focused on a description of these lands occurring by region across the western United States. The book also outlined the principles, developed mostly in the early 20th century, to manage these lands for provisioning food and fiber through livestock grazing. That description of nearly 60 years ago focused on the role of U.S. rangelands as grazinglands in support of pastoral (i.e., ranching) livelihoods as was commonly seen around the world.

In the last 60 years, these western rangelands have undergone a transformation as the U.S. population has grown to over 300 million, with a trend to relocation to urban areas within the western and southwestern states. This population dynamic, along with tremendous changes in agricultural production and a reduction in the population involved in agriculture, has resulted in significant changes in the uses and emphases placed on western U.S. lands. This land type is now anticipated to provide a multitude of goods and services not only to rural populations but also to tens of millions of people in large urban areas located within these rangelands. It is our intent in this chapter to reflect on the extent and nature of this transformation over the last 60 years. We start with a description of this human dynamic and its sociological implications. We describe the major regions of the western continental United States, the focal point of U.S. rangelands. Although rangelands occur in other regions, such as Florida, Hawaii, and Alaska, we concentrate on the contiguous western states (Fig. 5–1). Humid rangeland areas, such as those in Florida, are discussed in Chapter 6 (Sheaffer et al., 2009, this volume). Although Alaska and Hawaii have significant rangeland areas, they are relatively isolated areas, and the points discussed in this chapter have application to these rangelands. For each region discussed, we describe characteristic goods and services, as well as key aspects envisioned for its future. To further illustrate these transformations, we include a description of some of the changes that have occurred in the southwestern United States since 1950.

In a concluding section, we describe important management technologies and conservation practices that are now available to today's landowners and stewards. Interestingly, these practices still rely on many of the principles of management described in 1948, but the demands for and customers of these practices are now, in most locations, quite different.

The story line of this chapter is fairly simple and can be described as follows: the overall importance of these rangelands has not lessened since 1948, but their dynamic transformation in the ensuing years requires that these grasslands, and shrublands, now provide a wider range of goods and services than were emphasized six decades ago. These lands can provide these goods and services, but this provision requires management based on a thorough understanding that these areas are not just human-coupled but strongly urban-influenced, if not human-dominated, landscapes.

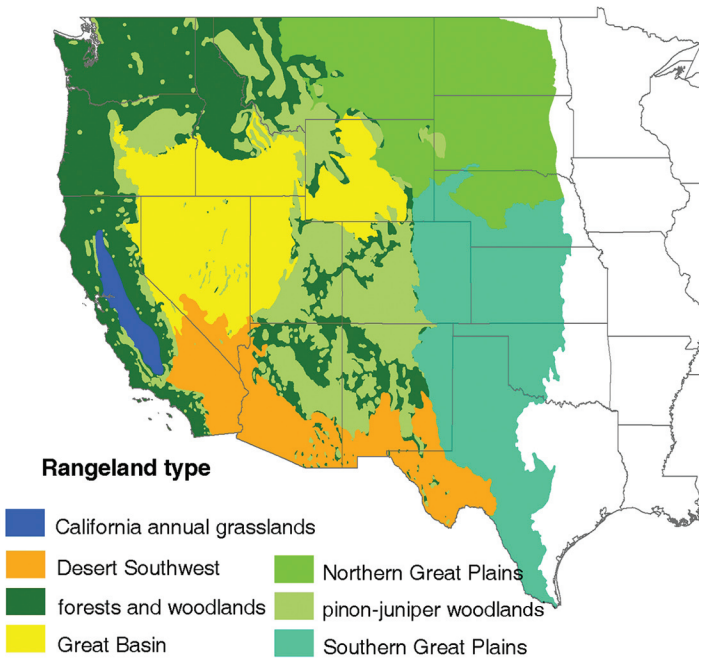

Fig. 5–1. Rangeland types in the contiguous western United States. Rangeland types are aggregations of ecoregions within a type as delineated by the National Geographic Society as detailed at http://www.nationalgeographic.com/wildworld/terrestrial.html. The forests and woodlands type encompasses a multitude of interspersed areas of diverse forest and woodland species.

HUMANS IN THESE LANDSCAPES

Mark Brunson

The rangeland region of the western United States is the most sparsely populated in the contiguous United States, as it probably has been throughout the course of human habitation due to its rugged terrain, relatively low and highly variable productivity, and often-long distances between water sources. While these circumstances persist today, the region has experienced more rapid population growth than other parts of the United States in recent years. This growth is having significant implications for rangeland management and conservation.

The contiguous western states have the nation's most urban population, with more than three-fourths of residents living in metropolitan areas. Metropolitan growth has accelerated in recent years, and the region contains 6 of the nation's 10 fastest growing metropolitan areas since the 2000 Census (http://ers.usda.gov/Data/TypologyCodes/). Consequences of urban growth for rangelands can be seen primarily in terms of shifts in demand for rangeland products and services. Two important shifts have been (i) the increased appreciation of the recreational and scenic values of rangelands, and (ii) a rapidly increasing demand for water that has led to a reallocation from agricultural uses (especially forage production) to municipal and industrial consumption.

Even more significant is the population growth in exurban areas, most of which occurs in counties adjacent to metropolitan areas and in areas having high amenity value such as towns near national parks or wilderness areas. Low-density exurban development is the nation's fastest-growing form of land use since 1975, and nowhere is this growth greater than in the western rangeland states. In the 1990s, nonmetropolitan population growth was three times greater in the West than in the United States overall. Most land converted to low-density home sites was previously part of a cattle ranch. Former ranches often remain in grazing use while new owners wait to be able to build—sometimes for years or decades—but they tend to get less management attention than working ranches. As a result, they may be more susceptible to overgrazing and motorized recreation damage, and they provide seed sources for invasive plants. Once homes are built, these rangelands typically support fewer livestock, have greatly reduced wildlife value, and have increased impervious surface area, changing or disrupting historic water flow patterns.

However, the majority of western rangelands, especially between the Rocky Mountain and Sierra/Cascade mountain ranges, are in public ownership. Citizen interest in these public rangelands has greatly increased over the past half-century. Demand for rangeland goods and services likewise has increased due to increased understanding of the multiple values rangelands can provide, shifts in citizens' attitudes toward public land management, and growth in the number of Americans living within a few hours' drive of public rangelands. Public rangeland management today emphasizes many more values than the livestock-oriented approach of the mid–20th century. The multiple uses and benefits of rangelands were recognized in various laws passed during the period of 1960 to 1980, including the Multiple-Use, Sustained Yield Act (1960), Wilderness Act (1964), Wild, Free-Roaming Horses and Burros Act (1971), National Forest Management Act (1976), and Federal Land Policy and Management Act (1976). At first, public pressure to manage for these uses and benefits was less for rangelands than other land types. As environmental movements have become more sophisticated and the region's population has become more urbanized and homogenized (due largely to migration from other parts of the United States), the attention paid by citizen groups to rangelands has greatly increased. In turn, the complexity of management and scientific information that can enhance the ability of rangelands to provide multiple goods and services has increased as well.

