Carol Raish

Chapter 5:

Historic and Contemporary Land Use in Southwestern Grassland Ecosystems

Introduction

This chapter encompasses the lands of the Southwest as defined by Region 3 of the USDA Forest Service (USFS): Arizona, New Mexico, and portions of western Oklahoma and the Texas Panhandle. I examine human use and modification of the grasslands/rangelands of this region, with an emphasis on those areas managed by the Forest Service. Because the majority of publications serving as sources for this chapter use both "rangelands" and "grasslands" when referring to a variety of different grassland and rangeland vegetation types, this section does not distinguish between the terms. An exhaustive examination of all human uses and related topics and issues in Southwestern rangelands is well beyond the scope of this discussion; thus, a selective review of historical and contemporary topics is presented. The section begins with a review of continuous regional land use and modification from pre-Euro-American settlement (that is, American Indian times) to the present to serve as a background for understanding current land uses and land-use-related problems and issues. I then examine contemporary rangeland condition and the major human uses and activities affecting these lands, focusing on domestic livestock grazing, mineral extraction, and recreation. I conclude the chapter with a brief discussion of continuing and future trends in Southwestern rangelands and rangeland management.

American Indian (Pre-Euro-American Contact) Land Use

Paleoindian Period

The earliest undisputed evidence of human occupation of the Southwest began between 11,650 and 10,250 years ago. Archeological complexes from this period are referred to as Paleoindian and represent the remains of ancestral Native Americans from late Pleistocene times. These people were hunters and gatherers using both plant and animal food sources, under climatic conditions and vegetational patterns that were markedly different from those of today. Areas from which data have been obtained indicate that climatic conditions were generally wetter than present with less seasonal variation resulting in relatively mild winters and cool summers (discussed in Cordell 1997: 67-100).

Owing to the paucity of archeological remains from this period and to the fact that such remains are often deeply buried, interpretations of Paleoindian economic practices and resource use are sketchier and less well documented than those from later times. According to the most commonly accepted scenarios, relatively small groups of highly mobile hunters and gatherers exploited a variety of plants and animals, including Pleistocene megafauna such as mammoth (*Mammuthus columbi*), at least during the early portion of the period. In later Paleoindian times there was considerable reliance on

bison (*Bison* spp.), including a now extinct larger form (*Bison antiquus*), as well as on modern fauna. In the eastern Southern Plains portions of the study area extending from present-day eastern New Mexico into present-day Texas and Oklahoma, human groups relied heavily on hunting bison supplemented by smaller game and plant foods. Studies have shown that bison numbers and range expanded and contracted throughout the Holocene with expansion and contraction of the grasslands, tied to climatic fluctuations and available moisture. Because the Southern Plains and Southwest are generally drier than more northern areas of the Plains, reliance on bison hunting may not have been a productive strategy at all times during this period. Sufficient numbers of animals may not have been present during periods of grassland contraction (Cordell 1997: 95; Reher 1977).

On the western margins of the Plains and in the foothills and mountains adjacent to the Plains, there was apparently a fairly equal reliance on hunting and gathering. The role and importance of bison hunting in these areas fluctuated to an even greater degree as bison range expanded and contracted. Mountain sheep (*Ovis canadensis*) and mule deer (*Odocoileus hemionus*) were also present and hunted in about equal numbers to bison. In the more western portions of the region, human groups were dependent upon plant foods and relatively small, nonmigratory game (Cordell 1997: 90-100).

Especially on the Plains and in the areas adjacent to the Plains, human population growth was tied to the availability of bison and the grasslands to support them. Thus, to understand important questions concerning the timing and effects of increasing regional populations, additional paleoenvironmental reconstruction studies are needed to determine the expansion, contraction, and spread of grasslands during this period. Little is also known concerning human manipulation of the physical environment in Paleoindian times (Cordell 1997: 90-100), although use of fire has been mentioned as a means of moving game during hunting drives (Bahre 1995: 232-235). Clearly, additional archeological and archeoenvironmental research is needed for this period to clarify Paleoindinan resource use and environmental manipulation strategies.

Archaic Period

Around 7,500 years ago (5500 B.C.) the Paleoindian period gave way to what is referred to as the Archaic, lasting until about A.D. 200. From about A.D. 200 until Euro-American contact, agricultural groups of varying intensity occupied the diverse environments of the Southwest. During this period from approximately A.D. 200 until the mid-1500s, Southwestern climate and vegetation assumed essentially modern forms (Cordell 1997: 101-102). There was a gradual climatic warming and drying from around 7,000 to 5,000 years ago (5000 to 3000 B.C.). This warm and dry period was followed by a gradual increase in moisture with a corresponding increase in woodland and forest vegetation (Hall 1985, Periman and Kelly 2000). A cooler period followed from approximately A.D. 1450 until 1900, which is referred to as the Little Ice Age (Kreutz and others 1997, Periman and Kelly 2000). As a whole, this entire period has been marked by climatic variability with both broad-scale and periodic climate fluctuations (Periman and Kelly 2000).

During the Archaic, human groups continued to rely on hunting and gathering but with a greater focus on food plants and locally available resources. Hunted game were all modern forms (Cordell 1997: 101-102). Although subsistence patterns varied throughout the Southwest, some generalizations can be made. In many areas, people relied on uplands with high topographic and vegetational diversity, which allowed use of a wider range of resources in a smaller geographic area (Gunnerson 1987, Tainter and Tainter 1996). Grasslands were also favored resource procurement locales of Archaic foragers.

Archeological information from various locations, such as from sand dune sites in the San Juan Basin and from grassland sites in southeastern Arizona, indicates heavy reliance on the seeds of weedy plants and grasses. These include Indian ricegrass (*Oryzopsis hymenoides*), dropseed (*Sporobolus* spp.), goosefoot (*Chenopodium* spp.), pigweed (*Amaranthus* spp.), mustard (*Descurainia* spp.), tickseed (*Corispermum* spp.), and mallow (*Sphaeralcea* spp.). Both goosefoot and pigweed favor disturbed ground and may have thrived and/or been semicultivated in areas where humans camped repeatedly (Bahre 1995: 233; Cordell 1997: 120-121). Small, medium, and large-sized game were taken. Faunal remains from cave sites in the highlands along the central New Mexico-Arizona border include bison (*Bison bison*), pronghorn antelope (*Antilocapra americana*), mountain sheep (*Ovis canadensis*), and deer (*Odocoileus* spp.). Rabbit (*Leporidae*) and deer were found at Ventana Cave in the low Sonoran Desert of southern Arizona (Cordell 1997: 122).

Southern Plains groups were apparently not heavily dependent upon bison during the Early Archaic but were concentrating on deer, small mammals, and plants. By later portions of the Archaic, however, bison increase in the area's archeological sites (Cojeen 2000, Drass and Turner 1989: 20-22; Simpson and others 1998). Bison may become a more abundant and predictable resource in the later Archaic owing to improved shortgrass range brought about by wetter conditions (Cojeen 2000, Creel and others 1990).

Ranging from about 1500 B.C. to 1000 B.C. in the low deserts, central mountains, and northern plateaus of the Southwest, human groups began to cultivate

corn (*Zea mays*). However, they remained hunters and foragers with a mobile lifestyle for many hundreds of years thereafter, using corn and later beans (*Phaseolus* spp.) and squash (*Cucurbita* spp.) to varying degrees in their diets. Even with the considerable emphasis on agriculture found among many Southwestern groups immediately prior to Euro-American contact, wild foods always retained an important role in diet and survival (Cordell 1997: 147-151).

Puebloan and Other Agricultural Groups

Beginning around A.D. 200 and continuing until European contact and colonization in the mid-to-late 16th century, people became more sedentary and more committed to the production of agricultural crops. The widespread appearance of permanent dwellings, increasingly larger settlements, and ceramics are indicators of these trends. Subsistence patterns varied throughout the region depending upon both agricultural productivity and locally available wild resources (Cordell 1997: 221-224). Settlement locations also varied, most probably conditioned by both economic and defensive factors.

As dependence on agriculture increased, settlement location moved away from high eminences and upland areas to alluvial terraces and benches associated with major rivers and their tributaries, and to arroyos and intermittent watercourses in the Four Corners area, southern New Mexico, and southeastern Arizona. Agricultural occupations in south-central Arizona, however, were located on open flatlands without apparent defensive considerations from the beginning (Cordell 1997: 241). The Southwestern farming groups are ancestral to contemporary Native Americans in the region and included the Anasazi or Ancestral Puebloan of the Four Corners and Rio Grande areas; the Mogollon of southern New Mexico, southeastern Arizona, and northern Mexico; the Hohokam of south-central Arizona; and the Patayan of western Arizona (discussed in Periman and Kelly 2000).

In northeastern New Mexico, western Oklahoma, and the Texas Panhandle, groups of the Plains Village Tradition practiced hunting and gathering and grew corn along the creeks and watercourses of the region. Although agriculturally based, these groups are considered to have had a greater reliance upon hunting deer and bison than the Puebloan groups to the west (Fredine and others 1999). A mixed dependence on agriculture and bison hunting continued until around A.D. 1500 when agricultural groups were pushed south and west by incursions of nomadic Plains Apachean groups who were both raiding and trading with the Pueblos bordering the Plains (Fredine and others 1999, Glassow 1972). Migration of Plains agricultural groups as a result of increasingly drier climates has also been suggested, as has coalescing or amalgamating into preexisting nomadic cultures such as the Kiowa Apache (Baugh 1984, Cojeen 2000, Hughes 1991: 43; Simpson and others 1998). Continuity between prehistoric and protohistoric groups in the area continues to be a matter of debate (Cojeen 2000, Drass and Turner 1989: 28; Hughes 1991: 43).

As in earlier times, grasslands were used as sources of wild plant and animal foods. Bahre (1995: 234) concludes that although there is not a great deal of information concerning American Indian use of southeastern Arizona's grasslands, groups were known to collect vegetal foods from arborescent and succulent taxa in the Desert Grasslands and to harvest grass seeds in the Plains Grasslands (Huckell 1995). Especially favored were the seeds of big sacaton (*Sporobolus wrightii*) and browntop panicgrass (*Brachiaria fasciculate*) (Bahre 1995: 234; Doebley 1984). In describing animals hunted by Puebloan and other groups of the Middle Rio Grande, Scurlock indicates that bands of hunters journeyed to the Llano Estacado (plains of eastern New Mexico and western Texas) in the fall to hunt bison for both meat and hides (discussed in Scurlock 1998: 98).

In addition, bison ranged seasonally into the San Augustín Plains and the grasslands of northeastern Arizona in late prehistoric times. A herd was reported in the Chama Valley as late as 1690 (Callenbach 1996: 17-18; Scurlock 1998: 209). There was also considerable trade in raw materials and food stuffs among regional groups occupying the Puebloan areas and those areas farther to the east on the Plains proper (Scurlock 1998: 104-105). As mentioned previously, the resident Southern Plains groups focused heavily on both hunted and gathered grassland resources (Cojeen 2000, Fredine and others 1999, Simpson and others 1998).

Understanding Pre-Euro-American Contact Land Use

Understanding the role, extent, and importance of American Indian use and manipulation of Southwestern environments prior to Euro-American contact is critical for understanding contemporary land conditions, as well as the past "reference conditions" called for in studies of ecosystem management and restoration. Tainter and Tainter (1996: 28-29) recommend a combination of information derived from contemporary environmental sciences and social sciences with information derived from the historical sciences to elucidate past land use and management practices. Both ethnohistoric and archeological research into past environmental conditions and land use practices can provide valuable information. Periman and Kelly (2000: 27-28) discuss the role of archeological data in describing the impact of

Native American use on certain Southwestern riparian ecosystems in terms of reductions in tree cover from cutting roof timbers and firewood and from tree clearance for agricultural fields (Le Blanc 1985). Ongoing studies of changing landscape use in the Rio del Oso valley of northern New Mexico are providing both new information and new methodologies for determining past use and manipulation of riparian, woodland, and grassland ecosystems (Periman 2001).

These studies will make a timely contribution as information on prehistoric human use and manipulation of grassland ecosystems is sorely needed. Much of the available information (and more is needed) focuses on the use of fire by aboriginal peoples to manipulate their environment. According to Scurlock (1998: 201, 268-269), Native American groups in the Rio Grande Basin intentionally burned the grasslands periodically, which, along with lightning-caused fires, may have killed encroaching half shrubs and shrubs and stimulated vigorous growth of grasses. Although Baisan and Swetnam (1997) generally conclude that natural processes account for fire frequencies at most of their 60 study sites in Arizona and New Mexico, they suggest that fire frequencies at sites in the Manzanita and Sandia Mountains of the Rio Grande Valley during pre-Euro-American settlement times may have been influenced by human-caused ignitions. High fire frequencies prior to Euro-American settlement in these areas where lightning occurrence is low led them to the conclusion that American Indian groups were igniting fires for resource manipulation (Baisan and Swetnam 1997).

In discussions of southeastern Arizona, Bahre (1995: 234-235) concludes that the extent to which American Indian groups influenced grassland ecology is unknown but that the accidental or intentional introduction of fire to the grasslands may have contributed to their largely brush-free state at the time of Euro-American contact. However, the full role of fire in maintaining desert grasslands is unknown (Bahre 1991: 138-141; Dick-Peddie 1993: 106-107).

American Indians used fire to drive game, stimulate the growth of understory and food plants such as berries, clear areas for campsites and agriculture, and produce nutrient-rich ashes in fields (taken from a discussion in Scurlock 1998: 269). Indeed, Sullivan (1996: 145-156) argues that Western Puebloan groups on the Colorado Plateaus actively managed their habitats to increase production of wild resources such as Indian ricegrass, sunflower (*Helianthus* sp.), and goosefoot by controlled burning of the pinyon-juniper woodland. We look forward in the coming years to archeoenvironmental research that will help to clarify the past human role in maintenance and manipulation of pre-Euro-American contact North American ecosystems.

Contemporary American Indian Uses of National Forest Grassland Areas

Contemporary American Indian groups use Western grasslands, many of which occur on public land, in a variety of ways, including hunting, and gathering plant materials for food, medicines, and basketry. They also use these lands for grazing domesticated animals. The following brief review cannot do justice to the complex topic of Native American wild and domesticated plant use and its body of ethnobotanical literature. Especially important, detailed information on this topic can be found in the work and publications of Gary Nabhan (1985, 1989), founder of Native Seeds/Search. Nabhan has worked to gather and preserve seeds used in aboriginal agriculture and to document Native American gathering and farming practices in the Southwest in grasslands, as well as in the Sonoran Desert region.

In recent years, the Forest Service has collaborated with indigenous groups to learn from their traditional practices and to assist in assuring continued supplies of materials needed for economic pursuits and craft production. As examples, several forests in California have cooperated with Native American groups to identify and assure the continued propagation of plant materials such as the bear grass (*Nolina* spp.) used in basket making. Information on the use of bear grass and other grassland plants in the Southwest can be found in Bell and Castetter (1941).

The Hopi have worked with the Kaibab National Forest in northern Arizona to develop a comprehensive plan to manage pinyon-juniper woodlands and rangelands to protect cultural and spiritual values, while addressing concerns related to watersheds, soils, wildlife, recreation, range, and other resources (Thakali and Lesko 1998). The Apache, Navajo, and Hopi still collect plants from various meadows on the San Francisco Peaks, Coconino National Forest, Arizona, and the Hopi consider Bonito Park, by Sunset Crater, New Mexico, a Traditional Cultural Property (Pilles personal communication 2002).

The Tohono O'odham collect bear grass for basketry, and the San Carlos and White Mountain Apache gather medicinal herbs in grassland and mountain meadow areas of the Coronado National Forest in southern Arizona. The Mescalero Apache report collecting small amounts of coral beans (*Erythrina flabelliformis*) from the Chiricahua and Dragoon Mountains. The Coronado is currently working on draft memoranda of understanding with the Apache Tribes that would authorize collecting of small amounts of plants and acorns by Tribal members for personal use without permit. A potential conflict arises with the desire of some Tribal members to collect agave (*Agave* spp.) from the grasslands around Patagonia because agave is an important food source for the endangered long-nosed

bat (*Leptonycteris sanborni*) in some areas (Farrell personal communication 2002). Discussions of the role and importance of agave as a food and fiber source to Native American groups are presented in Castetter and others (1938) and Gentry (1998), among others.