MAJOR REGIONS OF THE WESTERN UNITED STATES

The Great Plains

Patricia Johnson and David Briske

The physiography of the Great Plains consists of an enormous piedmont that flanks the eastern slope of the Rocky Mountains for a distance of several hundreds of miles. The climate is uniquely continental and is characterized by dominant north–south temperature and east–west precipitation gradients. These climatic gradients and physiographic features define the province and ecological attributes of these ecosystems. The Northern Great Plains are vast grasslands occupying most of the states of North Dakota and South Dakota and substantial areas of Montana, northeastern Colorado, and northern Nebraska (Fig. 5–2). This region is generally flat to rolling, with features such as the Black Hills, badlands, and rivers providing sharp breaks in the gentle topography. The influence of glaciation is quite evident in the northeastern portion of the Northern Great Plains where, during the Pleistocene, continental glaciers moved south as far as the Missouri River. When they receded, the glaciers left behind millions of shallow depressions that are now wetlands called prairie potholes. The Southern Great Plains are situated between the Rocky Mountains and the central lowlands and encompass portions of six states (Fig. 5–3). Native vegetation is dominated by short and mid-height perennial grasses that evolved with natural disturbance regimes characterized by grazing, drought, and fire.

The Great Plains states are decidedly rural and sparsely populated, with a few exceptions. Montana, South Dakota, North Dakota, and Wyoming are among the 10 least populated states in the United States, each having a population of less than one million. Wyoming is the least-populated state in the country, with just over a half million citizens. Several large population centers are located on the periphery of the Southern Plains, including the Front Range Corridor in Colorado (4 million), I-35 San Antonio–Austin Corridor in Texas (4 million), and the Dallas–Fort Worth metroplex (6.4 million) southeast of the province. The population of the Southern Plains has increased approximately 114% from 5.7 million in 1950 to 12.2 million in 2000 (excluding the Dallas–Fort Worth metroplex). The majority of this growth can be attributed to several population centers, and future population growth is anticipated to be greatest in regions that currently have the highest densities.

Fig. 5–2. The Northern Great Plains.

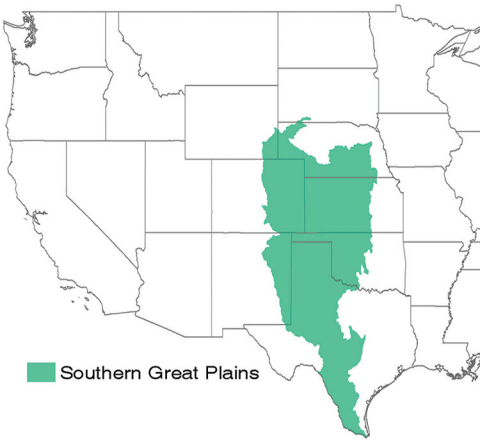

Fig. 5–3. The Southern Great Plains lies between the Rocky Mountains and the Central Lowlands and encompasses portions of six states.

Photo by Gary Kramer, USDA, Natural Resources Conservation Service

Ecosystem Goods and Services

The goods and services that could be sustainably provisioned from Plains ecosystems, primarily beef cattle and small grains with some irrigated cotton in the southern portion, were clearly defined by the drought of the 1930s. These hard-learned lessons were reflected in the 1948 yearbook (Stefferud, 1948), and they have been well heeded for the most part. Only minimal amounts of rangeland have been converted to cropland since that period, and substantial acreages of marginal cropland have been replanted to perennial grass cover. The Conservation Reserve Program (CRP), initiated by a provision of the 1985 Food Security Act, provided landowners with incentives to take erosive, marginal land out of cultivation to promote ecological sustainability. The number of beef cattle has remained relatively high, although it has declined slightly but steadily since the 1950s.

Recreation is a major contributor to the economies of all Plains states. Each state has capitalized on the open spaces and beautiful scenery associated with the prairies through highly active tourism industries. National parks and monuments are scattered throughout the region.

Rangelands of the Great Plains function as huge watersheds funneling precipitation into streams and rivers, with much of it flowing into the Missouri River and ultimately the Mississippi River to the east of the region. There is concern over the levels of sediment carried by the streams and ultimately ending up behind dams in the Missouri River. Prairie watersheds are also important in aquifer recharge. Agriculture and urban areas in the region depend on both surface and subsurface sources to meet their water needs. The Ogallala Aquifer underlies much of the Southern Great Plains, and it is the single most important source of water in the province. The aquifer supplies irrigation water to 13.6 million acres (5.5 million ha) of agricultural land, with Nebraska, Texas and Kansas extracting the largest amounts. Substantial aquifer depletion has occurred in the past 60 years, especially in the Texas and Oklahoma Panhandle and southwestern Kansas, and it continues to occur at approximately 2.6 feet per year (79 cm). Recharge occurs slowly because of the semiarid climate and limited permeability of substrates overlying much of the aquifer.

Future of Great Plains Rangelands

Livestock production on rangelands in the Great Plains will continue, although restrictions on those activities will likely increase. The region is primarily in private land; Wyoming has the greatest federal holdings (nearly 50%), Montana is about 30%, and other states are less than 10%. Regardless,

public land issues such as the Endangered Species Act of 1973 (public law #93-105 and amended in 2002) impact private land ranches and limit management options available on private holdings. The list of threatened and endangered species in the region is likely to grow, impacting private lands well into the future.

Noxious weeds have invaded throughout the Great Plains, and their control will continue to be a priority in the 21st century. The availability of effective control measures will be an issue as the use of herbicides and fire becomes more restricted. The sale of ranches to out-of-state owners for hunting preserves and the subdivision of ranches into small acreages are likely to exacerbate problems with invasive species by providing increased opportunities for their spread and increased aversion to the use of fire and herbicides for their control.

Conversion of native prairie to cropland has occurred predictably in the past with mesic weather cycles and/or fiscal incentives (e.g., federal programs and high crop prices). There is now great concern that a new incentive—the development of biofuels technology—will accelerate conversion of rangeland into very marginal cropland to profit from high corn and other biofuels prices. It is also likely that land currently enrolled in the CRP will be cropped once contracts have expired, especially with an increasing global demand for grains. Greater pressure will be applied to the remaining rangelands by recreation and wildlife interests, particularly on the limited public lands in the region. A probable result will be an even greater shift away from livestock production on public lands, putting a greater burden for meat production on private lands.

The Great Plains will continue to provide considerable opportunities for future national needs for open space, sequestration of carbon, recreation, and agriculture. Although human populations are increasing for most of the states in the region, the sparsely populated, rural character of the Northern Great Plains is unlikely to change significantly over the next several decades. Most of the population increases will occur in the vicinity of current urban centers, primarily in the Southern Plains, exacerbating localized issues such as water availability, air quality, and overgrazing on small "hobby" farms and ranchettes.

The decreasing portion of heirs that choose to retain title of inherited ranches have contributed to changing patterns of landownership and fragmentation. Ownership patterns have shown a decrease in mid-size (1240–51,400 acre [500–20,800 ha]) farms and ranches and an increase in both smaller and larger landholdings. Land fragmentation, including rangeland conversion to cropland, urban and exurban development, and increasing woody plant encroachment, has modified habitats for various mammal, reptile, and bird species. For example, populations of grassland obligate birds (birds that are highly dependent on grasslands) throughout the Great Plains, including both resident species as well as some neotropical migrants, have been decreasing more rapidly than those of other bird populations.