Prehistorically the Wichita and Affiliated Tribes occupied areas of western Oklahoma, northern Texas, and northeastern New Mexico that now comprise the Kiowa and Rita Blanca National Grasslands and the Black Kettle and McClellan Creek National Grasslands. In the 1700s and 1800s, horse-using groups such as the Cheyenne, Arapaho, Apache, Comanche, and Kiowa entered the area as a result of territorial dislocations caused by encroaching Anglo-American settlement. There is, however, little information concerning whether these groups still use the area for traditional practices, although they may consider it a traditional use area and/or important in their Tribal history (Black Kettle and McClellan Creek National Grasslands Geographic Area Assessments 2000, Kiowa and Rita Blanca National Grasslands Geographic Area Assessments 1999). Research to address these issues is planned for the near future (Benedict personal communication 2001).

Hispanic and Post-European Contact American Indian Land Use

The Spanish were the first Europeans to enter the Southwestern areas of present-day Texas, New Mexico, and Arizona beginning in the late 1520s with the shipwrecked Álvar Núñez Cabeza de Vaca. Over a period of about 6 years, Cabeza de Vaca and several companions made their way from the Texas coast through parts of New Mexico and probably Arizona to finally rejoin their countrymen on the west coast of Mexico (Stephens and Holmes 1989, Stout and Faulk 1974, Udall 1995, Weber 1992). Further expeditions followed in search of the fabled wealth reported by Cabeza de Vaca. In 1540, Francisco Vásquez de Coronado led an expedition that covered portions of New Mexico, Arizona, and the Southern Plains, probably passing through parts of the Texas Panhandle and into present-day western Kansas. However, the expedition route onto the Plains remains the subject of considerable debate (Bahre 1995, Bolton 1949, Fredine and others 1999, Trimble 1989, Wildeman and Brock 2000).

New Mexico

Significant Spanish influence began with colonization of the Rio Grande valley in 1598 by Juan de Oñate, initiating both the political and biological conquest of the region. Although the exact numbers are debated, Oñate brought with him soldiers, colonists, priests, and Mexican Indian servants, along with cattle, sheep, goats, and horses (Baxter 1987, Hammond and Rey 1953(1), Wildeman and Brock 2000). The settlers introduced domesticated plants and animals, as well as new technologies, which altered the flora, fauna, and landscape of the Southwest as has occurred throughout the New World (Crosby 1972, Melville 1994).

Throughout the 1600s, the Pueblo Indian populations of the Rio Grande declined as a result of diseases introduced by Euro-American contact, warfare, famine caused by a series of severe droughts, and destruction of food stores by raids from nomadic Indian groups. As the Native American population declined, the tribute and labor requirements of the Spanish colonists became more onerous. These conditions, along with forced relocations and intensive religious mission programs, led to the Pueblo Revolt of 1680. During this rebellion, the majority of Spanish were forced out of the Upper Rio Grande for 12 years. They returned in the period from 1692 through 1696 when Diego de Vargas initiated and completed the reconquest of New Mexico for the Spanish Crown (Simmons 1979).

Even though Hispano populations rose throughout the 1700s, the significant population declines of the Puebloan groups left a sufficient amount of land for both groups to farm and ranch along the rivers of the region. After the reconquest, the economic, political, and religious systems of New Mexico were significantly different from the earlier systems. The new generation of Spanish colonists were accomplished agriculturalists and stock raisers who worked their own land and maintained relatively cordial relations with the Pueblo Indian groups as both used the land in similar ways (Simmons 1979).

During both the Spanish Colonial and Mexican periods (1598 through 1846), land use and ownership throughout the Southwest were confirmed by land grants from the Spanish Crown or Mexican government. Although land grants were of several types, community grants to a group of settlers in common were of particular importance for later resource conflicts in the area (Eastman and others 1971, Harper and others 1943). Within community grants, settlers received individually owned building sites and agricultural plots of irrigated land near the ditch or stream. The irrigated plots were often quite small, averaging from 5 to 10 acres (Van Ness 1987). The villagers also used the grant grazing lands, timber lands, and pastures communally (Eastman and others 1971). Because kinsmen often worked their fields cooperatively and herded their animals together, they were able to manage on the small-sized, scattered agricultural plots.

Throughout the Colonial period, a subsistence economy based in small villages prevailed along the Rio Grande and its tributaries. Information on the community of Cañones (Kutsche and Van Ness 1981,

Van Ness 1987) provides a good description of farming and ranching in the Hispano villages. Both animal and plant production were critical for the success of the mixed farming system, with sheep and goats the most important stock for food. Cattle were used to plow fields, thresh grain, transport produce, and manure fields. The community stock were individually owned but cooperatively grazed. They were moved into the higher elevation pastures during the spring and summer and returned to the village after the harvest to graze and manure the stubble fields (Kutsche and Van Ness 1981, Van Ness 1987).

Livestock numbers were modest for the first two centuries after colonization. Raids by nomadic Apache, Navajo, Ute, and Comanche limited range expansion, commerce, and trade (Clark 1987: 19-23; Van Ness 1987). Thus, economic production was for subsistence, not for competition in a commercial market. Sheep were more numerous than cattle and horses in the early years, primarily because of sale and loss of the latter to surrounding nomadic Indian groups (Gonzales 1969). By the early 1800s, the number of sheep began to increase as the Spanish population expanded eastward onto the plains around present-day Las Vegas, across the Sandia and Manzano Mountains, and westward from the Rio Grande Valley. This movement resulted from growing human and animal populations, a decline in raiding by the nomadic groups, and an expanded trade in wool and sheep during the Mexican period (1821 to 1846).

Sheep were the mainstay of the livestock economy of New Mexico until after U.S. takeover in 1848 (Beck 1962). Scurlock (1998: 116-117) reports 1 million sheep in New Mexico during the 1820s rising to 3 million by the mid-1800s with a reduction to approximately 377,000 by 1850. The reduction occurred as a result of Apache and Navajo raids and losses from drought, blizzards, and predators. During the first half of the 1800s, New Mexico supplied sheep to the West and to extensive mining operations in Mexico. Beck (1962) and Schickedanz (1980) state that annual sheep drives to Mexico often averaged 200,000 head between 1815 and 1830. Baxter (1987: 90-95) offers more conservative figures, listing some 240,000 sheep in the Albuquerque and Santa Fe areas in 1827, with a total of approximately 200,000 driven south to Mexico between 1835 and 1840. For example, about 80,000 were exported in 1835. In spite of the contradictory figures, sheep were an extremely important part of the economy throughout the period.

Sheep numbers also increased in the Navajo areas of northwestern New Mexico during the 1800s, so much so that some Navajos were described as wealthy by the time of the Mexican-American War (Brugge and Gerow 2000: 449-451). Scurlock (1998: 117) suggests that rising sheep numbers and Navajo practices of grazing outward from the hogan during the day and returning the animals to associated corrals at night may have initiated the first regional overgrazing west and north of the Puebloan and Hispanic settlements.

Herding sheep near Los Ojos, NM, in the 1990s. (Photo by Anne R. Baldwin)

Although concentrations of sheep and cattle near Hispano and Puebloan settlements created areas of resource overuse during Spanish Colonial times, herds were generally small, and there was abundant land (Baxter 1987: 23-24; Rothman 1989: 196-197; Scurlock 1995a: 15). Thus, relatively small populations of subsistence farmers successfully used the region's resources over the long period of Spanish control (Raish 2000a: 495). Overuse of favored areas intensified during the Mexican period as commercial sheep production increased (Scurlock 1995a: 15). By the end of the Mexican era, range deterioration was noted by American military personnel in some areas of the Rio Grande Valley, the Rio Puerco watershed, and on the Navajo lands higher up the Rio Puerco (discussed in Elson 1992, Scurlock 1998: 117). Nonetheless, the majority of farms and ranches remained small and subsistence oriented prior to U.S. conquest. On several visits to New Mexico in the 1830s, Josiah Gregg described the irrigation systems and subsistence orientation of agriculture in the small Hispano settlements, among his many other observations on the life and people of the area. He especially noted the fertility of the bottomlands in contrast to the barren condition of the unirrigated uplands (Gregg 1954: 104; Wozniak 1995: 34).

Arizona

To the west, Father Eusebio Kino is credited with establishing missions and bringing domesticated livestock and crops into southern Arizona beginning in the later 1600s (Bahre 1995: 235; Bolton 1919, Hadley and Sheridan 1995: 7-11), although domesticates may have reached the area earlier through trade with Spanish colonists to the east in the Rio Grande Valley (Bahre 1995: 235-236; Bolton 1952). At about this time, Apaches also entered the area warring with resident Piman groups and later with the Spanish. By 1740 Spanish settlers had begun ranching in the area, and by 1775 Tucson had been established.

Decreased hostilities with the Apaches after 1786 led more Hispanic ranchers and miners to enter the region, but their numbers remained small. According to Bahre (1995: 236-237), their activities appeared to have had little impact on the grasslands. Although livestock may have degraded rangelands adjacent to settlements as in the Rio Grande Valley, their numbers were small and their effect on regional grasslands was probably minimal. In 1804, the two largest settlements, Tucson and Tubac, reported a total of 4,500 cattle and 7,600 sheep. In addition, Tucson reported 1,200 horses (Bahre 1995: 236-237; McCarty 1976).

Although land grants have never played the role in rangeland use and management in Arizona that they have in New Mexico, there were a few Spanish land grants in southern Arizona, and Mexican stock-raising land grants were established in the grasslands of the San Pedro, San Rafael, and Santa Cruz Valleys of southeastern Arizona. Large numbers of cattle were reported on these ranches, but increased Apache raiding during the Mexican period drove off the majority of the ranchers by the mid-1800s (Bahre 1995: 237-240; Mattison 1946, Officer 1987, Ruyle and others 2000, discussed in Wildeman and Brock 2000: 5). Considerable numbers of livestock were also reported in the area of the Hopi villages in northeastern Arizona with one having 30,000 sheep in 1776 (Schickedanz 1980). Overall, both human populations and livestock numbers were low prior to the American period. According to Bahre (1995: 240), both Spanish and Mexican populations were concentrated in the upper Santa Cruz Valley, and the most significant human impact on the grasslands was probably the establishment of the large-scale Mexican ranches.

Bahre (1995: 238-240) provides a good listing of the several American military and scientific expeditions that passed through the region in the mid-1800s, and provides descriptions of the grasslands. He notes that many of them mentioned wild cattle on the abandoned Mexican land grants, but none provided written evidence of overgrazing. He says that the numbers of animals and their effects are not known and further states: "No doubt some grasslands were severely affected, but, given the descriptions of the lush grasslands in southeastern Arizona in the 1850s and 1860s, ranching during the Mexican occupation seems to have caused little long-lasting and extensive disturbance" (Bahre 1995: 240). Many Spanish and Mexican archival records remain to be examined for information on the southeastern Arizona grasslands.

Southern Plains

The Early Historic period on the Plains of eastern New Mexico was also characterized by continuing conflicts between nomadic American Indian groups and Hispanic settlers. Highly mobile Comanche and Apache groups following the bison herds raided and traded with more sedentary Pueblos and Hispanic villages to the west. Actual Spanish settlement in the area began in 1794 with the establishment of San Miguel del Bado, the first Hispanic village east of Pecos Pueblo. Throughout the Spanish and Mexican periods, various attempts were made to settle and use the Plains grasslands, but these were generally not long lived owing to raiding by the nomadic groups (Baxter 1987, Fredine and others1999, Sebastian and Levine 1989a,b).

Farther to the east on the Plains of western Oklahoma, Spanish explorers out of New Mexico encountered nomadic hunters and traders, as well as the ancestors of the historic Wichita with whom they fought a battle on the Red River in 1759 (Hays and others 1989, Hofman 1989, Simpson and others 1998). By 1800 the area was controlled by France and became

part of the United States with the Louisiana Purchase in 1803 (except for the Oklahoma Panhandle, which became part of Oklahoma Territory in 1890). The land was designated Indian Territory in 1804 (Burgess and others 1963, Cojeen 2000).

Other Resource Use

Other resource use activities during the Spanish and Mexican periods, such as trapping, mining, and logging, played less of a role in the grasslands than in other areas of the Southwest. Extensive beaver (*Castor canadensis*) trapping, first in New Mexico and then extending into Arizona, reached its peak in the 1820s and concluded by the late 1830s with the decline in popularity of the beaver hat. The large numbers of animals taken by the trappers caused severe reductions and extirpation of some local beaver populations leading to habitat degradation and decreasing water retention in streams and valleys (Scurlock 1998: 119-121, 155-158; Wildeman and Brock 2000: 5-6, 11).

Small-scale mining occurred during the Spanish period in both Arizona and New Mexico with the first large-scale mining venture in New Mexico beginning with the copper mines at Santa Rita in 1804 (Gregg 1954, Scurlock 1998: 118-119; Wildeman and Brock 2000: 6). The impacts of mining did not become significant until the American period, however. Extraction of mineral resources was slow in the area owing to the nature of the ores, the lack of transportation, and raiding by the Navajo, Apache, Comanche, and Ute (Hadley and Sheridan 1995: 46-47; Paul 1963, Wildeman and Brock 2000: 6).

Although large-scale commercial logging did not occur during the Spanish and Mexican periods, there was considerable use of pinyon (*Pinus edulis*), juniper (*Juniperus* spp.), ponderosa pine (*Pinus ponderosa*), and fir (*Abies* spp.) for construction and for fuel wood. Pinyon and juniper were the preferred fuel woods for both Hispanos and Native Americans leading to intensive exploitation of the woodlands around settlements. Scurlock (1998: 118) states that as more land grants were established in the plains and mesas of eastern New Mexico, local residents packed fuel wood back to population centers in the Rio Grande valley for sale (discussed in Scurlock 1998: 117-118). This practice may have had considerable effect on local vegetation. Research in southwestern New Mexico has shown that precontact Native American groups profoundly affected local vegetation, greatly reducing tree cover in riparian and other areas. Areas were cleared for agriculture, and wood was routinely harvested for fuel and construction timbers. As an example, before A.D. 1000 cottonwood was a common source of fuel wood and construction materials. This source of wood became depleted, however, and wood charcoal remains show that groups were being forced to go farther from communities and use upland trees as substitutes because cottonwoods were no longer available (Le Blanc 1985, Periman and Kelly 2000).

Environmental Manipulation

As in earlier times, both the American Indian and Hispano populations of the Southwest manipulated the environment to enhance production of desired resources. Fire was often the management tool of choice in these endeavors. In New Mexico, Hispano ranchers and farmers reportedly burned forests to create grazing lands and drive game. They also burned livestock pastures to stimulate new grass growth and burned sheep rangelands to kill encroaching woody species (Allen 1984, Scurlock 1998: 269).

Wildfires were relatively common in the grasslands of southeastern Arizona during Spanish and Mexican times, based on historical records and fire scar data (Bahre 1985, 1991, Dobyns 1981, Pyne 1982). Bahre (1995: 240) suggests that American Indian groups, mainly the Apache, were responsible for the burning but also states that the incidence of lightning-caused fires is so high in the area that the cause of the burning is difficult to determine. Continued research, both archival and archeological, is needed to understand the incidence and scope of these practices and their full effects on both past and present landscapes.

Anglo-American Land Use

The majority of the lands in the study area became part of the United States at the conclusion of the Mexican-American War (1846 through 1848). Western Oklahoma and the extreme southern portions of Arizona and New Mexico were acquired with the Louisiana (1803) and Gadsden (1853) Purchases, respectively. The Oklahoma Panhandle and the eastern portion of New Mexico were part of disputed lands claimed by both Texas and Mexico. With the end of the war, these lands went to Texas and were turned over to the Federal government in 1850.

Changing Patterns of Land Ownership and Use

Annexation of the region ultimately led to changes in both landownership and patterns of range use especially in New Mexico. Differences in American and Spanish land laws combined with unscrupulous land speculation resulted in the loss of over 80 percent of the Spanish and Mexican land grants by their original owners (Eastman and others 1971, Harper and others 1943, Westphall 1965). Under the Treaty of Guadalupe Hidalgo, the United States was supposed to recognize and respect the property rights of the landowners of the region.