Projected climate change is anticipated to intensify agricultural and economic constraints currently confronting the Great Plains. Atmospheric warming (1.8°F, or 1°C) and decreasing rainfall (10%) have been observed over the past century in the northern, but not the southern, portion of the province. Continued warming is projected, especially during the winter and spring, with substantial increases forecast for the mean summer heat index (i.e., air temperature plus humidity). Global change models are less conclusive regarding rainfall amounts and patterns, but the projection is that net soil water will decrease throughout the current century in response to the combined effects of constant or decreasing annual rainfall and increasing evapotranspiration (the sum of water evaporated from the surface of land and vegetation and that transpired by plants back into the atmosphere) associated with higher air temperatures. This change in climate is anticipated to exacerbate current water limitations and promote further change in water-use strategies and prevailing land uses.

Great Basin

Tony Svejcar

The Great Basin has been defined in a variety of ways over the years. The two most common definitions are (i) an area that is drained internally and has no outlet to the sea, or (ii) a floristically

defined region that is characterized primarily by shrub steppes (shrub–bunchgrass communities). The region designated as Great Basin in Fig. 5–4 includes the area that is internally drained (hydrologic definition) but also includes additional areas of shrub steppe to the north and east.

Much of the Great Basin is in the Basin and Range Province, with isolated mountain ranges separated by valleys. The mountain ranges are a result of fault activity (the meeting of the Pacific and North American plates), and generally have a north–south orientation. The Basin and Range geography results in rainshadows and steep elevation gradients, which create high temporal and spatial variability in both climate and vegetation.

As is true in much of the western United States, the Great Basin has experienced rapid population growth in the past 20 to 30 years. Urban and exurban areas such as Reno (NV), Boise (ID), Bend-Redmond (OR), and the Wasatch Front (UT) are examples. The population of Nevada grew from 993,000 in 1986 to 2,623,000 in 2006. During the same period, the population of Reno grew from 118,380 to 214,371. The state of Nevada projects that its population will increase by almost 2 million from 2005 to 2026.

Ecosystem Goods and Services

Much of the region is public land, with Oregon having more than 50% public land, Idaho and Utah more than 60%, and Nevada more than 80%. During the past 40-plus years, there has been a multiple-use mandate for most public lands. The emphasis of land management depends on the agency involved and specific authorizations associated with a piece of land (such as national parks, wildlife refuges, and wilderness areas). In general, there has been a shift in emphasis on public land from producing economic returns to seeking a balance among economic production, environmental needs, and recreational uses. These public lands, as seen elsewhere, are now often valued for the open space and recreational opportunities provided to a growing human population.

In the faster-growing portions of the Great Basin, ranches are often purchased for development into suburban housing tracts or small acreage ranchettes. Although the concept is not new, there has also been a trend toward the purchase of agricultural water rights for either residential use or to enhance instream flow. If temperatures continue to increase in the region, projections suggest that water resources could become more limiting in the future. Lower snowpack, earlier snowmelt, and higher evaporative demand could combine to limit the availability of surface water, especially during late summer and fall.

In some portions of the Great Basin, mining was a historically important activity. Today, mining is probably less widespread than it was 100 years ago, but due to large mining tracts within Nevada, it is still a very economically important activity within the region.

The Great Basin will continue to provide clean air and water, diverse plant and animal populations, an array of recreational opportunities, open space, and a sustainable harvest of livestock forage. However, excessive development pressure, inappropriate land management, some forms of recreation, and some extractive industries can place a strain on the ecosystem services listed above. The need for appropriate rangeland management in the face of changes in vegetation, climate, and human populations will create challenges for all involved.

Future of the Great Basin

It seems clear that population growth in the Great Basin will continue into the future. Major population centers will continue to grow, which will cause outflow to surrounding small and medium-size towns. An increasing number of retirees will also seek places with a favorable climate and recreational opportunities. These individuals do not require jobs and are often able to live in areas with a limited economic base. The increasing population will place more pressure on recreational opportunities and increase the impacts of recreation on a variety of ecosystem services.

There is likely to be more pressure on agriculture to apply conservation practices and sustainable management for a variety of resources (water, wildlife habitat, vegetation diversity, clean air and water, and even carbon sequestration). The focus on these issues has a long history in much of the Great Basin and will continue.

Some of the major challenges will revolve around the expansion of invasive species (especially the introduced annual cheatgrass [*Bromus tectorum* L.]), interacting with changing fire cycles, atmospheric carbon dioxide (CO_2), and climate. For example, recent research has clearly shown that cheatgrass responds very favorably to increasing atmospheric CO_2. Evidence also exists that winter temperatures are increasing and growing seasons are slightly longer than they were in the recent past. These factors all pose potential risks for those interested in favoring native rangeland species and minimizing invasions. With an expansion in invasive annual grasses comes more frequent fires, loss of wildlife habitat and livestock forage, and risks to air and water quality. Whether recent trends in climate (temperature and precipitation) will continue into the future is less certain. Numerous efforts are underway to restore and revegetate non-native annual grass–dominated Great Basin rangelands. Many of these efforts have met with limited success, especially when native species are seeded as the first step in restoration. The challenges posed in managing extensive rangelands and rehabilitating degraded rangelands will require close cooperation among researchers, land managers, and other interested parties. Some have expressed the sentiment that recent arguments over grazing, water, and land use designations will seem trivial if weedy species such as cheatgrass come to dominate our Great Basin rangelands.

Desert Southwest

Debra Peters, Kris Havstad, and Jin Yao

The desert rangelands in the southwestern United States are the driest, hottest, and least-productive rangelands in North America (see Fig. 5–5). Desert rangelands consist of three hot deserts: Chihuahuan, Sonoran, and Mojave (see Fig. 5–6).

Most of the Chihuahuan Desert—the largest desert in North America, covering more than 193,000 square miles (310,600 km^2)—lies in Mexico. In the United States, it extends into parts of New Mexico, Texas, and sections of southeastern Arizona. The Sonoran Desert covers 120,000 square miles (193,000 km^2) in southwestern Arizona and southeastern California. The Mojave Desert, the smallest of the three hot deserts, is located in southeastern California and portions of Nevada, Arizona, and Utah and occupies more than 25,000 square miles (40,200 km^2).

These three desert rangelands share a number of characteristics related to climate, vegetation, and land-use dynamics associated with human activities, yet they differ in elevation, seasonality in rainfall, and plant species composition. Despite the differences among these three deserts, the goods and services provided to human populations are remarkably similar.

All of the hot deserts have experienced dramatic increases in human population growth, particularly since 1950 with the development of air-conditioning technologies (i.e., evaporative coolers). A pleasant year-round climate combined with amenities designed to attract a broad

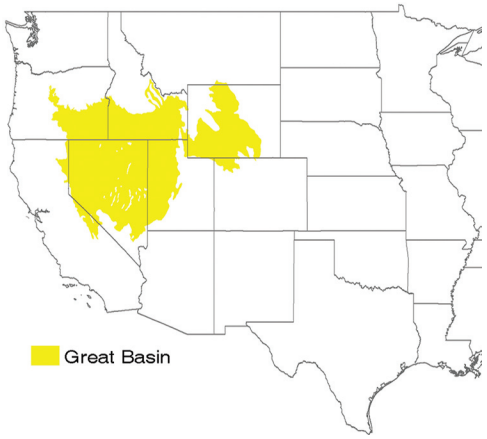

Fig. 5–4. The Great Basin region.

Fig. 5–5. Desert Southwest rangeland region.

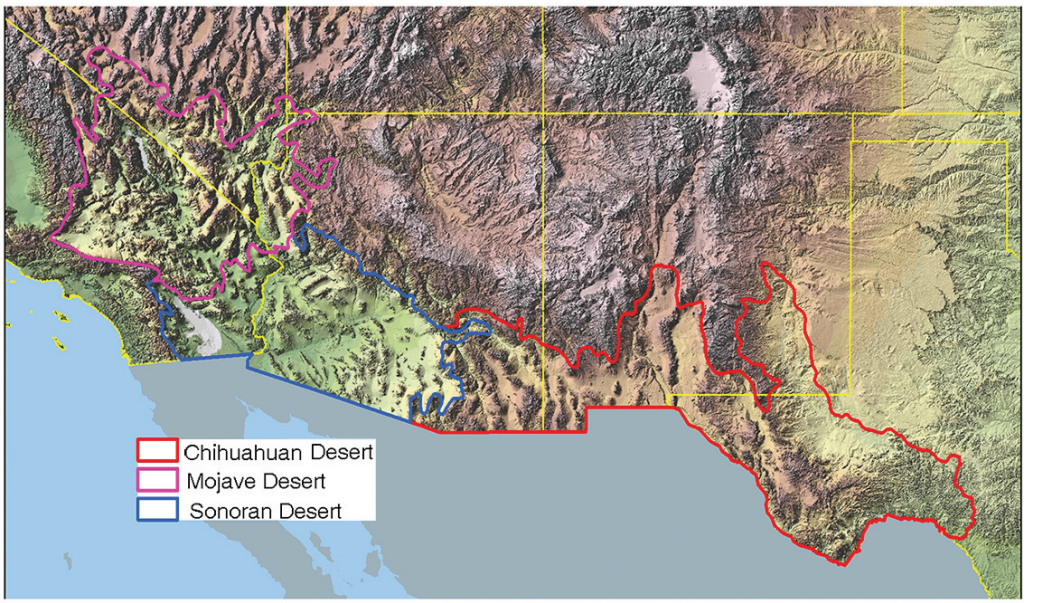

Fig. 5–6. Location of the three hot deserts that comprise the Desert Southwest region (http://www.nationalatlas.gov).

range of potential interests (e.g., golf courses, wilderness areas) and inexpensive land has resulted in an influx of people to this region. Most counties in the Southwest have increased in population density, with the largest changes occurring in southern California, central Arizona, and southern New Mexico–northwestern Texas.

Ecosystem Goods and Services

Historically, a primary good provided by the hot deserts to human populations was beef production on areas used for rangeland. However, much of this region is public land. As human populations have increased, public land stewards have emphasized management for multiple uses as the rangeland livestock industry has become constrained. Thus, these lands now provide a greater diversity of ecosystem goods and services than previously, including cultural services (e.g., educational value), regulatory services (e.g., waste treatment), supporting services (e.g., water cycling), and provisioning services (e.g., genetic resources). For example, the proportion of the population living in rural areas has declined through time, with the largest decreases since the extended drought during the 1950s. Increasingly, people are moving to the Desert Southwest in search of open space for recreation and aesthetic value. Thus, land has been and continues to be converted from large, working ranches often of marginal value for livestock production to small, multi-use acreages (see Fig. 5–7, 5–8, 5–9, and 5–10). Land previously valued for livestock production is now being sold for housing development at prices that are a magnitude more than their value as rangeland. There is also an increasing awareness of the need for natural systems to provide high-quality water in sufficient quantities to serve the increasing human population. However, because water is a scarce resource throughout the desert region, there are competing demands on water among agriculture, urban, recreation, and wildlife used that need to be resolved. The increasing urban population across the region will likely overwhelm agricultural water needs not only within the region but from other regions as well.

Future of the Desert Southwest

Future predictions for the hot deserts include increased climate variability and human population pressures that will widen the chasm between water availability and water demand. Most

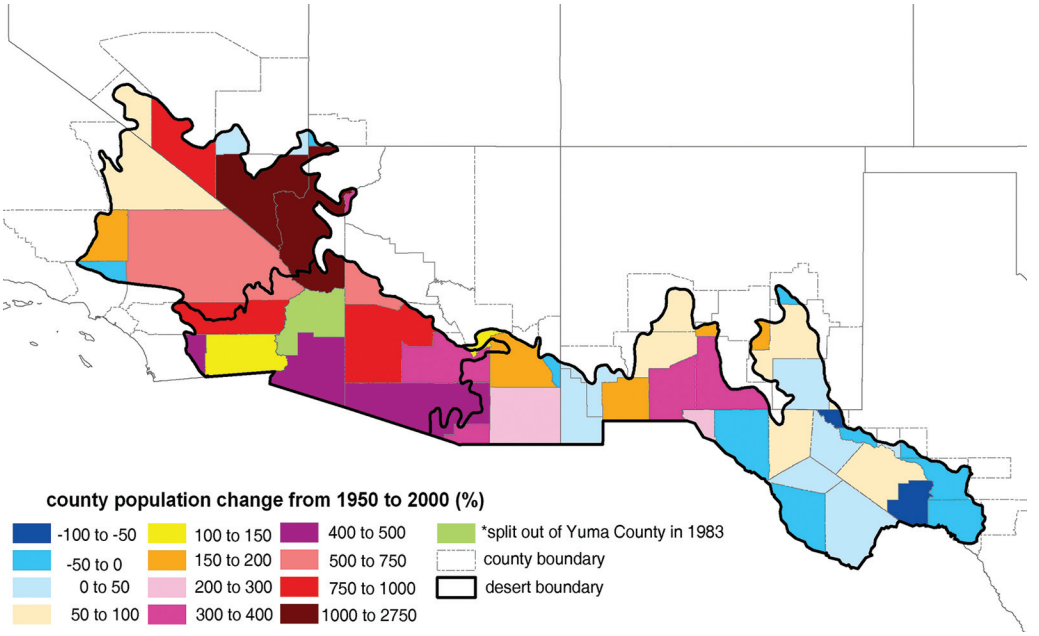

Fig. 5–7. Change in human population: proportional change in human population density in the Desert Southwest by county between 1950 and 2000 (U.S. Census Bureau, http://www.census.gov/).