To obtain sound titles according to U.S. law, however, land grantees had to petition for title confirmation, at first through the Surveyor General to the Congress and after 1891 to the Court of Private Land Claims (Eastman and others 1971, Eastman and Gray 1987). To accomplish this, claimants usually had to hire an attorney, file their claim, and obtain necessary supporting documents. Eastman (1991: 103) notes, "...landholders were turned into claimants who had to incur a substantial expense to have their property respected." Money was scarce in the subsistence economy of New Mexico, so many claimants signed over portions of their land as payment for legal fees. Because of this, even successful claimants lost land since the legal fees often amounted to from one-third to one-half of the land involved (Eastman 1991: 103). Additionally, many land claims were rejected; about 24 percent of the acres claimed in New Mexico were confirmed compared to about 73 percent in California (Ebright 1987: 33). Lands from unconfirmed claims became part of the public domain.

The Surveyor General and the Court of Private Land Claims did not confirm grants for a variety of reasons. Boundaries were sometimes vague, original titles may have been lost, and communal ownership of pasture and woodlands did not conform to 19th century American ideas of private ownership (Eastman and others 1971). The court often confirmed house lands and irrigated plots but did not confirm community pastures, surrounding rangelands, and woodlands that had always provided the Hispano villagers with their primary grazing and fuel wood resources. Villagers also lost confirmed land because they could not pay property taxes under the American system of monetary tax payments.

There was also during this time considerable unscrupulous land speculation, which took advantage of many Hispanic farmers who did not speak English and did not understand the American legal system (de Buys 1985 personal communiction). Large parcels of land were bought and sold by outside investors, often depriving families of land they had occupied for generations. These losses were a source of bitterness throughout the region—a bitterness that has surfaced periodically since U.S. annexation and came to a head in the land grant movement of the1960s (Gardner 1970, Knowlton 1967, 1980, 1985, Rosenbaum 1981, Schlesinger 1971).

Large-Scale Commercial Livestock Ranching of the Mid to Late 1800s

Other forces of change were also at work during this time as the economy changed from subsistence to commercial orientation, and the population of the territory grew tremendously with in-migration from the United States. Many of these immigrants brought considerable amounts of capital for investment in large-scale operations and a 19th century, entrepreneurial resource utilization ethic focused on maximum harvest for maximum profit (Scurlock 1995b: 2). To add to the climate of growth and development, Federal and Territorial legislation promoted intensive use of the environment (McCormick 1865, Scurlock 1995b: 2). Detailed discussions of this legislation are beyond the scope of this chapter but can be found in Clark (1987), Scurlock (1998), and Donahue (1999), for example.

These growth and development factors, combined with expanding markets opened by the development of military bases and the entrance of the railroad into Arizona and New Mexico in the 1870s and early 1880s, as well as the final subjugation of the nomadic Indian groups, led to rapid increases in large, commercial ranching operations (Bailey 1994, 1998). These operations often displaced the older, subsistence farms and ranches of the Hispano villagers. Commercial farming, timbering, and mining also flourished (Harper and others 1943: 48; Rothman 1989: 192-204; Wildeman and Brock 2000: 17).

Prior to the Civil War, substantial numbers of sheep and cattle were driven to the gold mining camps of California from the Southwest. Between 1852 and 1860 more than 550,000 sheep were trailed from New Mexico (Bailey and Bailey 1986), with an estimated 15,000 to 20,000 head of cattle driven from Texas through southern Arizona in the peak year of 1854 (Hadley and Sheridan 1995, Wildeman and Brock 2000: 13). The Civil War disrupted ranching operations and put an end to these drives, as ranchers left to fight in the war and Native American raiding increased with soldiers occupied elsewhere. By the end of the war, there were extremely large herds of free-ranging cattle in Texas from ranches that had been abandoned during the war. There were markets for these animals both in the North and in the West with the reestablishment of military posts and American Indian reservations (Wildeman and Brock 2000: 15-16).

Thus began the period of cattle drives out of Texas lasting from 1866 to 1880. During this time an estimated 10 million to 12 million animals were driven out of Texas, often through New Mexico and Arizona. This period also saw the decimation of the Plains bison herds between 1868 and 1881 (Schickedanz 1980). The herds were slaughtered for both economic and political reasons. Their decimation caused intense retaliation by the Plains Indian Tribes, who were ultimately subjugated by the U.S. Army. What had been bison range became cattle range, leading to the westward spread of the livestock industry and its full development in the Southwest (Wildeman and Brock 2000: 16-17).

Although there are conflicting livestock numbers, the cattle industry in Arizona grew from an estimated 5,000

Corral on the road to Gallina, NM, 1993. (Photo by Alice M. McSweeney)

animals in 1870 to around 200,000 in 1872. By 1891 various authors report cattle numbers ranging from over 980,000 to 1.5 million (Antle 1992, Ferguson and Ferguson 1983, Peplow 1958, discussed in Wildeman and Brock 2000: 18), in addition to an estimated 700,000 sheep brought into the State from New Mexico and California. In 1870, some 17,000 sheep were reported for the State. This growth was fueled by an extremely large flow of capital into the area, primarily from nonlocal investors (Bailey and Bailey 1986, Wildeman and Brock 2000: 18).

The livestock industry in New Mexico grew in the same way, with the entry of large numbers of animals into the area fueled by financial investment from outside the region. Extremely large numbers of both sheep and cattle were put on the rangelands with more than 1.5 million sheep in 1870 rising to 4 million or 5 million in 1883. In addition to the sheep, there were an estimated 250,000 cattle (Bailey and Bailey 1986, Schickedanz 1980). Rangeland use in both Arizona and New Mexico reached its peak in the late 1880s to early 1890s with almost 9 million animal units (AU) in New Mexico and 4.5 million in Arizona (Bailey and Bailey 1986, Wildeman and Brock 2000: 19).

Land Degradation and Reform Legislation

The land could not sustain the large number of animals being grazed in the attempt to achieve maximum economic gain. In the Southwest, the cattle population crashed after severe drought in the summers of 1891 and 1892. Severe ecosystem degradation resulted from several interacting factors including overstocking of rangelands, decrease of herbaceous plant cover, drought, suppression of natural fires, and removal of beaver along streams by trapping earlier in the century (Tellman and others 1997, Wildeman and Brock 2000: 19-20). Heavy stocking of the rangelands stressed native grasses, leading to decreased cover and root depth. In addition, some of the Southwestern grasses may have had less resistance to grazing than plains grasses that evolved with grazing by bison (Hyder 1972, Loftin and others 2000). Fire suppression, which became a major factor early in the 20th century, in combination with reduced plant cover from grazing, allowed woody shrubs and plants with low grazing preference to increase across the landscape. The combination of drought and overgrazing led to soil cover loss from wind and water erosion (Wildeman and Brock 2000: 20).

An example from the Pajarito Plateau west of Santa Fe discussed in Raish (2000b: 287) can help to illustrate the environmental and social consequences of commercial development that resulted in overstocking and subsequent environmental damage. Throughout the 1800s, local Hispanic and Pueblo residents of the area used the plateau as common property. They brought small herds to the plateau for summer grazing, harvested timber for personal use and small-scale ventures, and planted occasional summer crops. They were not attempting to maximize profit by developing large herds because for much of the period there was limited access to commercial markets. The small size and noncommercial nature of these operations ensured that sufficient grass and fuel wood were available for those who needed them (Rothman 1989: 192-194).

During the livestock boom period in 1885, a commercial Texas cattle operation leased a large amount of land on the plateau and brought in 3,000 head of cattle. The area could probably support around 300, according to modern calculations. This large operation drove off the small-scale Hispanic and Puebloan operations that had used the area for many years, as the resources were simply not sufficient to provide for both commercial and subsistence economies simultaneously. The large Texas enterprise failed after the severe winter of 1886 to 1887, and the small, local operators returned with their herds. However, the considerable overstocking had caused long-lasting damage to the resources of the plateau (Rothman 1989: 200-204). Rothman (1989: 202) notes:

> In an arid marginal region, the impact of comprehensive overgrazing persists for generations. Ecological climax communities in arid areas like the Pajarito Plateau take hundreds of years to mature. Because its soils were fragile, thin, and highly erodible, the removal of first-growth cover by overstocking precluded the slow process of natural recovery.

This damage was increased by commercial timber operations that began after the failed cattle business. Small-scale timber and personal-use fuel wood harvest was replaced by clear-cutting on large areas of the plateau. The combined effects of the commercial cattle and timber enterprises damaged the native grasses and removed much of the old-growth timber. Destruction of the grass cover and the spread of less palatable plants affected the subsistence of the local people, forcing them to pasture their animals farther away and compete among themselves for increasingly poor range (Rothman 1989: 203-204). This small vignette was repeated throughout the Southwest with effects lasting to the present day.

To deal with such problems of land degradation and resource overexploitation throughout the West, the direction of Federal legislation changed from promotion of intensive resource use to promotion of resource conservation. Scurlock (1998: 331-384) provides a detailed review of the development and implementation of conservation legislation and the resulting Federal land management agencies and programs. In brief, first attempts to deal with resource conditions occurred with creation of Forest Reserves from public domain lands in 1891 during the presidency of Benjamin Harrison. He set aside more than 13 million acres, and President Grover Cleveland reserved another 21 million acres during his time in office. President Theodore Roosevelt added over 16 million acres (Ferguson and Ferguson 1983, Steen 1976: 22-46). In 1905 President Roosevelt signed the bill transferring the Forest Reserves to the Department of Agriculture, and in July of that year the Bureau of Forestry was renamed the United States Forest Service (Steen 1976: 74-75). In 1906 fees were charged for grazing on Forest Service land. By 1908, there were 21 Forests in Forest Service District 3, which would become the 11 National Forests of contemporary Region 3 (Tucker 1989: 1-2, 68). Tucker (1989, 1992) provides an excellent discussion, personal interviews with early day Forest Service employees, and general sources of information on the development and early days of the Forests of Region 3.

The National Grasslands administered by Region 3 in eastern New Mexico, the Panhandles of Texas and Oklahoma, and western Oklahoma had a somewhat different history. Between 1900 and 1930 increasing numbers of farmers settled in the area as higher than normal rainfall levels and high wheat prices encouraged local farmers to move from stock raising and planting a variety of crops to a single cropping system. As grasslands were plowed under, the ground surface became destabilized and susceptible to erosion. In the 1930s, drought and dust storms hit the area prompting the Federal government to attempt to restore Dust Bowl areas to grassland (Bonnifield 1979, Cojeen 2000, Fredine and others 1999, Lewis 1989, Simpson and others 1998).

Much land reverted to the government during this period owing to foreclosures and sale incentives. In 1934, Congress passed the Taylor Grazing Act, which established the U.S. Grazing Service within the Department of the Interior to rehabilitate overgrazed and eroded lands and manage grazing on public lands. Under this act the bulk of unappropriated grassland was closed to further settlement. In 1946 the Grazing Service merged with the General Land Office to form the Bureau of Land Management. From 1938 until the early 1950s the Soil Conservation Service assumed responsibility for restoring grasslands in the areas under discussion. In 1953, the Forest Service took over responsibility for managing what became the Kiowa, Rita Blanca, and Black Kettle National Grasslands (Bonnifield 1979, Cojeen 2000, Fredine and others 1999, Lewis 1989, Simpson and others 1998).

Forest Service Response to Rangeland Degradation

The 20th century Forest Service response to issues of grassland condition and overutilization has been discussed in various publications and reports going back to and preceding Aldo Leopold in 1924 and *The Story of the Range* in 1926 (see for example Alexander 1997, Barnes 1926, Leopold 1924, Roberts 1963, Robinson 1975, Rowley 1985, Scurlock 1998, Steen 1976). Concerning the condition of lands that became part of the National Forest system, Robinnson (1975: 199) states:

> So long as the forests were part of the public domain, their access and use [were] virtually unrestricted. As a consequence, many of the lands were heavily overgrazed…When management responsibility was transferred to the Forest Service, regulation of grazing, through a system of permits and grazing fees, was established as one of the first and foremost management tasks.

In the West, where much rangeland is Federally owned and ranchers are heavily dependent upon public land for grazing, most grazing permits are issued for 10 years. This term provides greater security for the rancher than do annual permits, which are more common in the East and South where much more land is privately owned (Robinson 1975: 200). Since agency establishment, regulation of livestock grazing on National Forest land has been a compromise, although an often contentious one, between the interests of the livestock industry, the range management goals of the Forest Service, and, more recently, the preservation/protection concerns of the environmental movement.

Research on rangeland condition has been ongoing in the Forest Service since the early years of the agency and its predecessors with the development of the section of Special Investigations in the first year of Gifford Pinchot's tenure at the Bureau of Forestry. By 1902, the section had become a division, and by 1908 the Fort Valley Experiment Station, with Gus Pearson as Director, was established in northern Arizona (Steen 1998: 5-8). In 1915, the Branch of Research was officially established, and by the end of the 1920s, 12 regional Research Stations were operating (Steen 1976: 131-137). In 1915, the Santa Rita and Jornada Experimental Ranges in Arizona and New Mexico were transferred to the Forest Service from the Bureau of Plant Industry, with the research goals of restoring, improving, and maintaining basic range resources and obtaining the greatest returns on livestock (Steen 1998: 17). Medina (1996) has provided a comprehensive annotated bibliography of the work of the Santa Rita Experimental Range.

Early and continuing issues of major concern between the Forest Service and the livestock industry included grazing fees and regulations surrounding issuance of grazing permits, including their duration, use limits, and transferability (Robinson 1975: 209-214). These issues are discussed in detail by Robinson (1975), Rowley (1985), and Steen (1976), among others, and will not be reviewed here. Of great concern to the agency (throughout the early years of the 20th century and continuing to the present) have been improving the condition of and/or restoring Western grasslands and rangelands. As Robinson (1975: 202) notes: "The task of surveying the range and adjudicating individual permits to conform with range capacity began in 1910. Sixty years later it is still unfinished, and range improvement continues to be a major concern of management."

Suffice it to say that the condition and sustainability of the region's rangelands remains an issue of concern and considerable philosophical debate today among not only land managers but also among many concerned groups.

Over the years, the Forest Service and other land management agencies have undertaken range improvement practices using a variety of techniques including reducing stocking levels, shortening grazing seasons (postponing entry into allotments), implementing specialized grazing systems (discussed in greater detail in following sections), and emphasizing range improvements by permittees such as development of waters and fencing (Alexander 1997: 179-194; Robinson 1975: 202). Additional programs, some of which are considered controversial by today's standards, were also implemented in the region. According to Bahre (1995: 247), the contemporary grassland landscape of southeastern Arizona resulted from many Forest Service and BLM practices designed to protect watersheds and improve the livestock industry. Some of these included contour plowing, fencing, using specialized grazing systems, prescribed burning, suppressing fire, controlling woody plants with herbicides, introducing nonnative forage plants, constructing check and spreader dams, and controlling weeds, as well as chaining and bulldozing pinyon (*Pinus edulis*), juniper (*Juniperus* spp.), mesquite (*Prosopsis* spp.), and oak (*Quercus* spp.).

Often, agency-mandated improvement programs met with varying degrees of resistance from user groups and the livestock industry. An example from the forests of northern New Mexico is instructive in this regard, highlighting the tension between traditional use practices and Federally mandated management programs. In this part of the region, loss of land grant lands limits the grazing areas open to small, local communities, many of which are now surrounded by National Forest (Van Ness 1987: 201). In 1938 a Forest Service report estimated that demand for grazing on portions of the Carson and Santa Fe National Forests exceeded potential by 111 percent (Hassell 1968: 12). In the late 1960s, estimates showed grazing

obligations on the two Forests for 21,637 cattle and 32,203 sheep, compared to an estimated capacity of 14,370 cattle and 25,237 sheep. Over the years the agency attempted to deal with these discrepancies using a variety of techniques.

Beginning in the 1920s and continuing into the 1960s, livestock ranching on the two Forests changed as the economy changed and the Forest Service implemented range improvement programs (de Buys 1985: 247-249). There was a steady decline in both the number of permittees and the number of animals, from 2,200 permits in 1940 to fewer than 1,000 in 1970. For example, the permittees of the village of Canjilon who grazed animals on the Carson lost permits for 1,000 cattle over a period of a few years (de Buys 1985: 247-259). Free-use permits, issued for animals used in household operation such as milk cows and draft horses, were completely phased out by 1980.