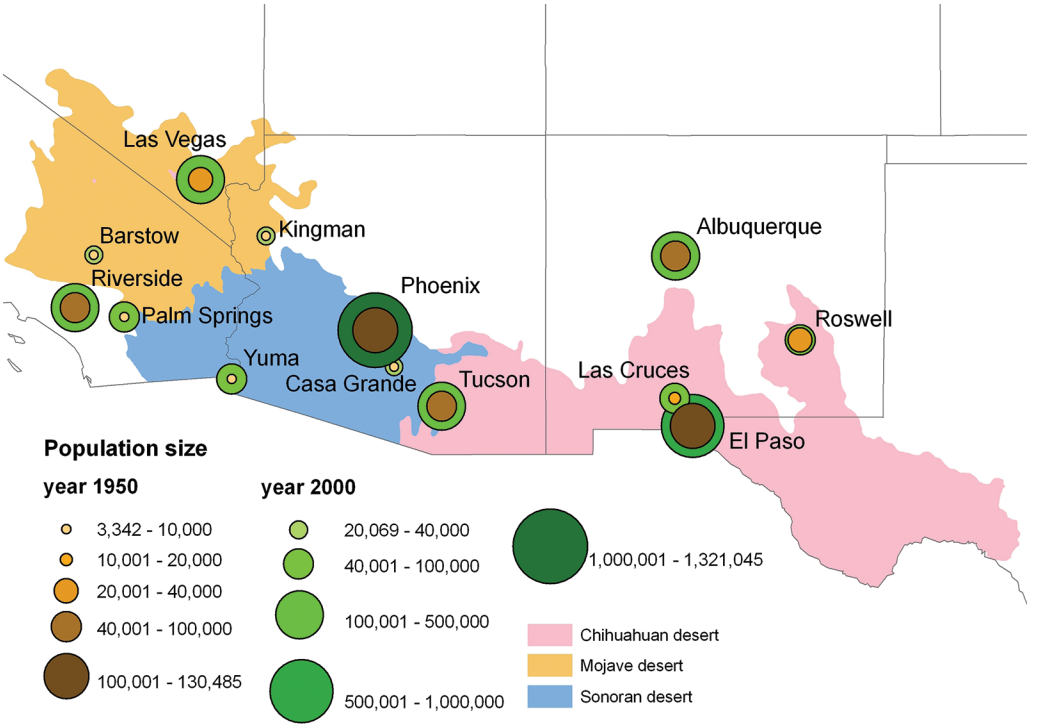

Fig. 5–8. Change in human population: change in population numbers for major cities in each desert in the Desert Southwest between 1950 and 2000 (U.S. Census Bureau http://www.census.gov/).

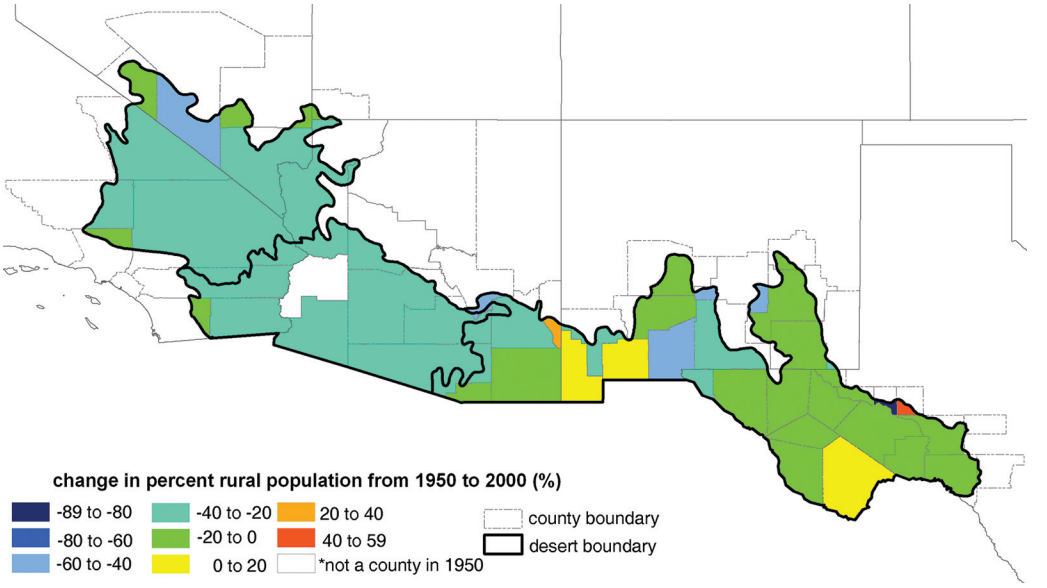

Fig. 5–9. Change in ecosystem goods and services through time: nonurban population as a percentage of the total for these counties in the southwestern United States between 1950 and 2000. (http://www.census.gov/)

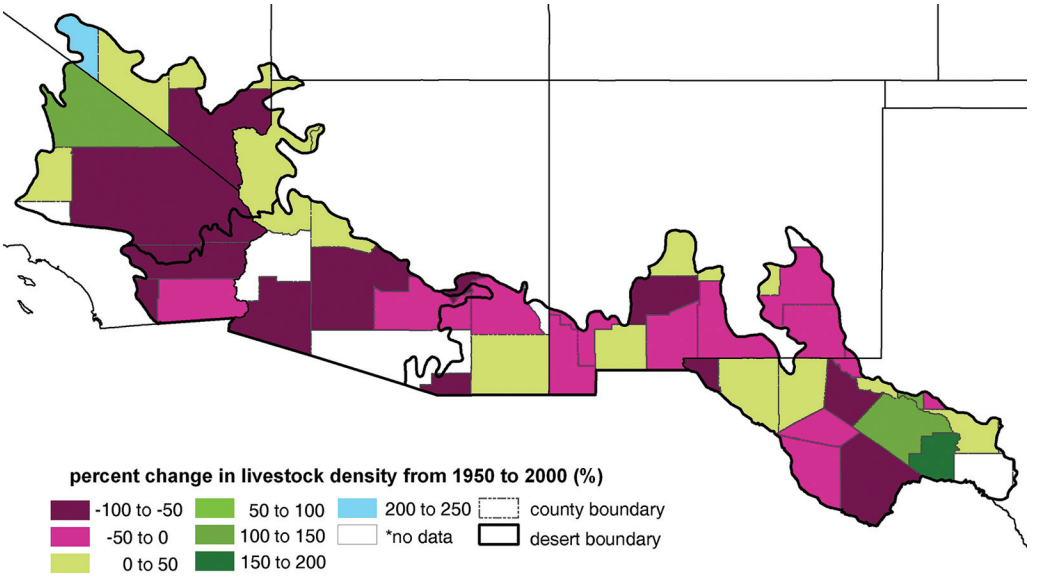

Fig. 5–10. Change in ecosystem goods and services through time: change in livestock numbers by county in the southwestern United States for U.S. Bureau of Land Management allotments or districts between 1950 and 2000.

THE SOUTHWEST: AN EXAMPLE OF ALTERED HUMAN LANDSCAPES IN THE 21ST CENTURY

Jin Yao, Debra Peters, and Kris Havstad

The population of the 11 contiguous western states grew by more than 46 million people from 1950 to 2000 and is expected to grow by an additional 20 million by 2025. These increases were particularly pronounced in the southwestern United States. For example, other than counties in western Texas, population increases for most counties across southern California, Arizona, and New Mexico were 200% or more since 1950 (see Fig. 5–7). This has resulted in a region that is now heavily urbanized (see Fig. 5–8).

This human dynamic has resulted in substantive changes in the demands placed on the rangelands in this region. For example, the reduction in the percentage of the rural population across the Southwest (Fig. 5–9) has occurred concurrently with a substantive reduction in livestock using federal rangelands (Fig. 5–10). Approximately 50% of the counties across the southwestern United States saw a reduction in livestock numbers over the past half-century, and many of these counties have less than half of the grazing livestock than they did in the first half of the 20th century. Analyses by the Economic Research Service of U.S. census data from 2000 indicated that many of these counties across the Southwest are no longer economically dependent on agriculture (http://ers.usda.gov/Data/TypologyCodes/). Many counties now depend on a service economy in support of recreational and/or retirement demands.

of the hot desert region is predicted to become more arid throughout the 21st century. Regional climate change models predict a reduction in precipitation of 0.004 inches (0.01 cm) per day by midcentury, a value similar to the Dust Bowl period between 1932 and 1939 (0.0036 inches [0.009 cm] per day). A reduction in precipitation combined with warmer temperatures will lead to rangelands with even lower productivity and vegetation cover, thus increasing the potential for erosion by wind and water and resulting in localized losses of nutrients, soil particles, and propagules. Efforts to revegetate disturbed areas will be even more challenging than currently faced. Increasing human population numbers will lead to greater demands for ecosystem services, particularly water and land, to be provided by natural systems. A collaborative environment of private landowners and managers of natural systems working with city, county, state, and federal planners at relevant watershed and larger landscape spatial scales will be required to meet these demands, yet maintain the integrity of natural systems.

Woodlands and Forests

Rex Pieper and Linda Joyce

The woodlands and forest region includes both the piñon–juniper (*Pinus–Juniperus*) woodlands (Fig. 5–11) and the widely dispersed forested lands of the western United States. Woodland vegetation is widely distributed in the West and is distinguished from more classically described forested land by the reduced height of the tree layer (30–50 ft. [9–15 m]).

Forested lands regarded as rangeland (Fig. 5–12) have often been synonymous with forestland that is grazed by livestock. These lands, at least periodically, produce sufficient understory vegetation suitable for forage that can be grazed without significantly impairing wood production and other forest values. These lands comprise nearly 20% of the total area grazed in the United States (about 145 million acres [59 million ha]). Reflecting the diversity of ecosystems and western topography, these forested rangelands are interspersed with meadows, high-elevation grasslands, riparian ecosystems, and, often, with piñon–juniper woodlands at their lower elevation margins.

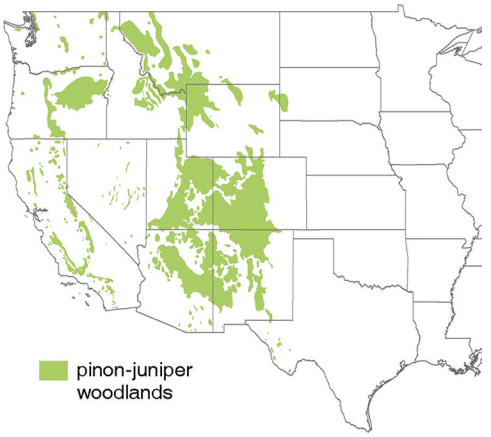

Fig. 5–11. Piñon–juniper woodlands.

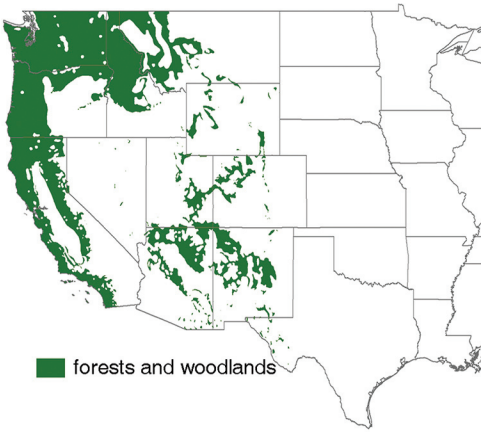

Fig. 5–12. Distribution of forested rangelands across the western United States.

Ecosystem Goods and Services

Livestock have grazed on piñon–juniper woodlands and forested lands since they were introduced into the western United States by early Spanish settlers in the 17th century. The traditional use of forested range for livestock grazing continues in most of the provinces throughout the West. Large areas of federal land (National Forest and U.S. Bureau of Land Management) are available for grazing through permits. Much of the National Forest land is at higher elevations, with private landholdings in the valleys. This historical land ownership pattern led to summer grazing on forested federal lands. Grazing numbers on federal lands have remained somewhat steady over the last 20 years. Environmental concerns about the legacy of overgrazing in parts of the West have resulted in close scrutiny of grazing management and the role of grazing in forested rangelands.

The woodlands and forests occupy large areas in the West; hence, they are important watersheds. Over much of the western forested ecosystems, precipitation comes primarily as snow, and this large snowpack is critical as a water resource for agriculture, energy, and human consumption. The snowpack provides much of the surface water for the demands of the population of the western United States living at lower elevations and may be the most important of all ecosystem goods and services in the region. Because many of these forested rangelands are public lands under the jurisdiction of the U.S. Bureau of Land Management, the U.S. Forest Service, or various state agencies, use of these areas is often intensely scrutinized. Many of these watersheds are managed under plans developed with intense involvement of local communities and public interest groups.

Clearly, western forested rangelands are relatively productive environments that support a wide diversity of habitats and species that in turn provide an array of goods and services. The recreational, hunting, fishing, and fuel wood goods and services provided by the national and state forest systems alone represent an annual multibillion dollar set of enterprises. These lands have become increasingly accessible in the past 60 years and are highly sought after destinations by urban, suburban, and exurban populations in the West.

Future of Woodlands and Forests

Historically, many western woodland and forested ecosystems were dependent on periodic fire to reset ecosystem dynamics. Prior timber management practices, drought, epidemic insect infestations, and catastrophic fire over a period of several years following the legacy of fire exclusion have resulted in conditions within these ecosystems that threaten the natural resources and associated social and economic systems. In addition, fire suppression has resulted in some ecosystem-type conversions with an increased density of trees on site and reduced understory vegetation and forage quality and quantity. These intense fire threats will continue to loom large across this

Photo by Sally King, National Park Service, U.S. Department of the Interior

region over the coming decades, and catastrophic fires should be anticipated as fuel loads will likely further increase.

Quaking aspen (*Populus tremuloides* Michx.) forests can be found throughout the western United States from Canada to Mexico. Aspen stands are valued for wildlife habitat, summer livestock forage, high recreational use during the early fall, and high understory biodiversity. As fire frequencies have declined within the aspen range and because this species sprouts vegetatively after fire, aspen has declined throughout the West. Aspen is typically found within a matrix of conifer species, and the loss of aspen often results in an increase in conifer species, with a decline in forage available for grazing. Estimates on the decline of aspen in the western United States suggest a loss of 60% of the area originally occupied by aspen before the mid–19th century. These losses will likely continue unless prescribed fires can be used as a management strategy. One major issue to be addressed in the future will be how to minimize burning impacts on resulting air quality.