Also during this period, there was a major change in the kinds of animals being grazed, with large declines in sheep and goats under permit. By 1980, there were no goats on either Forest and no sheep on the Santa Fe (de Buys 1985: 247-248; Van Ness 1987: 202). These changes occurred both as a result of Forest Service direction and as a result of changes brought about by the switch from a subsistence-based to a cash-based economy. Land losses and cutbacks in herd size undoubtedly pushed many people into the cash-based economy of wage work. Although there were important rangeland health issues that required treatment, these changes seriously impacted the livelihoods of many villagers who had ranched and farmed in northern New Mexico for generations prior to U.S. conquest. These losses have contributed to resentment of and protest against the Forest Service that continues to the present day.

Today, Federal agency grassland/rangeland management is critiqued by both user groups and the organized environmental community (for example, see Donahue 1999 for an argument against livestock grazing on arid and semiarid Western public lands). In recent years, Region 3 has been increasingly involved in appeals and lawsuits related to efforts to align livestock grazing activities with Federal environmental statutes such as the National Environmental Policy Act (NEPA), National Forest Management Act (NFMA), and the Endangered Species Act (ESA). Under NEPA, environmental assessments are required for issuing and reissuing grazing permits to determine if livestock grazing is an appropriate and suitable use of the land (Recision Act of 1995, PL 104, Section 504). In an example of this type of analysis, the Black Kettle National Grassland has produced an environmental assessment of livestock grazing and associated vegetation management, which includes all 114 rangeland units of the grassland (Black Kettle and McClellan Creek National Grasslands Geographic Area Assessments 2000). The role and impact of environmental legislation and efforts at mediation and conflict resolution on the management and sustainability of grassland areas will be discussed in greater detail in following sections of this chapter.

The following portions of this chapter also briefly discuss the current condition of rangeland vegetation resulting from human uses, which are primarily ranching/grazing by domesticated livestock followed by recreation and mineral extraction. Certain effects of recreation and mineral extraction on wildlife are also presented. Rangeland/grassland condition and the effects of grazing on wildlife in general and on threatened, endangered, and sensitive species in particular are examined in detail in volume 2 of this report.

The effects of livestock grazing and recreational use on archeological sites of varying types are taken into consideration in environmental assessments and must be considered in issuing and reissuing grazing permits. Several studies have examined the damaging effects of trampling and rubbing (against the walls of standing structures) by both domesticated livestock and wild ungulates such as elk; other ongoing problems are human visitors' trampling, leaning, or sitting on walls, or removal of artifacts (Gifford-Gonzalez and others 1985, Knudson 1979, Osborn and others1987). Rubbing or leaning against fragile walls can lead to their collapse. Fencing off standing structures in grazing allotments has been used as a means of excluding domesticated animals from the structures. Trampling can damage sites and interfere with their correct interpretation by reducing artifact size through breakage and by displacing artifacts from their original positions. Adding additional fractures to chipped stone tools can obscure interpretations of functionality and production technique. This type of damage primarily affects surface artifact scatters of ceramics and chipped stone but can also affect buried deposits near the surface (Osborn and others1987).

Contemporary Condition of Federal and Non-Federal Rangelands

Despite improvements in the condition of many grasslands since the early years of the 20th century, significant issues remain to be addressed. Land use and management activities such as domesticated livestock grazing, fire suppression, agriculture, and urban/suburban development impact the grasslands of the region as do the expansion of woodlands and the introduction of nonnative plant species (Bahre 1995: 243-255; Mitchell 2000). Mitchell (2000) reviews these issues for the entire United States, as well as for the region. The following discussion is primarily

drawn from his work, with other sources cited where appropriate.

Information from the National Resource Inventory (NRI) conducted on non-Federal lands by the Natural Resources Conservation Service (NRCS) in 1982 and 1992, including an unpublished supplemental study conducted in 1992, is used to characterize rangeland condition on non-Federal lands during the late 20th century (USDA Natural Resources Conservation Service 1995, USDA Soil Conservation Service 1987, 1990). The assessments use a species composition model (estimated on a biomass basis and compared to a typical "climax" plant community for the site) to evaluate range condition (Dyksterhuis 1949, Mitchell 2000: 28).

Mitchell (2000: 27-28) discusses problems with this classificatory scheme and reviews the scientific advances in understanding rangeland condition of the past 25 years as follows. Earlier concepts of range condition were based on the Clementsian equilibrium theory of retrogression produced by overgrazing, and by secondary succession to a stable climax after removing the disturbance caused by grazing (Dyksterhuis 1949 discussed in Mitchell 2000). Rangeland condition was divided into four classes: excellent (rangeland in a near climax condition with 76 to 100 percent remaining climax), good (rangeland in a late successional stage with 51 to 75 percent remaining climax), fair (rangeland in a midsuccessional stage with 26 to 50 percent remaining climax), and poor (rangeland in an early seral stage with 0 to 25 percent remaining climax) (discussed in Holechek and others 1998). Many range managers now use the terms climax (or Potential Natural Community, PNC), late seral, mid-seral, and early seral to replace the terms excellent, good, fair, and poor, distinguishing range ecological condition from how well existing vegetation may be suited for specific uses such as grazing by domesticated animals (Holechek and others 1998). Tables 5-1 and 5-2 show use of these classifications.

U.S. land management agencies have maintained these classification schemes in inventory and assessment programs although scientific evidence has challenged the Clementsian theory of succession (discussed in Mitchell 2000). Work by Westoby and others (1989) set forth an alternate hypothesis for nonequilibrium vegetation dynamics on disturbed rangelands. In addition, the view that ecosystem behavior under stress should be described only in terms of vegetation responses has been questioned by ecologists from various disciplines (Rapport and others 1985). Joyce (1993) has summarized the changes in the conception of range condition from a prior simplistic model to the current changing, complex situation (discussed in Mitchell 2000).

In 1994, the Committee on Rangeland Classification proposed a new paradigm for assessing rangeland conditions based on several years of review and study. This assessment paradigm is based on nonequilibrium, state-and-transition models of succession, focusing on ecosystem function rather than state or plant community composition. Three major criteria of ecosystem function are soil stability and watershed function, distribution of nutrient cycling and energy flow, and recovery mechanisms (Committee on Rangeland Classification 1994). The Society for Range Management also assembled a Task Group on Unity in Concepts and Terminology (1995) that called for making sustainability—defined in terms of maintaining soil productivity—the fundamental goal of range management. Unfortunately, these advances have not yet been incorporated into national data sets. Thus, the older classificatory system is used in Mitchell's review and discussion (2000).

Table 5-1 shows the condition of non-Federal rangelands in Arizona, New Mexico, Oklahoma, and Texas in both 1982 and 1992. Arizona and New Mexico have slight improvements (defined as increases in excellent and good condition classes) over the 10-year period, while Oklahoma shows greater improvement. Texas, on the other hand, has virtually no improvement, and according to Mitchell (2000: 30), the non-Federal rangelands of Texas are more degraded than those of any other Great Plains State. Since less than 2 percent of Texas ranges are Federal, these condition estimates essentially cover the entire State (USDI Bureau of Land Management 1997).

Federal ranges of the area include lands managed by the BLM and the Forest Service. Discussing their condition is complicated because the two agencies report condition in different terms. The BLM currently uses the Ecological Site Inventory (ESI) procedure (USDA Soil Conservation Service 1976, USDI Bureau of Land Management 1984), and the Forest Service assesses the condition of rangeland vegetation in terms of established Forest Plan Management Objectives (FPMO). Uplands and riparian range areas are described separately by both agencies. Mitchell (2000: 33) is critical of the Forest Service evaluation system, observing that many National Forests are operating under plans approved in the 1980s, "…and the elements relating to rangeland health are not well correlated to trends in indicators judged to be relevant by contemporary standards" (Committee on Rangeland Classification 1994).

Table 5-2 gives information on the condition of upland BLM rangelands in Arizona and New Mexico in 1986 and 1996. There are but a few hectares in Oklahoma and none in Texas. Both Arizona and New Mexico have increases in areas with late seral

Table 5-1. Condition of non-Federal rangelands in Arizona, New Mexico, Oklahoma, and Texas, 1982 and 1992, from the National Resource Inventory (adapted from Mitchell 2000: 29, 31, table 3.2 and 3.6).

		Year			
State	**Condition class**	**1982**		**1992**	
Arizona	Excellent	518[1]	2%	650	2%
	Good	4,923	16%	8,446	27%
	Fair	16,574	54%	15,886	50%
	Poor	8,832	28%	6,661	21%
New Mexico	Excellent	659	2%	591	2%
	Good	12,262	30%	14,314	36%
	Fair	22,617	55%	21,227	53%
	Poor	5,422	13%	3,645	9%
Oklahoma	Excellent	907	6%	1,749	12%
	Good	3,601	24%	4,492	32%
	Fair	7,639	51%	5,835	42%
	Poor	2,904	19%	1,951	14%
Texas	Excellent	480	1%	174	<1%
	Good	13,546	15%	16,324	18%
	Fair	53,543	57%	49,899	55%
	Poor	25,681	27%	24,922	27%

[1]Acres x 10^3 and percent of total area for which condition ratings were applied.

Table 5-2. Condition of rangelands managed by the Bureau of Land Management (BLM) in Arizona and New Mexico, 1986 and 1996 (adapted from Mitchell 2000: 32, table 3.7).

		Year			
State	**Condition class**	**1986**		**1996[1]**	
Arizona	PNC[2]	467[3]	4%	521	9%
	Late seral	2,801	24%	2,217	40%
	Mid seral	6,068	52%	2,217	40%
	Early seral	2,334	20%	652	12%
	Unclassified	0		913	
	Not inventoried			5,123	
New Mexico	PNC	125	1%	102	1%
	Late seral	3,002	25%	3,555	36%
	Mid seral	6,003	50%	4,673	48%
	Early seral	2,877	24%	1,422	15%
	Unclassified	500		305	
	Not inventoried			2,540	

[1]The acres and percentages by condition class for 1996 are based only on those acres inventoried using the Soil-Vegetation Inventory Method (used for 5 years prior to the ESI) or the Ecological Site Inventory (ESI) and classified by condition.
[2]Potential Natural Community (Kuchler 1964)
[3]Acres x 10^3 and percent of total.

communities (developmental stages of an ecological succession) and decreases in the areal extent of early seral communities, distinct from other BLM rangelands in Western States, which show little change during the period (Mitchell 2000:31). Table 5-3 presents upland range condition information for Forest Service grazing allotments in Arizona and New Mexico, showing virtually no change over the 3 years of assessment used in the study (1995, 1996, 1997). Slightly over 25 percent of the ranges under discussion are verified or estimated as neither meeting nor moving toward FPMO, as compared to 15 percent in the Rocky Mountain Assessment Region as a whole. This assessment region encompasses Forest Service grazing allotments in Montana, Idaho, Wyoming, North Dakota, South Dakota, Nevada, Utah, Colorado, Kansas, Nebraska, Arizona, and New Mexico (Mitchell 2000: 35-37). Mitchell (2000: 36) notes:

> Vegetation in the mostly dry Southwestern Region has been subjected to a history of fire suppression since the late 19th century and improper grazing, primarily between the 1880's and World War I (Secretary of Agriculture 1936, Rasmussen 1941, Cooper 1960, Buffington and Herbel 1965, Mortensen 1978). These factors and others have caused upland vegetation and soil changes that are slow to improve, some of which probably will not ever recover to pre-existing conditions (Schlesinger et al. 1990, Wang and Hacker 1997). As a result, the higher percentage of rangeland in R-3 (USFS Southwestern Region 3) that is not meeting or progressing towards FPMO's, roughly 25 percent, should not be surprising…

Conditions of riparian rangeland areas in Arizona and New Mexico managed by the BLM are reported in terms of Proper Functioning Condition (PFC) (Barrett and others 1995, USDI Bureau of Land Management 1991), while those managed by the Forest Service are reported in terms of FPMOs, as are upland ranges (Robertson 1992). In Arizona, 39 percent of BLM-managed riparian areas are reported in Proper Functioning Condition, while 33 percent of those in New Mexico are considered to be in PFC. Arizona reports 58 percent Functioning at Risk and 3 percent Nonfunctional. New Mexico has 45 percent Functioning at Risk and 22 percent Nonfunctional (Mitchell 2000: 41, table 3.20). These BLM data are for 1997.

The Forest Service assessment of riparian area condition within grazing allotments is reported for the Rocky Mountain Assessment Region as a whole for the years 1995, 1996, and 1997. Table 5-4 gives this information and shows that about 1 out of 6 acres of riparian land does not meet and is not moving towards FPMO; this is roughly the same as reported for the entire BLM Rocky Mountain Assessment Region (Mitchell 2000: 41). As discussed for the upland areas and reviewed in following paragraphs, various historical and contemporary factors and activities, as well as site-specific attributes of different locales, must be taken into consideration when assessing the condition of riparian areas throughout the region.

Table 5-3. Condition of rangelands in grazing allotments managed by the Forest Service in Arizona and New Mexico (combined) as related to Forest Plan Management Objectives (FPMO), 1995, 1996, 1997 (adapted from Mitchell 2000: 37, table 3.14).

	Year		
Land category	**1995**	**1996**	**1997**
Verified meeting FPMO	1,676[1]	1,859	1,945
Estimated meeting FPMO	2,541	2,595	2,376
Total	4,217	4,454	4,321
	(26%)	(27%)	(27%)
Verified moving toward FPMO	1,486	1,456	1,455
Estimated moving toward FPMO	6,227	6,208	6,105
Total	7,713	7,664	7,560
(47%)		(46%)	(47%)
Verified not meeting or moving toward FPMO	788	673	741
Estimated not meeting or moving toward FPMO	3,663	3,702	3,548
Total	4,451	4,375	4,289
	(27%)	(27%)	(26%)
Undetermined status 1,938	1,839	1,849	
Total (Lands with range vegetation management objectives)	18,319	18,322	18,019

[1] Acres x 10^3 and percent of total lands with range vegetation management objectives.

Table 5-4. Area of riparian range vegetation within grazing allotments on National Forest System lands in relation to Forest Plan Management Objectives (FPMO), Rocky Mountain Assessment Region (adapted from Mitchell 2000: 42, table 3.22).

	Year		
Land category	**1995**	**1996**	**1997**
Verified meeting FPMO	1,391[1]	1,450	1,777
Estimated meeting FPMO	4,549	4,421	4,662
Total	5,940	5,871	6,439
	(42%)	(45%)	(47%)
Verified moving toward FPMO	922	858	875
Estimated moving toward FPMO	4,519	3,973	4,092
Total	5,441	4,831	4,967
	(39%)	(37%)	(37%)
Verified not meeting or moving toward FPMO	402	266	208
Estimated not meeting or moving toward FPMO	2,226	2,059	1,905
Total	2,628	2,325	2,113
	(19%)	(18%)	(16%)
Undetermined status	2,331	2,290	2,241
Total (Lands with range vegetation management objectives)	16,340	15,317	15,760

[1] Acres x 10^2 and percent of total.

Specific information on the rangeland condition of the National Grasslands in New Mexico, Texas, and Oklahoma is presented in a somewhat different manner in the Geographic Area Assessments prepared by grasslands management during 1999 and 2000. The Black Kettle and McClellan Creek National Grasslands are located in Oklahoma and Texas. Two of their four geographic areas (High Plains and Redbed Plains) are used for regular livestock grazing under permit. The Lake Marvin Area is not currently grazed, and the Lake McClellan Area has occasional grazing as a management tool. All rangelands within the four geographic areas are described as in satisfactory range condition, which is defined as follows (Black Kettle and McClellan Creek National Grasslands Geographic Area Assessments 2000: appendix 38): "Satisfactory Rangelands—Those that have sufficient vegetative cover to protect the soil resource and provide a sustainable base for desired plant/animal communities." Satisfactory rangelands are those where current soil loss (the amount of soil that would be lost under the current or existing vegetative ground cover) is less than tolerance soil loss (the amount of soil that would be lost under conditions of the potential natural vegetative ground cover and where soil development equals soil loss) (TES Handbook 1986). Further information on rangeland condition can be found in the Geographic Area Assessments and in the Environmental Assessment for Livestock Grazing and Associated Vegetation Management, Black Kettle National Grassland—Roger Mills County, Oklahoma (1999).