The most significant change in forested range will be the continued expansion of residential development and associated changes in land use. Scenic parts of the western United States have become attractive for residential development, particularly for retirement or for individuals associated with high-tech professional industries that do not need to be physically located in metropolitan centers. Demand for housing has resulted in the subdivision of large ranches into much smaller parcels and a shift away from commercially raising livestock. The wildland–urban interface can be defined as the area where structures and other human developments meet or intermingle with undeveloped wildland. New housing units built in the United States are increasingly located within this interface. While found throughout the United States, the wildland–urban interface is particularly widespread in the eastern part of the country, but major areas are also located along the West Coast, the Colorado Front Range, southeast Texas, and the northern Great Lakes states.

The changes in infrastructure associated with the growing wildland–urban interface (including increases in road density and impervious surfaces) can alter or increase landscape fragmentation, alter ecosystem functions, and create opportunities for invasive species. These changes also may reduce wildlife habitat and affect management opportunities, such as prescribed fire use, within national forest lands. Increased expansion of the wildland–urban interface is likely to continue in the West. Associated with this expansion will be all of the resulting conflicts and confrontations

typical of an urban–wildland interaction. Expectations should be for increased human–wildlife confrontations, increased threat of native species and habitat losses, and the likely continued expansion of invasive species.

California Annual Grasslands

Barbara Allen-Diaz, James Bartolome, and Lynn Huntsinger

The California Annual Grassland occupies about 13.6 million acres (5.5 million ha), primarily in the foothills of the Central Valley and in coastal valleys (see Fig. 5–13. This region has three major subtypes: Inland Valley grassland, Coastal Prairie, and the Coast Range grassland. The original dominants of the California grassland were perennial grasses interspersed with native annual grasses and annual and perennial herbs, probably with a higher proportion of annuals in drier areas. Conversion of this grassland to an ecosystem dominated by non-native annuals began with the introduction of livestock, cultivation, and seed dispersal of annual plants of Mediterranean origin in the late 18th century. This introduction expanded dramatically with a series of severe droughts in the late 19th century. Plants from the Mediterranean region, mainly annual grasses, now dominate the Valley grassland. The Coastal Prairie grassland retains a greater proportion of native species but has also been invaded by both perennial and annual plants from the Old World. The Coast Range grassland is in some ways intermediate and is characterized by some native perennials mixed with native and introduced annuals.

California has one of the most rapidly growing human populations in the world: from less than 160,000 people in 1850, to more than 36 million people today, for an average annual rate of growth of 3.4% The population is projected to reach 63 million people in the next 50 years. The ecosystem goods and services available from California grasslands have changed dramatically over time, as the ecosystems, people, and industries of the state have changed. The grasslands have been valued as a source of sustenance and homesteading, for livestock forage, as real estate, and increasingly for a diverse array of tangible and intangible services.

Ecosystem Goods and Services

The grasslands harbor rich floristic diversity with 10 or more species per square yard not uncommon. There are altogether more than 500 grassland plant species, with many grassland-dependent wildlife species, including birds, lagomorphs, small mammals, carnivores, and reptiles. Grasslands are critical foraging grounds for raptors and numerous other species. While the state's water supply is largely generated in montane regions, most of it flows through grasslands and is augmented by overland flow and grassland seeps and springs.

Ranch owners have long been termed lifestyle "consumers," in that the ranching lifestyle and beautiful environment are ecosystem services supported by grasslands and consumed by ranchers, such that ranch land prices are well above agriculture production values. In recent decades,

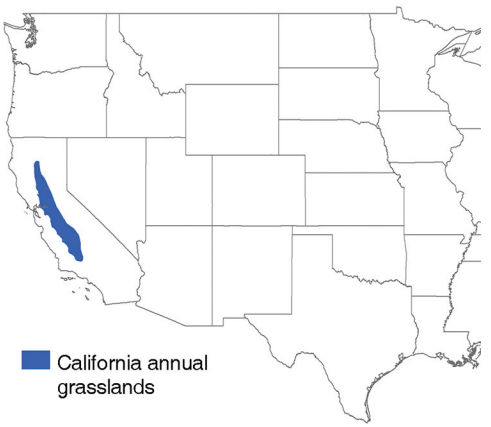

Fig. 5–13. Extent of the inland Valley grassland subtype of the California Annual Grasslands.

with the increasing popularity of ranchette-type developments, more of the grassland has been devoted to the grazing of horses and other recreational stock, as well as viewsheds, wildflowers, hiking, picnicking, mountain biking, and other recreational pursuits. On coastal grasslands, small-scale specialty dairy and niche meat operations have increased in number in response to consumer demand, often supported by the high productivity and long growing season typical of this environment.

Future of the California Annual Grassland

Most annual grasslands in California are privately owned. A growing phenomenon in California is ownership by land trusts to preserve public values of grasslands and related rangeland. The amount of land conserved by trusts through purchase, transfer, or easement increased by 147% between 1998 and 2003 and is now more than 1.4 million acres (0.6 million ha). Of this land, 300,000 acres (121,000) are protected by conservation easements. There are now at least 173 land trusts in California, more than in any other state.

Much of California's grassland has already been converted for agricultural purposes, and some agricultural industries continue to expand. The wine industry, for example, increased the acreage of its vineyards by 50% between 1991 and 2001.

While California climate models are highly variable with regard to precipitation, they all consistently predict warming. Even models based on lowered greenhouse gas emissions predict an increase in temperature. Average annual temperatures are expected to increase by anywhere from 3.1 to 10.4°F (1.7–5.8°C) between the years 2000 and 2100 based on different greenhouse gas emissions scenarios, with greater temperatures increases predicted in summer than in winter. Warmer temperatures are also expected to increase evaporation rates, resulting in drier conditions. These drier conditions are expected to increase the risk of large wildfires by 35% by 2050 under a moderate-level greenhouse gas emissions scenario. This model does not account for changes in wind patterns and extreme fire weather, so the risk could potentially be even higher.

MANAGEMENT TECHNOLOGIES AND CONSERVATION IN THE 21ST CENTURY

Jeff Herrick, Brandon Bestelmeyer, and Joel Brown

In general, conservation practices applied to rangeland have changed little over the past 60 years. For example, the fundamental principle of livestock grazing management remains the application of a proper stocking rate (number of animals per unit area per unit time) for a given environment, a principle recognized for over a century. The expectations of landowners and of society about the goods and services derived from rangelands have changed dramatically, however. Yet the inherently low and variable productivity of rangelands has greatly limited opportunities for both the development and the deployment of new technologies as a basis for conservation practices. Even though the emphasis has shifted across the western United States from production of food and fiber with grazing livestock to a more multiple-use approach that includes wildlife habitat, watershed conservation, and low-density development and open-space values, the component practices that make up management systems are largely unchanged.

In the past, relatively cheap fossil fuels heavily influenced economic analyses that justified both federally funded cost-share programs on private land and conservation initiatives on public land. As energy prices have steadily climbed, the benefits derived from the application of practices have failed to keep pace with the costs. The changing economics of energy-intensive conservation practices, such as mechanical and chemical vegetation manipulation, fencing, and water development (ponds and wells), and the emergence of a new concept of rangeland ecosystem behavior have dramatically altered our views of costs and benefits associated with conservation practice application. In addition, we now understand that effecting change on a landscape where ecological processes have changed drastically is extremely difficult, no matter what practices are used. Reversing changes in soils and vegetation that have occurred over decades and are being driven by global-, continental-, and regional-scale processes with one-time intensive application of expen-

sive technologies is increasingly viewed as a risky investment by both private- and public-sector land managers.

The basic suite of conservation practices typically used includes improvements of livestock distribution, brush management, application of prescribed fire, and erosion control and stream restoration. However, newer technologies also exist that allow managers to more effectively target practices to those areas where they are likely to have the biggest impact. These technologies allow managers to select the most appropriate combination of practices and to adapt these practices by monitoring data that reflect responses of fundamental ecosystem processes.

One key technology that provides this capacity for targeting is land classification. Numerous land classification systems have been developed on the basis of various combinations of climate, topography, soils, and historic, current, and potential vegetation. One of the most effective types of systems uses climate and relatively static soil profile properties to stratify rangeland based on its ability to produce particular types and amounts of vegetation. The Natural Resource Conservation Service (NRCS) originally developed these site potential-based units as *range sites*. At the end of the 20th century, this land use classification system now emphasizes ecological processes and properties. The basic land classification unit is an *ecological site*, defined as a distinctive kind of land with specific soil and physical characteristics that differs from other kinds of land in its ability to produce distinct kinds of vegetation and its responses to management. Descriptions of ecological sites are readily available through the NRCS Ecological Site Information System (http://esis.sc.egov.usda.gov/ESIS/). Conservation practices and management technologies need to be properly matched with the ecological capacities as characterized within an ecological site description. The ecological sites that comprise the landscape can then be managed on the basis of the particular state or status of that site at the time of management and what is potentially possible in the future for a particular ecological site. An approach based on knowledge of ecological sites ensures that any management application will be ecologically viable, the first step in working toward sustainable management of these rangelands. Clearly, rangeland management has increasingly become based on an ecological understanding of these landscapes, irrespective of the goods and services desired from a particular rangeland.

Technologies based on photographic or satellite imagery and global positioning also have an increased relevance for western rangeland management. High-resolution aerial photography can be used to rapidly detect general changes in vegetation composition and pattern across large areas that reflect rangeland status, or health. These remotely sensed indices of live vegetation generated from multispectral sensors on satellites and aircraft are already being used to guide short-term management. For example, one important index is the amount of bare ground, and remotely based sensors have the capacity to detect seasonal and interannual changes in bare ground. Earlier limitations to the application of remotely sensed data are being overcome through image analysis automation, integration of land classification information using GIS (geographic information system), and careful calibration using geolocated ground sampling points. However, high costs and training requirements and limited detectability of many soil and vegetation attributes by these sensors continue to limit their application. These limitations are being addressed and will likely be resolved in coming years.

These technologies increase the ability of managers to prioritize areas within a region for application of conservation practices and to select, apply, and adapt those practices. In the future, real-time or near real-time acquisition of monitoring data displayed in a geospatial format should increase the ability of managers to make short-term adjustments in land use to promote long-term changes in the capacity of rangelands to support multiple ecosystem services. Wireless technologies may eventually allow managers to adjust on-site management from remote locations. Given the complexity of rangelands and their responses to management, however, site-specific knowledge and experience will continue to be essential to successful applications of management technology.

Without doubt, the most influential conservation practice applied to rangelands in the past half-century is the large-scale conversion of marginal cropland to perennial vegetation cover in

conservation programs, especially the CRP. Of the total 36 million acres (15 million ha) enrolled in CRP from 1985 to 2007, approximately 25 million acres (10 million ha) are located in the 17 western states, primarily in the Great Plains. In many counties, more than one-third of the existing cropland was converted to perennial grasses through the CRP. In addition to the expected benefits of reducing wind and water erosion, substantial increases in wildlife habitat benefited a host of grassland birds and other species. In conjunction with a host of other land retirement and conservation easement programs, many conservation benefits have accrued from the CRP to both individuals and the public. These benefits may be lost if these lands are taken out of CRP and used again for agronomic production of grains or biofuels.

One dramatic sociological change in the past 20 years has been the emergence of public–private partnerships in the application of conservation practices and the emphasis on conservation easements as a means of preserving rangeland. Many relatively well funded nongovernmental organizations (NGOs) have established leadership in working with both public and private sector landowners over large spatial scales for extended time periods to achieve conservation objectives. The NGO leadership has prompted changes in government programs to increase opportunities for cooperative conservation across political and landownership boundaries that were previously unattainable.

Two movements in particular hold the potential to increase the effectiveness of rangeland conservation in assisting society as a whole to set and achieve rangeland conservation. Although landscape ecology as a discipline is well established, its application to conservation is only now being developed. In the near future, we expect an enhanced ability to observe, analyze, and predict changes in rangeland ecosystems in response to changes in climate and management. Similarly, advances in technology that can improve the effectiveness of existing conservation practices by appropriately targeting sites across a landscape can be expected to greatly reduce costs and increase benefits. Logically, these technologically based advances should result in an improved ability to manage rangelands if similar advances in social systems and policy development can be realized.

The potential of conservation science to contribute to the management of rangeland ecosystems is very promising. As new demands and markets form, rangeland management and the implementation of conservation practices can find new outlets as well as new incentives. However, the ability to realize this potential will depend almost exclusively on the ability of scientists to develop new concepts and technologies for prediction and measurement, the ability and willingness of rangeland managers to implement practices and pursue new objectives, and the willingness of policy makers to provide the incentives for creativity and risk taking that will best serve society.

SUMMARY

Western U.S. rangelands have provided important goods and services to the United States for nearly two centuries. The regions that characterize these lands are quite diverse, and they face distinct ecological challenges in the 21st century. The general ecological principles important to the management of these rangelands have not changed dramatically in the past 60 years, but today these landscapes must be managed not as a land type, as in the past, but as complex sociobiological systems. Even though the western United States is sparsely populated, its human population has grown tremendously over the last 50 years, it is primarily urban in nature, and it is placing greater demands on nonagricultural goods and services from these rangelands. These lands are now surrounded and imbedded within major urban populations and expanding exurban developments. In 1948, these lands were described in terms of what they could provide to human populations. Now, they are described in terms of how they are impacted by human activities. In fact, given the escalating impacts of humans across these landscapes over the past two centuries, it is appropriate to not just regard these rangelands as human-coupled but as strongly urban-influenced, if not human-dominated systems. The grasslands of the West described in the *Grass: 1948 Yearbook of Agriculture* (Stefferud, 1948) have become the urban watersheds and recreational areas of major cities of the United States. Although traditional agricultural enterprises, such as ranching, are still important, especially in the Great Plains, other enterprises such as recreation

and services in support of retired citizens are increasingly prominent throughout the West. Conservation of these rangeland resources will still require ecologically based management practices, as in the past, but technologies, applications, rationales, and justifications will be needed that are increasingly suited to a nonagricultural and urban public.

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