The Kiowa National Grassland is in New Mexico and contains the Mills Canyon, Mills Upland, and the western third of the Southern Prairie Geographic Areas. The Rita Blanca, in Oklahoma and Texas, comprises the remainder of the Southern Prairie Geographic Area. The three areas are described as in satisfactory rangeland condition with the exception of small areas occupied by playa lakes, which contain substantial portions of bare ground. The floodplain of the Mills Canyon Area is also described as in unsatisfactory condition resulting from severe flood events (Kiowa and Rita Blanca National Grasslands Geographic Area Assessments 1999). Again, more detailed information can be found in the Geographic Area Assessment.

As the previous discussion indicates, regional rangeland condition and the ways in which it is measured and assessed are topics of both concern and debate. The Southwestern rangelands/grasslands are used for and impacted by many activities, which are also topics of debate. Discussions of these activities, such as livestock grazing, mining/energy extraction, recreation/tourism, and other special uses, follow.

Certainly the most widespread and increasingly scrutinized use, especially on public lands, is livestock grazing. Mitchell (2000: 31) summarizes:

> The two predominant opposing viewpoints (on grazing) are epitomized by Fleischner (1994) and Box (1990). Fleischner believes grazing has caused a loss of biodiversity, disruption of ecosystem function, and

> irreversible changes in ecosystem structure, while Box concludes that the trend of U.S. public rangelands, on the average, has been upwards over a number of decades and the land is in the best ecological condition of this century.

For a detailed argument supporting the view expressed by Fleischner, see Donahue (1999). For a rebuttal to the Fleischner paper, see Brown and McDonald (1995).

Mitchell (2000: 42) states further:

> Some reviewers conclude that grazing by domestic livestock is not compatible with restoring watersheds and water quality, at least in the short term (Belsky et al.1999). However, comparative [sic] research and case studies show that improved rangeland and livestock management practices are compatible with watershed and water quality improvement when designed to address the attributes of each individual site (Elmore and Kauffman 1994). Ultimately, social and political values, along with scientific knowledge, will drive future laws and regulations affecting the grazing use of riparian areas, just as they will for uplands (Lee 1993).

Livestock Ranching on Federal and Non-Federal Lands

The section describes the form and occurrence of ranching in the Southwest, as well as its socioeconomic and cultural contributions to local communities and the region. The focus is on livestock ranching on public lands. Ranching and range condition on Tribal lands are beyond the scope of this review, but information on this topic can be found in Brugge and Gerow (2000). Ranches in Arizona and New Mexico are generally composed of a base of private land augmented by Federal and/or State grazing allotments. Ranchers do not hold fee-simple property rights to grazing allotments, but these public lands are traditionally seen as part of the ranch and are considered in determining ranch sale prices and appraisals for Federal estate tax purposes (Ruyle and others 2000: 380).

The number of cattle ranches in Arizona varies depending on the definition of a ranch. Ruyle and others (2000: 387) note that during 1995 there were about 2,500 farms and ranches reporting at least one beef cow. Most livestock operations in the State have fewer than 50 cows, which is consistent with the national average. The majority of Arizona ranches are cow-calf operations, consisting of a base cow herd and the animals needed to support them.

Most of the ranches in New Mexico are also small, cow-calf operations with from one to 99 head. This size class comprised 70 percent of the State's 8,313 ranches in 1996. In the north-central mountain area of the State, the small operations made up 82 percent of the listed 1,804 ranches. This area also has fewer large (greater than 500 head) ranches—3 percent of the total; Statewide, they account for 7 percent of the total (Torell and others 1998: table 1). In both New Mexico and Arizona, 30 percent of ranches range from medium to large with at least 100 head (Ruyle and others 2000: 387-388). In northern New Mexico, however, only 17.5 percent fall within this size range (Torell and others 1998: table 1). Thus, northern New Mexico has considerably fewer medium-to-large ranches than either Arizona or New Mexico as a whole.

New Mexico has over twice as many grazing permittees on National Forests as Arizona, but New Mexico has 35 percent fewer animals (Raish and others 1997: 28-35). These figures result in large part from the small ranches and small herd sizes of northern New Mexico, as well as from the tendency to have multiple-permittee grazing allotments on National Forests in the area. These figures indicate the continuity of the long-standing tradition of small-sized operations and communal herding prevalent in the area since Spanish colonial times (Raish and others 1997: 28-35).

Because many ranching operations in the region rely to some degree on public land, regulations and management decisions affecting these lands can impact the operation and future of ranching throughout the area. Ruyle and others (2000: 380-383) found that for Arizona, but also applicable to New Mexico, many operators rely on a combination of privately leased land as well as State and Federal (USFS and BLM) grazing allotments. In Arizona, public and State grazing permits and leases account for roughly 85 percent of the State's grazing land, excluding American Indian lands. In New Mexico, 53 percent of the land is nonprivate (Fowler 2000: 423).

The degree to which a ranch relies on leased and permitted land affects the complexity of ranch management, with regulations, fees, and enforcement often varying between agencies and within the same agency from location to location. Because ranchers rely on government grazing permits, they are affected by the permitting agency's regulations. The managing agency defines grazing seasons and stocking rates, which are often limited by competing uses and values such as recreation or riparian restoration. Restrictions stemming from the Endangered Species Act (ESA), the National Environmental Policy Act (NEPA), and the National Historic Preservation Act (NHPA), for example, can affect the timing and construction of range improvements such as water developments and fencing (Ruyle and others 2000: 382-383).

The grassland areas of northeastern New Mexico, Texas, and Oklahoma comprise significantly greater amounts of private land than do other portions of the Southwest (Fowler 2000: 423-427; USDI Bureau of Land Management 1997). Fowler (2000: 423-427: table 2) notes that northeastern New Mexico has the most productive rangeland, supports the greatest number of ranches (27 percent), and the greatest number of

large ranches (35 percent) in the State. These figures come from the total of 8,313 ranches identified in 1996 (Torell and others 1998: 4, table 1). Both cow-calf and the majority of the State's yearling operations are located in the area. Yearling operations—not including cow-calf ranches that purchase weaned calves when forage is available—purchase calves to put on leased pasture. They are generally grazed on winter wheat until they reach sufficient size to be sent to the feedlot (Fowler 2000: 426).

The grasslands of the Great Plains States (North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas) contained almost 40 percent of the nation's beef cow herd according to 1996 statistics (USDA National Agricultural Statistics Service 1997). In these six States income from livestock generally exceeds income from other agricultural commodities, and cattle grazing is the predominant land use. There are twice the numbers of stocker cattle in these States, especially in Kansas, Oklahoma, and Texas, than in the Western States (including Arizona and New Mexico). Engle and Bidwell (2000: 105) found:

> For a variety of reasons, including closer proximity to feedlots and lower winter feed costs for cow-calf enterprises, overall costs of cattle production in the Great Plains are lower than in the regions to the west. The sum of these factors provides a competitive edge for Great Plains grassland cattle over cattle production elsewhere in the western United States (Cheeke and Davis 1997).

Livestock Numbers on Forest Service Land

Nationally, Region 3 ranks second to Region 4 (southern Idaho, Nevada, Utah, and western Wyoming) in permitted grazing use, according to the Forest Service Grazing Statistical Summary available at the time of this report, which reports information for the 1998 grazing season (USDA Forest Service 1999). Table 5-5 gives figures on the numbers of permittees, animals, animal unit months (AUMs), and head months (HMs) both permitted and authorized to graze on National Forest system lands (including the grasslands) in Region 3 in 1998. An AUM is the amount of forage required to support a mature, 1,000-lb cow and calf or its equivalent for 1 month, while an HM is the time in months that livestock spend on National Forest system land (used for billing purposes) (USDA Forest Service 1999). "Permitted to graze" indicates "Livestock permitted by a grazing permit, grazing agreement, livestock use permit, or other permitting document." "Authorized to graze" indicates "The number of livestock that are authorized and billed for grazing on National Forest System land" (USDA Forest Service 1999: 96). Authorized livestock are those that are actually grazing on the Forest and being paid for. Tables 5-6, 5-7, and 5-8 present the same information broken down for the National Forests in Arizona and New Mexico (excluding the National Grasslands), and for the National Grasslands of the region located in New Mexico, Texas, and Oklahoma.

Table 5-5. Livestock grazing on National Forest System lands in Region 3 in 1998.

	Number of animals	AUMs	HMs
Permitted	258,279	2,452,253	2,115,615
Authorized	217,970	1,900,545	1,650,336
Total of 1703 permittees.			

The figures from tables 5-6, 5-7, and 5-8 show that the average permitted number of animals per permittee is around 318 for the National Forests in Arizona, 102 for the Forests in New Mexico, and 65 for the Grasslands. There are 2.5 times as many permittees in New Mexico (1,082) as in Arizona (425) with the Arizona permittees averaging roughly three times as many permitted animals. The larger numbers of permittees and smaller numbers of animals in New Mexico in many cases reflect the persistence of traditionally small operations with multiple permittees per allotment, especially in the

Table 5-6. Livestock grazing on National Forests in Arizona in 1998.

	Number of animals	AUMs	HMs
Permitted	135,188	1,327,115	1,113,027
Authorized	107,081	916,392	779,235
Total of 425 permittees.			

Table 5-7. Livestock grazing on National Forests in New Mexico in 1998.

	Number of animals	AUMs	HMs
Permitted	110,393	1,044,416	928,407
Authorized	98,466	904,940	798,381
Total of 1082 permittees.			

Table 5-8. Livestock grazing on National Grasslands in Region 3 in 1998.

	Number of animals	AUMs	HMs
Permitted	12,698	80,722	74,181
Authorized	12,423	79,213	72,720
Total of 196 permittees.			

north-central portion of the State. Figures from the Grasslands tend to be somewhat misleading because livestock operations in the Plains areas generally have access to considerably greater amounts of private land on which to graze other portions of their herds. There are also a fair number of part-time farmers and ranchers with small herds using the Grasslands (Dickerson personal communication 2001) as there are throughout the Southwestern Region.

Region 3 rangeland use statistics show a fluctuating but primarily downward trend from 1982 to 1995 in numbers of permittees, animals permitted and authorized to graze, and AUMs. During this period, permittee numbers in both Arizona and New Mexico dropped by about 25 percent, and animals authorized to graze dropped by approximately 25 percent in Arizona and 20 percent in New Mexico (Raish and others 1997: 36). Declines are apparently related to climatic and market fluctuations, permit consolidation, and growing urbanization in the area (Raish and others 1997: 36). From 1996 through 1998, regional permittee numbers rose from 1663 to 1703, an increase of 2.4 percent. Permitted animals declined from 270,068 to 258,279, or a 4.4 percent decrease. AUMs increased by 1.9 percent from 2,406,708 in 1996 to 2,452,253 in 1998 (USDA Forest Service 1997, 1998, 1999). These are relatively slight fluctuations when compared to the declines of the period from 1982 to 1995.

Grazing Management Systems on Forest Service Land

A considerable body of information exists concerning grazing systems in use on the arid and semiarid rangelands of the Southwestern and Western United States. This information is ably defined, reviewed, and discussed elsewhere, for example in Holechek and others (1998) and Kruse and Jemison (2000), to name only two. From a relatively rough assessment and review of grazing systems used in the Southwestern Region (USFS), it is apparent that systems incorporating deferment, rest, and rotation are the most common. (All regional rangeland information used in this discussion and in table 9 was provided by Gene Onken, Rangeland Management Staff, USFS Southwestern Region). According to Holechek and others (1998: 228-229):

> Deferment involves delay of grazing in a pasture until the seed maturity of the key forage species. This permits the better forage plants to gain vigor and reproduce. Rest is distinguished from deferment in that the range receives nonuse for a full year rather than just during the growth period. This gives plants a longer period to recover from past grazing influences and provides wildlife with a pasture free from livestock use during the critical dormant period…Rotation involves the movement of livestock from one pasture to another on a scheduled basis. It is the critical feature of all specialized grazing systems.

Table 5-9. Grazing systems in use on the range management units of the National Forests in Arizona and New Mexico.

	Number and percentage	
Grazing system	**Arizona**	**New Mexico**
Continuous	33 (6%)	109 (23%)
Deferred	95 (18%)	51 (11%)
Deferred-Rotation	200 (37%)	130 (28%)
Rest Rotation	183 (34%)	132 (28%)
Rotation or Alternate	13 (2%)	42 (9%)
Other/Unlisted	18 (3%)	3 (.6%)
Total	542 (100%)	467 (100%)

Out of approximately 1,009 allotments that I was able to determine for the Forests of the Region (excluding the National Grasslands), 330 (33 percent) report using deferred-rotation, 315 (31 percent) rest-rotation, 146 (14 percent) deferred, and 142 (14 percent) continuous systems (table 5.9). Another 55 (5 percent) use rotation or alternate forms (table 5-9). Thus, around 83 percent are using some form of deferment, rest, or rotation.

Deferred-rotation "discontinues grazing on various parts of a range, allowing each part to rest successively during the growing season…two, but usually three or more, separate units, or pastures, are required" (Kruse and Jemison 2000: 41). In rest-rotation, grazing is deferred for a complete year on various portions of the range during succeeding years. Two or more units are required but most rest-rotation systems involve three or four pastures (Holechek and others 1998: 244; Kruse and Jemison 2000: 42). Deferred systems discontinue grazing on an area for a specified period (during the growing season, for example) to promote plant reproduction, establishment of new plants, or restoration of vigor to older plants (Kruse and Jemison 2000: 40). Continuous grazing, on the other hand, refers to grazing the same area throughout a year or that portion of the year when grazing is feasible. It may be yearlong or shorter depending upon environmental or other restrictions (Kruse and Jemison 2000: 37). Table 9 presents information on the primary systems in use on the National Forests in Arizona and New Mexico broken down by State. It should be noted that many of the continuous systems reported for New Mexico are seasonal in that grazing is not feasible in high altitude units during portions of the year.

As with the Forests of the Region, a rough count from the available information was used to examine grazing systems in use on the National Grasslands. The Geographic Areas Assessments for the Kiowa and Rita Blanca (1999) show deferred-rotation as

the system in use for the range management units with available information. These comprise approximately 80 units in the Mills Canyon and Mills Upland Geographic Areas. The Black Kettle and McClellan Creek National Grasslands systems are described as variable season grazing and variable season rotational grazing. Grazing units occur in the High Plains and Redbed Plains Geographic Areas. The vast majority of the 114 rangeland units are described as being grazed in a rest-rotation type of system with variable livestock numbers and/or seasons. According to the description for the High Plains Geographic Area (Black Kettle and McClellan Creek National Grasslands Geographic Area Assessments 2000: 27-30), a maximum number of AUMs is set forth according to season and vegetative conditions with a minimum 30-day recovery period during the growing season.

Sociocultural and Economic Role of Livestock Ranching

Ranching in New Mexico and Arizona, as well as on the Federally managed grasslands of eastern New Mexico, Oklahoma, and Texas, provides both economic and sociocultural contributions to families, communities, and the region. As discussed by Ruyle and others (2000: 379):

> Despite major shifts toward urbanization in the state, livestock grazing remains the most widespread use of Arizona rangelands. Through the sale of calves, yearlings, stocker cattle, and culled cows and bulls, cattle ranching accounts for nearly 25% of the agricultural economy in the state. However, based on profit alone, the economic viability of ranching in Arizona is questionable. Because of economic factors related to income production, decisions to remain in the ranching business are not entirely financial. Lifeway considerations have long played an important role in the process.

Economic status of ranches is determined by the larger factors of productivity, market prices, and production costs. More specific factors include range conditions, weather, the number of AUMs assigned to a grazing permit, management decisions, and ranch size (Fowler and others 1994, Ruyle and others 2000). Ranch size can be extremely important. Fixed costs, which remain the same whether animal numbers rise or fall, drive the move toward larger ranches. Seperich and others (1995) show that large-sized ranches do cover the fixed cost of operator salary better than do medium or small-sized ranches. A ranch should exceed 150 AUs to meet minimal family living expenses, a greater number than the one to 99 AUs of the small-sized ranches. Ruyle and others (2000: 393) estimate that small-sized operations would need to bring in about 50 percent of their income from nonlivestock sources to meet living expenses (for Yavapai County, Arizona). Fowler and others (1994: 1, appendix 4) discuss off-ranch income in New Mexico as follows:

> Seventy-five percent of the small ranches (1-99 A.U.) had people employed off the ranch contributing 44 percent of the family's income. Fifty-five percent of the medium size (100-350 A.U.) ranches had family members working off the ranch also earning 20 percent of the income. Forty-three percent and 36 percent of the large and extra large ranches had people working off the ranch, respectively, earning 13 percent and 6 percent of the family's income.

In addition to economic considerations, culture, tradition, and quality of life seem to become increasingly important in the decision to continue ranching among owners of the smaller ranches. Of course, these qualities are also valued by the owners of larger ranches. In addition, other factors influence the decisionmaking process among the small ranch operators. Eastman and others (2000: 543) found that small ranches in northern New Mexico, but equally applicable to other areas of the Southwest, are often viewed as an investment and a form of savings:

> While the ranch may produce little or even a negative operating income, the assets have a high value, which is expected to increase. Most northern ranchers own their homes, land, and cattle, and these constitute a significant investment and form of savings, which often has very high value. Managed properly, operating losses often provide income tax write-offs against other income. Thus, small operators stand to benefit from a reduced tax burden while their assets increase in value.
>
> The ranchers often view their animals as *banks-on-the-hoof,* which can be used…for emergencies, for periods of unemployment, or for special needs such as college tuition for the children…(Eastman and Gray 1987; de Buys personal communication 1995).

In addition to providing family income at various levels, ranching operations pay a variety of taxes that contribute to community, State, and Federal resources. At the State level, average ranches in Arizona paid $10,468 in combined property, livestock, and other taxes in 1991 (Fowler and others 1994). In New Mexico average ranches paid $4,479 in 1991 (Fowler and others 1994). Of course, property taxes vary according to millage rates and the amount of private land owned by the ranch. Property and other taxes (workmen's compensation, unemployment, and sales tax) are considerably higher in Arizona than in New Mexico (Fowler and others 1994).

Local communities also benefit from ranch-related expenditures from all size classes of livestock operation. Fowler and others (1994) estimate that ranch expenditures in local communities averaged $20,680 in Arizona and $16,529 in New Mexico in 1991. Although smaller ranches spend less in their local communities than larger ranches, basic family expenses, such as food, clothing, medical expenses, gasoline, and vehicle repairs, must be met to maintain a viable operation.

Feeding on the mesa, northern New Mexico, 1993. (Photo by Alice M. McSweeney)

Ranch business also contributes to veterinary and livestock supply businesses as well as to restaurants and movie theaters. "If these ranches were no longer viable the local economies could expect a sharp decrease in their business, as many of these (businesses) are very dependent upon the ranches of the rural regions of the state (New Mexico)" (Fowler and others 1994: 2, appendix 4).

As discussed for the Kiowa and Rita Blanca National Grasslands but applicable to the Black Kettle and McClellan Creek as well, agriculture and the rural lifestyle are strongly predominant, almost to the exclusion of other forms, in these areas. Grazing is the primary agricultural use, with few if any other industries present or predicted to develop. The local communities are almost entirely supported by agricultural income, and taxes on rangeland and livestock contribute the majority of the county's tax revenue. Many of the ranchers in the immediate area are dependent upon the National Grasslands because of their extent and the pattern of intermingled private and Federal lands. Most could not sustain their operations without grazing permits on the Grasslands (Kiowa and Rita Blanca National Grasslands Geographic Area Assessments 1999).

In addition to economic studies, various authors have examined the sociocultural contributions of the rural ranching lifeway to the continuity of culture and tradition in the Southwest. For example, recent studies by Atencio (2001), Eastman and others (2000), McSweeney (1995), and Raish and McSweeney (2001), among others, examine the role of ranching in maintaining the culture, heritage, and ties to ancestral lands of the Hispanic villages of northern New Mexico. In many cases in this area public land serves as a replacement for grazing lands and resource collection areas lost by local communities in the period following U.S. conquest. Thus, their continued use is considered to be critically important in maintaining community solidarity and traditional lifeways (Eastman and others 2000). These cultural values often outweigh the purely economic contributions of agricultural operations (Hess 1990; also discussed in Raish and McSweeney 2001).

This is the case in many other areas of the Southwest as well, especially with respect to family-owned farms and ranches. Research conducted on rancher motivations in Arizona showed that approximately 72 percent of the 89 ranchers interviewed indicated that profits were not a primary motivating goal for them (Smith and Martin 1972). Other research between 1970 and 1991 showed that ranchers had noneconomic values, obtaining social and psychological benefits from ranch ownership that offset economic problems (discussed in Ruyle and others 2000). According to Fowler (2000: 440):

> Ranchers in New Mexico and Arizona were similar…Arizona ranches had been in the business for 36 years and New Mexico 35 years; the average (rancher's) age was 56 years. Arizona ranch families had been in their respective states for over 64 years. This information strongly suggests longevity in the industry (and) is usually associated with long-term commitment and stewardship. Ranching as a "way of life" was also supported by such demographic information.

Writings by ranch owners express strong attachment to one particular place with enduring ties to the local community and its economy and considerable reluc-

tance to relocate (discussed in Ruyle and others 2000). Although more recent writings express concern over low income returns from ranch operations, ranchers place tremendous value on their operations and want their children to carry on the family tradition even if it provides lower income than other professions. These writers express pride in agricultural occupations, feeling that they are superior to urban occupations. They respect the knowledge of the older generation, which is often based in experience rather than formal education. They believe that ranching allows them to feel closer to the earth and provides a sound place to rear children. There is high value placed on rural life with a strong attachment to the land and land stewardship and a deeply felt sense of place (Cofer n.d., Duncklee 1994, Flieger 1991, Hughes 1980).

Mineral Resource Extraction on Forest Service Lands

Without doubt, livestock grazing is an important use of Forest Service grasslands in the Southwest; however, other uses of these lands merit attention. This section focuses on mineral/energy extraction, and the next section focuses recreation—two other major land uses.

Both surface and hard rock mining and oil and gas extraction occur on National Forest System lands, although the proportion of grasslands that support these activities is not known. The mining laws of 1866, 1870, and 1872 set the stage for mineral extraction activities; under the Mining Act of 1872 and the Mineral Leasing Act of 1920, mining and energy concerns are allowed to explore, stake claims, and apply for leases on the public domain (Robinson 1975: 4; Roth 1997: 242). Rules and regulations for mineral extraction on Forest Service land are presented in 36 Code of Federal Regulations (CFR) Chapter 11 (7-1-00 Edition), Part 228—Minerals. Standards are also contained in Surface Operating Standards for Oil and Gas Exploration and Development (USDI Bureau of Land Management and USDA Forest Service Rocky Mountain Regional Coordinating Committee 1989) and in the Uniform Format for Oil and Gas Lease Stipulations (USDI Bureau of Land Management and USDA Forest Service Rocky Mountain Regional Coordinating Committee 1989).

Although mining has a long history in the region going back to American Indian and Spanish Colonial times, large-scale mining efforts primarily developed after U.S. takeover. In addition to collecting and quarrying many types of rocks, minerals, and clays, American Indian groups mined turquoise for ornamentation and religious purposes with major quarries and mines located near present-day Cerrillos, NM. Galena, or lead ore, was also mined in the Cerrillos area, as well as in the San Pedro, Sandia, and Sangre de Cristo Mountains in New Mexico. Much of the lead was used in producing lead glaze paint for Puebloan pottery (Scurlock 1998: 100-103).

Mining became progressively more developed under the Spanish, Mexican, and American governments. Although exploration for mineral wealth was a major impetus for Spanish exploration, these riches were never realized in the region. In the Middle Rio Grande, the Spanish colonists did mine turquoise and lead, as the American Indian groups had done, as well as copper, silver, and gold. They also extracted nonprecious minerals and rocks, such as mica, which was used to cover window openings (discussed in Scurlock 1998: 118-119). Silver and gold were sought during the Spanish and Mexican periods in southern Arizona, although mining in the area was limited. There is some evidence of mining for gold, silver, and lead in the region, but since later operations often used traditional Spanish and Mexican techniques, it becomes difficult to determine whether the mining occurred before or after the United States assumed control of the area (Hadley and Sheridan 1995: 46-47). According to Whittlesey and others (1997: 288), there were no mining centers north of the Gila River until 1860.

Anglo-American takeover led to major changes in the mining industry in technology, extent, and intensity. Transportation was limited until entry of the railroad from 1879 into the 1890s, with construction of both major lines and spurs into specific mining locations. After railroad entry, serious commercial markets developed. In the Rio Grande, Mexican period gold mines in the Ortiz and San Pedro Mountains continued to be productive after U.S. conquest. Other productive locations for gold, silver, lead, and other minerals included Elizabethtown, Cerrillos, Bland-Albemarle (which remain as ghost towns within the Santa Fe National Forest), and Socorro-Magdalena (Scurlock 1998: 129-134). Scurlock (1998: 130-132) gives a detailed listing of mining locations with types of minerals and dates of production for the Rio Grande area. Most of these locations are found in the forested, montane regions, however; Scurlock does not detail the extent of grasslands or meadows that might also be present.

American period mining in southern Arizona is described by Hadley and Sheridan (1995: 47-65) as producing several mining booms after the Gadsden Purchase (1854) and into the 1880s despite threats from Apache raiding. Lead and silver were produced in the Mowry area from the Mowry and adjacent mines near Patagonia into the 1950s. Other mines produced silver, lead, zinc, copper, and gold ores. Mining occurred at Washington/Duquesne, Sunnyside, Harshaw, and Meadow Valley. Mines in central and western Arizona increased during the 1860s as a means of financing the

Civil War (Whittlesey and others 1997: 288). Central Arizona mines produced gold, silver, and copper and were dependent to a considerable degree on the state's network of railroads. Copper mines along the Verde River led to the boomtown of Jerome, and copper and other minerals drew settlement to the Tonto Basin and surrounding areas (Whittlesey and others 1997: 290).

As in New Mexico, many of the historic hardrock mining locations are situated in or adjacent to contemporary National Forests and are generally located in the more mountainous, forested zones as opposed to the grasslands. Nonetheless, growth of the mining industry affected livestock production and associated grasslands as demands for meat, milk, hides, and tallow from the mining camps increased, encouraging greater livestock production and ranch development, producing what has been discussed by West (1993) as a mine-ranch complex (Hadley and Sheridan 1995). Contemporary mining activities include those for both locatable (for example, gold and silver) and common variety minerals (for example, common variety pumice). Some examples include gold, silver, and copper mines on the Kaibab, Tonto, Lincoln, and Gila National Forests and common variety mineral and rock extraction on virtually all Forests in Region 3. Common variety pumice, caliche, sand, gravel, landscape/building stone, and cinders are all extracted and, collectively, have considerable value to forest users (Linden personal communication 2001).

The most prevalent mineral extraction activities on the grasslands of Region 3 consist of oil and gas leases, which occur on several Ranger Districts of the Santa Fe and Carson National Forests and on the National Grasslands, as well (Linden personal communication 2001). In some cases, these leases have been in effect for 50 to some 100 years. The government receives a 12.5 percent royalty from producing oil and gas wells, with approximately 50 percent of revenue from public domain lands returned to the county and 25 percent of revenue from acquired lands (such as the majority of the National Grasslands) going back to the county. The Jicarilla Ranger District of the Carson National Forest, primarily grazed woodland/canyon country, is located within a major oil and gas field in the San Juan Basin with an estimated 630 producing wells (Linden personal communication 2001). Coal bed methane is also extracted from some 150 to 200 of the producing wells. In fiscal year (FY) 2000 oil and gas production on the Carson generated $9,168,935.69 in rents and royalties. The Cuba and Coyote Ranger Districts of the Santa Fe have about 60 oil and gas wells located mainly in sagebrush mesa country. The forest as a whole reported $287,905.71 in rents, bonuses, and royalties (USDA Forest Service 2000, Linden personal communication 2001).

Concerning the National Grasslands themselves, the Kiowa and Rita Blanca report no drilling on the Kiowa portion in New Mexico with minimal drilling (about two wells) on the Rita Blanca in Texas (Kiowa and Rita Blanca National Grasslands Geographic Area Assessments 1999, Linden personal communication 2001). The Black Kettle and McClellan Creek, on the other hand, report that most of the land tracts within the High Plains and Redbed Plains Geographic Areas (approximately 21,500 acres) are under oil and gas leases effective for 10 years unless a producing well is drilled. If a producing well is drilled, the lease remains effective as long as the well produces. The lands in the Lake Marvin (577 acres) and Lake McClellan (955 acres) Geographic Areas are also under oil and gas leases with producing wells. Both Marvin and McClellan are under private development; the Forest Service does not own the mineral rights, although the facilities are located on Forest Service land. Overall, the Black Kettle and McClellan Creek listed $1,425,083.82 in rents, bonuses, and royalties from oil and gas operations in FY 2000 (Black Kettle and McClellan Creek National Grasslands Geographic Area Assessments 2000, USDA Forest Service 2000, Linden personal communication 2001).

Issues and controversies related to mining on public land vary according to the type, extent, location, and management of the extraction activity. Extraction and processing can cause environmental impacts through earth removal and the distribution of metals and chemicals. Removed earth can obstruct watercourses resulting in redirection and/or downstream erosion. Both groundwater and soil may be impacted by acid tailings and processing chemicals percolating downward into the water table (Dean 1982:1-10, discussed in Hadley and Sheridan 1995: 62-65). Indirect impacts come from increased settlement and mine working activity including building roads, hauling ore, and clearing and leveling home sites. Historically, woodcutting for fuel, construction, and ore processing had significant impacts on forested lands surrounding mine sites in the region. In many cases, impacts from historic mine sites are still apparent today. Hadley and Sheridan (1995: 64-65) describe the effects of mining at some of the historic southern Arizona locations in terms of seriously altered topography from earth removal, denuded lands on which trees have not regenerated, and eroded, downcut watercourses.

Although recent years have seen growing opposition to mining on public land, the Forest Service has little authority to deny mining on its lands. Congressionally designated Wilderness areas, however, have been closed to mining exploration since 1984 under provisions of the Wilderness Act of 1964 (Robinson 1975: 158-160; Roth 1997: 238-242). States hold the permitting

regulations for mining, and the New Mexico regulations are stringent in terms of bonding, close-out plans, and engineering plans (Linden personal communication 2001). Many of the small operators cannot meet the standards and are forced out of business. Those that remain can cause difficulties for Forest Service administrators in terms of obtaining sound operating and reclamation plans and proper environmental clearances.

Although the larger mining concerns generally contract for their own environmental work, Forest Service administration and review of these efforts can still be costly in terms of time and personnel. As an example, the proposed Carlota Copper Mine on the Tonto National Forest, with an environmental impact statement prepared by a private company, still required the time and effort of considerable numbers of Forest Service employees for review and comment. There are also ongoing monitoring and clean-up programs for abandoned mines that are on Forest land or on lands bordering National Forests. These can be both costly and time consuming (Linden personal communication 2001).

Oil and gas leasing follows the standards set out in the previously mentioned Surface Operating Standards and Uniform Format for Oil and Gas Lease stipulations developed by the BLM/Forest Service Rocky Mountain Regional Coordinating Committee (USDI Bureau of Land Management and USDA Forest Service Rocky Mountain Regional Coordinating Committee 1989). Stipulations cover surface uses such as road construction, drilling and producing operations, reclamation, and abandonment. The density of wells, referred to as well spacing, is regulated by the State based on efficient draining of underground reservoirs. Spacing varies by formation, depth, and the kind of resource being exploited and is generally one well per 80, 160, or 320 acres. Many of the older leases, especially those on the Jicarilla Ranger District, were approved over 50 years ago and do not fall under the contemporary standards. In these cases, operators are "encouraged" to conform to the current guidelines, with greater success reported for the larger, richer operators than for the smaller ones (Linden personal communication 2001).

The timing and location of drilling must be consistent with cultural resources, wildlife, and other resource values in the vicinity, as is the case with other projects on Federal lands. Drilling takes 2 weeks to a month with the resulting well in production for many years. Impacts from drilling and production can include habitat fragmentation from road density, as well as disturbance from truck traffic hauling out water and oil and servicing the well. Noise from both road traffic and compressors used to pump is an additional disturbance (Linden personal communication 2001). Research is still needed to assess the standards for density of surface mining structures (well spacing) and the impacts of general operations on the varying grassland ecosystems and human cultural values of the area (Seescholtz personal communication 2000).

Recreation on Forest Service Lands

Recreation in the National Forests of the Southwest has a long history and includes many varied activities such as camping, hiking, picnicking, trail biking, hunting, fishing, water sports, and viewing wildlife and historic sites. In recent years, participating in volunteer archeology projects such as Passport in Time and heritage tourism activities, such as Heritage Expeditions, have increased in popularity. Since World War II, recreation has played an extremely significant role in National Forest System management by virtue of the large numbers of people engaged in recreational activities on public lands. Indeed, the economic impacts of recreation outweigh those from traditional resource extraction activities (discussed in Menning and Raish 2000, among others).

The national trend toward increased recreation (Boyle and Samson 1985, Flather and Cordell 1995) is evident in the Southwest in the rising numbers of recreationists in the Forests in Arizona and New Mexico (Raish and others 1997: 38). Although a great amount of recreational activity occurs in the ponderosa pine forests of the region, grassland areas also contribute to the trend in rising recreational use. Holechek and others (1998: 15) note:

> The large human population increases in the United States since the 1940s have made rangelands increasingly important as places for people to engage in outdoor recreational pursuits. Hiking, camping, trail biking, picnicking, hunting, fishing, and rock hounding are some of the important recreational uses of rangelands. The importance of open space, scenery, and aesthetic values from rangelands in the United States is difficult to quantify.

Recreation use increased in Region 3 (including the National Grasslands) from 1992 to 1995 with over 40 million visitor days recorded in 1995 (Raish and others 1997: 38, fig. 8). Most visitors were viewing scenery, camping, picnicking, or swimming. Hiking, horseback riding, and river rafting have increased rapidly (Flather and Cordell 1995), while hunting, fishing, winter sports, and resort camping have remained fairly stable. Nonconsumptive wildlife recreation, such as bird watching, has also increased (Raish and others 1997: 38, fig. 8), as has visiting historic sites and heritage tourism in general.

In 1996, wildlife-related recreation expenditures tied to National Forests totaled $6.8 billion, with anglers spending $2.7 billion, participants in nature-related activities spending $2 billion, and hunters spending $2 billion (NatureWatch 1996). In the same year,

wildlife watching expenditures/sales totaled $426.9 million in Arizona and $223.2 million in New Mexico (NatureWatch 1996). With respect to fishing in the Southwest, the following information was drawn from the Region 3 Forest Service Web site (www.fs.fed.us/r3, select Recreation, FishUS, September 2001):

> The uniqueness of the Southwestern Region's fisheries is a valued resource. Fishing…is big business, critical to the rural economies of the arid Southwest. The streams and lakes of the Southwest provide 10 percent of all angling (3.9 million angler visits per year) in national forests and grasslands across the nation. Fishing is so popular in the Southwest that no other Forest Service region has the fishing pressure per surface acre of water (more than 300 hours of fishing per acre annually on 48,735 surface acres). According to the latest United States Fish and Wildlife Service survey (1996), fishing in the Southwest brings in more than $550,000,000 annually. More than 4,000 jobs are directly related to fishing enterprises, with another 10 to 15 thousand jobs indirectly associated with fishing in Arizona, New Mexico, and Texas…In Arizona 54 percent of the fish habitat is in the national forests; in New Mexico, 25 percent.

This section covers fishing, hunting, and wildlife viewing—all major recreational activities along the rivers and lakes in the grassland areas of the region.

Examination of recreation trends on all the forested lands of the region is well beyond the scope of this discussion, so the focus here is on recreation in the grasslands. Regionally, grassland recreation occurs on the Apache-Sitgreaves National Forest in the montane grasslands around Big Lake and within the Escudilla Wilderness, as well as at artificially created lakes in the Tonto Basin (Tonto National Forest), although much of this latter area is Sonoran Desert. The Valle Vidal (Carson National Forest) and the Pecos and San Pedro Parks Wilderness areas (Santa Fe National Forest) have considerable acreages of montane grassland that provide recreation, elk hunting, and livestock grazing (Moir personal communication 2003). According to Brent Botts, Recreation Assistant Director for the Southwestern Region, a request was sent to the Forests of the Region for information on recreational activities and issues on their grassland area, but little additional information was received except from the officially designated National Grasslands—Kiowa/Rita Blanca and Black Kettle/McClellan Creek (Botts personal communication 2001). Hence, these areas form the basis of the present review.

Visitor use figures are reported by Forest and are not separated out by grassland portions of specific National Forests. National Visitor Use Monitoring reports for 2000, 2001, and 2002 were sought for the Kiowa/Rita Blanca and Black Kettle/McClellan Creek National Grasslands to determine visitor days for these units, but figures for these areas are included with figures for the Cibola National Forest (which manages the Grasslands) as a whole and are currently not broken out for the National Grasslands themselves.

Recreation use on the three geographic areas of the Kiowa/Rita Blanca includes both developed and dispersed sites. There is one developed campground in Mills Canyon located adjacent to the Canadian River, and three developed day-use areas on the Southern Prairie, including two picnic grounds and an interpretive hiking trail associated with the Santa Fe Trail. There are no developed facilities in the Mills Upland Geographic Area (Kiowa and Rita Blanca National Grasslands Geographic Area Assessments 1999).

The majority of recreation use on the Kiowa/Rita Blanca is dispersed. In the Mills Canyon Geographic Area hunting and fishing are the two primary uses, which include hunting bear (*Ursus americanus*), Barbary sheep (*Ammotragus lervia*), mountain lion (*Felis concolor*), deer (*Odocoileus hemionus*), (scaled) quail (*Callipepla squamata*), dove (*Zenaidura macroura*), and pronghorn antelope (*Antilocapra americana*), as well as warm-water fishing in the Canadian River. There is also dispersed camping, hiking, picnicking, water play, and scenery and wildlife viewing. Mills Canyon has been designated a New Mexico Wildlife Viewing site in cooperation with the New Mexico Department of Game and Fish. Mills Upland has only dispersed recreation with hunting deer, quail, dove, pronghorn antelope, and coyote (*Canis latrans*) the main use. Other recreational uses of the area include camping, hiking, picnicking, viewing scenery, and wildlife watching. Southern Prairie also has a predominance of dispersed recreation featuring the same types of uses as the other areas (Kiowa and Rita Blanca National Grasslands Geographic Area Assessments 1999).

Although three developed camping sites exist within the High Plains and Redbed Plains Geographic Areas of the Black Kettle/McClellan Creek National Grasslands, the majority of recreation use is dispersed, with an emphasis on hunting and fishing as described for the Kiowa/Rita Blanca. Other uses include developed and dispersed camping, hiking, bird watching, and horseback riding. The Black Kettle is considered one of the best public hunting locations in the country for Rio Grande turkey (*Meleagris gallopavo intermedia*) and bobwhite quail (*Colinus virginianus*) and is the largest public hunting area in the western half of Oklahoma. It is also the only public hunting unit in this region where an over-the-counter permit can be purchased. These qualities have led to problems with hunting pressure during some seasons. Surveys found one hunter per 54 acres on the Black Kettle during the opening day of the 1999 deer rifle season, leading to a potentially unsafe situation for the public (Black Kettle and McClellan Creek National Grasslands Geographic Area Assessments 2000).

Another problem related to dispersed recreation use has been indiscriminate driving on interior (unpaved, undeveloped) roads and indiscriminate parking in

undeveloped areas. These activities have impacted soil, water, and wildlife resources. Holechek and others (1998: 446-447) and Payne and others (1983) discuss the damage that unregulated, off-road vehicle travel can cause to soils and vegetation under different moisture regimes and during different cycles of the growing season. They conclude that unregulated off-road vehicle travel can be as destructive as uncontrolled grazing. They recommend regulation of recreation use on rangelands, just as other uses are regulated (Holechek and others 1998: 447). The High Plains and Redbed Plains Geographic Areas have moved in this direction by creating designated parking locations for dispersed recreation, which are designed to reduce vehicle access and encourage walk-in use. The areas have also instituted road closures in conjunction with the parking spaces for the same purpose (Black Kettle and McClellan Creek National Grasslands Geographic Area Assessments 2000).

Recreation on the Lake McClellan and Lake Marvin Geographic Areas (in Texas) tends to be considerably more developed than on the High Plains and Redbed Plains, although dispersed recreation is also present. Lake Marvin offers warm-water fishing, developed camping (two campgrounds and a recreation building), picnicking, hiking, and bird watching. The primary uses are fishing and camping, but hiking the trails and viewing birds and other wildlife are also popular. Hunting is prohibited owing to the area's small size (Black Kettle and McClellan Creek National Grasslands Geographic Area Assessments 2000).

Developed recreation facilities in the Lake McClellan Area are managed under a concessionaire permit and consist of several campgrounds and picnic grounds, as well as a store offering rentals such as paddleboats and lifejackets. Activities at the lake include camping, picnicking, fishing, hiking, and wildlife viewing, as well as boating, jet skiing, bicycle riding, and motorcycle riding. The north end of the area is open all year, while the south end is closed from November 1 to March 31 to protect eagle roost habitat. Dispersed recreation throughout the area consists of fishing, boating, water play, camping, and motorcycle riding; fishing is the primary dispersed use. Hunting is generally not allowed. Motorcycle riding is permitted by the concessionaire and is popular on the motorized trail system. It is, in fact, the primary use of the trail (Black Kettle and McClellan Creek National Grasslands Geographic Area Assessments 2000). No problems were mentioned concerning the impact of motorcycle use, which is apparently being controlled and regulated by designation of the motorized trail.

As discussed previously, however, off-road vehicle use by recreationists is growing in extent and numbers of occurrences and has considerable potential for negative environmental impacts. All-terrain vehicles (ATVs), in particular, are growing in popularity, and their use is on the rise in many areas, with the potential for serious environmental damage. The growing use of off-road vehicles has prompted a study by the San Dimas Technology and Development Center (USFS) on the resource impacts of off-road vehicles on soil, water, air, vegetation, wildlife, and aquatic species of National Forests throughout the country. The ongoing project is a survey examining types of uses, equipment, resource impacts, and use regulations.

A Nevada study examined by Holechek and others (1998: 446-447) compared the effect of motorcycle, four-wheel-drive truck, and no traffic on infiltration rate and sediment production. In the study, infiltration rates were decreased and sediment production was increased by both forms of traffic, with the four-wheel-drive truck having considerably greater impact than the motorcycle (Eckert and others 1979). As populations and urbanization increase in the Southwest, all forms of recreational use will increase on the region's rangelands. Assessing, regulating, and controlling the effects of these uses will become increasingly important. The population growth, with its attendant urbanization and suburbanization, are the topics of the final section of this chapter.

Continuing/Future Trends in Southwestern Rangelands and Rangeland Management

Conversion of rangeland to nonagricultural uses during the past 20 years is becoming an important concern for public land managers and private ranchers and farmers. In the United States, this trend primarily results from human population increases and a demographic shift from the eastern to the western portion of the country (Holechek 2001: 39). World population projections show the North American population rising from 172 million in 1950 to 297 million in 1995 with a projected increase to 384 million in 2050 (Holechek 2001: 39, table 1; McQueen 2000, United Nations 1998). In a listing of States with the greatest population growth rate from 1990 through 1994, Arizona ranks third and New Mexico ranks eighth (Mitchell 2000: 25, table 2.9; Riebsame and others 1997). Increasing urbanization and suburbanization result from both population growth and inmigration from other areas. For example, Bahre (1995: 243-244) describes southern Arizona:

> The rapidly growing population of Arizona, especially since the 1940s, has led to expanded urban and rural development on privately owned lands and is threatening federal and state trust lands, which are continually being sold to the public for development. Since 1950 the number of rural sub-divisions being built in southeastern Arizona has exploded,

especially in Cochise County, which has both the largest area of grassland and the largest amount of private land (41 percent)—almost all of it being used for agriculture, ranching, or subdivision development (Hecht and Reeves 1981). Cattle numbers in the county have declined, in part because of tract development in former rangelands, and much private grazing and agricultural land has been purchased by people seeking rural retirement or investment opportunities.

It often seems that the urban residents, as well as those newly arrived in the region, have different land attitudes and values from many of the long-time rural residents. These differing views can lead to conflict over land use and land management goals and strategies. Conflicts over environmental protection legislation and the role of organized environmental groups are examples. Many present-day environmental issues and concerns in the Southwest are aligned with a national shift in public attitudes and values concerning the appropriate use of public land, primarily in the West (Macon 1998). Many urban Americans now hold environmental protection oriented public land values, in contrast to the commodity and community economic development orientation of the earlier conservation era (from approximately 1900 to 1969) (Kennedy and others 1995, Macon 1998). As Kennedy and others (1995) point out, rural agricultural communities use and view land differently from urban groups, thus producing contrasting perceptions and values. A large amount of contemporary conflict over timber, wildlife, and rangeland issues stems from disjunct rural and urban values concerning human relationships with nature and its uses.

Nature values are not intrinsic but are human creations originating in the minds of individuals and groups as their changing perceptions and needs interact with environmental, political, and economic systems (Kennedy and others 1995: 128). For example, the conservation movement of the early to mid-20th century fit well with the needs of an industrialized nation for sustained-yield timber and forage production to provide commodities for growing factories and cities. Even though recreational, biocentric, and esthetic values were a part of some early conservation visions, these views did not become a dominant force in public attitudes until the 1960s, with the advent of an urban, postindustrial society and the environmental movement (Kennedy and others 1995).

The later 1960s and 1970s saw passage of the main body of environmental protection legislation. Mitchell (2000: 7) in a discussion of legislation affecting rangelands stated:

> From a legislative context, the 1970's could be considered the decade of the environmental movement. The Wilderness Act was enacted in 1964. Then, starting in January 1970 with the Environmental Policy Act of 1969, no fewer than 12 major environmental laws affecting the conservation and management of U.S. rangelands were signed into law during the following 10 years. Among such laws were the Resources Planning Act of 1974 (RPA) and the National Forest Management Act of 1976 (NFMA), which called for a recurring assessment of America's forest and rangeland situation.

Other pertinent legislation includes the landmark Endangered Species Act of 1973, the Federal Land Policy and Management Act of 1976 (FLPMA), the Forest and Rangeland Renewable Resources Research Act of 1978, the Public Rangelands Improvement Act of 1978, and the Archeological Resources Protection Act of 1979.

The orientation of range research has also changed over the years from a more traditional range/livestock grazing system approach to a more integrated ecosystem approach. Contemporary research now includes more ecologically based subjects such as watershed and riparian area management, biodiversity, disturbed site reclamation, and wildlife/livestock interactions, to name a few (Evans 1990, Everett 1992). Additionally, studies concerning grazing on public land now include information on visitor attitudes about grazing (Mitchell and Fletcher 1996), which indicates the increasing role of public concern and input into land management agency decisionmaking.

One result of the growing role of both public and interest group involvement in Federal agency planning and decisionmaking is increased litigation over agency projects, programs, and plans. A rising number of appeals and lawsuits from both environmental and industry groups have resulted from the agency's efforts to bring livestock grazing into compliance with Federal environmental statutes. For example, during 2001, there were 11 grazing-related lawsuits against the Southwestern Region of the Forest Service (Gonzales personal communication 2002).

The increasingly litigious environment surrounding rangeland management has spurred the rise of regional conflict resolution groups such as the Malpai Borderlands Group in southeastern Arizona and southwestern New Mexico, the Diablo Trust in northern Arizona, the Arizona Common Ground Roundtable, and the Quivira Coalition in New Mexico, to name a few (Raish 2000c, Ruyle and others 2000, Sheridan 2001). These groups attempt to protect both the environment and traditional lifeways and to diminish conflict, controversy, and litigation. They often include environmentalists, ranchers, and public land managers and espouse collaborative stewardship, mutual education, and citizen participation in agency decisionmaking. They emphasize that sound land management and healthy ecosystems can coexist with traditional rural economic practices such as ranching (Guess 1999).

Ruyle and others (2000) describe the work of the Malpai Borderlands Group and the Diablo Trust to coordinate management of multiagency lands as a

promising means of maintaining the viability of ranching on public land, protecting open space, and reducing habitat fragmentation. The Malpai Borderlands Group has worked with the Nature Conservancy to protect and restore wildlife habitat and with public land managers in projects to restore fire to the ecosystems of the area. They have also developed a program of conservation easements to protect open space from future development and subdivision (Clifford 1998, Guess 1999).

These groups focus on the threat of growing development and suburbanization to Western lands and landscapes, as escalating rates of development are impacting both private lands and adjacent public lands. U.S. Department of Agriculture statistics show that the nation lost almost 1.4 million acres a year to development from 1982 to 1992. In the mid-1990s the rate more than doubled to almost 3.2 million acres per year (Rome 2001: 264). Land-use change from population growth is greater in rural areas than urban ones because of the dispersed nature of exurban development. Exurban development refers to rural residential development that occurs beyond incorporated city limits and often results from the subdivision of ranches into smaller parcels for home sites ("ranchettes") generally ranging from 1 to 20 acres or so (Sullins and others 2002, Theobold 2000). Almost 80 percent of the land used for houses built between 1994 and 1997 was in nonmetropolitan areas (Heimlich and Anderson 2001). In addition, locations in proximity to public land are particularly desirable for development (Riebsame and others 1996, Swanson 2001).

Sheridan (2001: 146-147) describes development, which has escalated since the late 1960s, in the Sonoita-Elgin area of southern Arizona plains grassland near the Coronado National Forest. In 1989 Sonoita had approximately 400 homes, which had risen to 707 by 1995, a 76 percent increase. Numerous ranches have been subdivided in the region in the past 20 years, leading to segmentation of the open grassland into ever smaller parcels (the minimum lot size is currently 1 to 3 acres). Sheridan (2001: 146-147) discusses the ways in which the resulting land use and human occupation can affect wildlife, native vegetation, and soil cover. Problems can include house and outbuilding construction, fencing (which inhibits the movement of large wildlife), removal of native vegetation, introduction of exotics, and introduction of domestic pets that prey on or harass wildlife. This type of land fragmentation acts against maintaining the biodiversity that stems from large, unfragmented ecosystems, as wildlife habitat and corridors that link grasslands with montane use areas are fragmented or destroyed. There is also a growing constraint on large-scale ecosystem management, such as the reintroduction of fire as a natural process or management tool, which is generally resisted as a threat to homes and property.

According to James H. Brown, a University of New Mexico biologist and past president of the Ecological Society of America, "Far more habitat has been destroyed to provide water for cities, subdivisions, and irrigated (commercial) agriculture than by even the heaviest grazing pressure" (quoted in Clifford 1998). In an effort to explore this notion of the negative effects of development, Maestas and others (2002) conducted a study designed to examine wildlife species and plant diversity on ranches, protected areas (Colorado Division of Wildlife's State Wildlife Areas), and exurban developments in the foothills of the Colorado Front Range of the Rocky Mountains northwest of Fort Collins. The wildlife species studied were mammalian carnivores and songbirds. The study found that biodiversity differed among the different land use categories, with wildlife species occurrence and densities more similar between ranches and protected areas than on exurban developments. In terms of plant communities, the most nonnative species were found on exurban developments, with more species of native plants found on ranches than on the other two land uses. The most common nonnative was cheatgrass. However, the cover of native species did not differ statistically across the land uses (Maestas and others 2002). The information derived from this study has considerable implications for conservation efforts. Maestas and others (2002: 27) stated:

> A generalization from our study is that there is an increase in human-adapted wildlife and non-native plant species with exurban development. Interactions among native, non-native, and human-adapted species could result in the simplification of the Mountain West's natural heritage favoring species whose evolutionary life histories allow them to exist with humans. This change has negative implications for the maintenance of biodiversity at both the site and landscape scales and its consequences are increased with increasing development (Knight 2002).

This chapter has shown how Southwestern grasslands have been impacted by human activity for thousands of years. Native American groups used and modified the area for hunting, gathering, and agriculture before and after the arrival of Spanish colonists in the 1500s. European settlement brought a wide array of new domesticated plants and animals, as well as new technologies and land-use strategies. However, changes and impacts to the area's land base accelerated more rapidly with commercialization of both farming and ranching after U.S. takeover, with development of railroad transport and wider national markets. In the years since the beginning of the 20th century and especially after World War II, conservation and preservation efforts have come to the fore as concerns for ecosystem health and sustainability have increased as national priorities. New challenges now

face the region in terms of population growth and inmigration resulting in a proliferation of urban, suburban, and exurban developments, affecting rural land uses, water supplies, and wildlife habitat. Sheridan (2001: 147) notes: "Some human impacts can be reversed but subdivisions are forever." Managing this new challenge of human population growth and development will undoubtedly be a major effort of public land managers, environmental groups, and farmers and ranchers into the 21st century.

Acknowledgments

For their well-thought-out, helpful reviews of this chapter, I thank John Brock, Arizona State University; Clyde Eastman, New Mexico State University (retired); Will Moir, Rocky Mountain Research Station (retired); Rex Pieper, New Mexico State University; and George Ruyle, University of Arizona. Their efforts have improved the final product considerably.

References

Alexander, T.G. 1997. From rule-of-thumb to scientific range management: the case of the Intermountain Region of the Forest Service. In: Miller, C., ed. American forests: nature, culture, and politics. Lawrence: University Press of Kansas: 179-194.

Allen, C.D. 1984. Montane grasslands in the landscape of the Jemez Mountains, New Mexico. Madison: University of Wisconsin. Thesis.

Antle, J.J. 1992. Grazing on Arizona's National Forests, 1891-1960: an environmental history. Tempe: Arizona State University. Thesis.

Atencio, E. 2001. Of land and culture: environmental justice and public lands ranching in northern New Mexico. Santa Fe, NM: Quivira Coalition; Santa Fe Group of the Sierra Club.

Bahre, C.J. 1985. Wildfire in southeastern Arizona between 1859 and 1890. Desert Plants. 7: 190-194.

Bahre, C.J. 1991. Legacy of change: historic human impact on vegetation in the Arizona borderlands. Tucson: University of Arizona Press.

Bahre, C.J. 1995. Human impacts on the grasslands of southeastern Arizona. In: McClaran, M.P.; Van Devender, T.R., eds. The desert grassland. Tucson: University of Arizona Press: 230-264.

Bailey, G.; Bailey, R.G. 1986. A history of the Navajos: the reservation years. Santa Fe, NM: School of American Research Press.

Bailey, L.R. 1994. "We'll all wear silk hats," the Erie and Chiricahua Cattle Companies and the rise of corporate ranching in the Sulphur Springs Valley of Arizona, 1883-1909. Tucson, AZ: Westernlore Press.

Bailey, L.R. 1998. Henry Clay Hooker and the Sierra Bonita. Tucson, AZ: Westernlore Press.

Baisan, C.H.; Swetnam, T.W. 1997. Interactions of fire regimes and land use in the central Rio Grande valley. Research Paper RM-RP-330. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Barnes, W.C. 1926. Story of the range. In: Public Lands and Surveys Committee, Senate hearings before a subcommittee. Washington, DC: 69th U.S.Senate, 1st Session, 2: 1579-1640.

Barrett, H.; Cagney, J.; Clark, R.; Fogg, J.; Gebhart, K.; Hansen, P.L.; Mitchell, B.; Prichard, D.; Tippy, D. 1995. Riparian area management: process for assessing proper functioning condition. Revised edition. TR 1737-9.Washington, DC: USDI Bureau of Land Management.

Baugh, T.G. 1984. The physical and cultural setting of the mixed grass prairie. In: Baugh, T.G., ed. Archaeology of the mixed grass prairie, phase I: Quartermaster Creek. Archeological Resource Survey Report No. 20. Norman: Oklahoma Archeological Survey: 167-187.

Baxter, J.O. 1987. Las carneradas: sheep trade in New Mexico, 1700-1860. Albuquerque: University of New Mexico Press.

Beck, W.A. 1962. New Mexico: a history of four centuries. Norman: University of Oklahoma Press.

Bell, W.H.; Castetter, E.F. 1941. The utilization of yucca, sotol, and beargrass by the aborigines in the American Southwest. Ethnobiological studies in the American Southwest VII. Albuquerque: University of New Mexico Press. 74 p.

Belsky, A.J.; Matzke, A.; Uselman, S. 1999. Survey of livestock influences on stream and riparian ecosystems in the Western United States. Journal of Soil and Water Conservation. 54: 419-431.

Benedict, C. 2001. (Personal communication). July 10. Albuquerque, NM: USDA Forest Service, Cibola National Forest.

Black Kettle and McClellan Creek National Grasslands. 2000. Black Kettle and McClellan Creek National Grasslands geographic area assessments, version 1. Unpublished report on file at: USDA Forest Service, Southwestern Region, Albuquerque, NM.

Black Kettle and McClellan Creek National Grasslands. 1999. Environmental assessment: livestock grazing and associated vegetation management: Black Kettle National Grassland—Roger Mills County, Oklahoma. Unpublished report on file at: USDA Forest Service, Black Kettle National Grassland, Cheyenne, OK.

Bolton, H.E., trans. and ed. 1919. Kino's historical memoir of Pimeria Alta (2 vols.). Cleveland, OH: A.H.Clark.

Bolton, H.E. 1949. Coronado, knight of Pueblos and Plains. New York: Whittlesey House.

Bolton, H.E., ed. 1952. Spanish Exploration in the Southwest, 1542-1706. New York: Barnes and Noble.

Bonnifield, P. 1979. The Dust Bowl. Men, dirt, and depression. Albuquerque: University of New Mexico Press.

Botts, B. 2001. Personal communication. September 2001. Albuquerque, NM: USDA Forest Service, Southwestern Region.

Box, T.W. 1990. Rangelands. In: Sampson, R.N.; Hair, D., eds. Natural resources for the 21st century. Covelo, CA: Island Press: 101-120.

Boyle, S.A.; Samson, F.B. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110-116.

Brown, J.H.; McDonald, W. 1995. Livestock grazing and conservation on southwestern rangelands. Conservation Biology. 9(6): 1644-1647.

Brugge, D.; Gerow, P.A. 2000. American Indian livestock operations on tribal lands in Arizona and New Mexico. In: Jemison, R; Raish, C., eds. Livestock management in the American Southwest: ecology, society, and economics. Amsterdam, Netherlands: Elsevier Science: 445-521.

Buffington, L.C.; Herbel, C.H. 1965. Vegetational changes on a semi-desert grassland range from 1858 to 1963. Ecological Monographs. 35(2): 139-164.

Burgess, D.L.; Nichols, J.D.; Henson, O.G. 1963. Soil survey of Roger Mills County, Oklahoma. Washington, DC: USDA Soil Conservation Service in cooperation with Oklahoma Agricultural Experiment Station.

Callenbach, E. 1996. Bring back the buffalo! A sustainable future for America's Great Plains. Washington, DC: Island Press.

Castetter, E.F.; Bell, W.H.; Grove, A.R. 1938. The early utilization and the distribution of agave in the American southwest. Ethnobiological studies in the American Southwest VI. Albuquerque: University of New Mexico Press. 92 p.

Cheeke, P.R.; Davis, S.L. 1997. Possible impacts of industrialization and globalization of animal agriculture on cattle ranching in the American West (Can environmentalists save the ranch?). Rangelands. 19: 4-5.

Clark, I.G. 1987. Water in New Mexico: a history of its management and use. Albuquerque: University of New Mexico Press.

Clifford, F. 1998. Ranchers seek economic, environmental balance: middle way redefines life in the West. The Press Democrat (Santa Rosa, Calif.), August 23.

Cofer, I.C. n.d. The lunch tree. Kingman, AZ: H & H Printers.

Cojeen, C.A. 2000. Report on the archaeological survey of the midway deep 3-D seismic

study, United States Forest Service portions, Roger Mills County, Oklahoma. Norman, OK: Cojeen Archaeological Services. Unpublished report 2000-03-021 on file at: USDA Forest Service, Cibola National Forest, Albuquerque, NM.
Committee on Rangeland Classification. 1994. Rangeland health: new methods to classify, inventory, and monitor rangelands. Washington, DC: National Academy Press.
Cooper, C.F. 1960. Changes in vegetation, structure, and growth of southwestern pine forests since White settlement. Ecological Monographs. 30: 129-164.
Cordell, L. 1997. Archaeology of the Southwest. San Diego, CA; London: Academic Press.
Creel, D.; Scott, R.F. IV; Collins, M.B. 1990. A faunal record from west central Texas and its bearing on Late Holocene bison population changes in the Southern Plains. Plains Anthropologist. 35: 55-69.
Crosby, A. 1972. The Columbian exchange: biological and cultural consequences of 1492. Westport, CN: Connecticut.
Dean, S.A. 1982. Acid drainage from abandoned metal mines in the Patagonia Mountains of southern Arizona. Tucson: University of Arizona. Thesis.
de Buys, W. 1985. Enchantment and exploitation: the life and hard times of a New Mexico mountain range. Albuquerque: University of New Mexico Press.
de Buys, W. 1995. Personal communication. Santa Fe, NM: Conservation Fund.
Dickerson, J. 2001. Personal communication. December 3. Cheyenne, OK: USDA Forest Service, Black Kettle National Grassland.
Dick-Peddie, W.A. 1993. New Mexico vegetation: past, present, and future. Albuquerque: University of New Mexico Press.
Dobyns, H.F. 1981. From fire to flood: historic human destruction of Sonoran desert riverine oases. Anthropology Papers 20. Socorro, NM: Ballena Press.
Doebley, J.F. 1984. Seeds of wild grasses: a major food of southwestern Indians. Economic Botany. 38: 52-64.
Donahue, D.L. 1999. The western range revisited: removing livestock from public lands to conserve native biodiversity. Norman: University of Oklahoma Press.
Drass, R.R.; Turner, C.L. 1989. An archeological reconnaissance of the Wolf Creek drainage basin, Ellis County, Oklahoma. Archeological Resource Survey Report No. 35. Norman: Oklahoma Archeological Survey.
Duncklee, J. 1994. Good year for the buzzards. Tucson: University of Arizona Press.
Dyksterhuis, E.J. 1949. Condition and management of range land based on quantitative ecology. Journal of Range Management. 2: 104-115.
Eastman, C. 1991. Community land grants: the legacy. Social Science Journal. 28(1): 101-117.
Eastman, C.; Carruthers, G.; Liefer, J.A. 1971. Evaluation of attitudes toward land in north-central New Mexico. Agricultural Experiment Station Bulletin 577. Las Cruces: New Mexico State University.
Eastman, C.; Gray, J.R. 1987. Community grazing: practice and potential in New Mexico. Albuquerque: University of New Mexico Press.
Eastman, C.; Raish, C.; McSweeney, A. 2000. Small livestock operations in northern New Mexico. In: Jemison, R; Raish, C., eds. Livestock management in the American Southwest: ecology, society, and economics. Amsterdam, Netherlands: Elsevier Science: 523-554.
Ebright, M. 1987. New Mexico land grants: the legal background. In: Briggs, C.L.; Van Ness, J.R., eds. Land, water, and culture: new perspectives on Hispanic land grants. Albuquerque: University of New Mexico Press: 15-64.
Eckert, R.W.Jr.; Wood, M.K.; Blackburn, W.H.; Peterson, F.F. 1979. Impact of off-road vehicles on infiltration and sediment production of two desert soils. Journal of Range Management. 35: 715-716.
Elmore, W.; Kauffman, B. 1994. Riparian and watershed systems: degradation and restoration. In: Vavra, M.; Laycock, W.A.; Pieper, R.D., eds. Ecological implications of livestock herbivory in the West. Denver, CO: Society for Range Management: 212-231.
Elson, J.W. 1992. Tri cultures of New Mexico. Rangelands. 14(5): 261-264.
Engle, D.M.; Bidwell, T.G. 2000. Plains grasslands. In: Jemison, R; Raish, C., eds. Livestock management in the American Southwest: ecology, society, and economics. Amsterdam, Netherlands: Elsevier Science: 97-152.
Evans, K.E. 1990. Rangeland research: past, present, and future. Washington, DC: USDA Forest Service, Forest Environment Research.
Everett, R.L. 1992. Change on the range: new perspectives for rangeland research in the 90's. Washington, DC: USDA Forest Service, Forest Environment Research.
Farrell, M.M. 2002. (e-mail message to C.Raish). February 8. Message on file at: USDA Forest Service, Rocky Mountain Research Station, Albuquerque Lab, Albuquerque, NM.
Ferguson, D.; Ferguson, N. 1983. Sacred cows at the public trough. Bend, OR: Maverick Publications.
Flather, C.H.; Cordel, H.K. 1995. Outdoor recreation: historical and anticipated trends. In: Knight, R.L.; Gutzwiller, K.J., eds. Wildlife and recreationists. Washington, DC: Island Press: 3-16.
Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology. 8: 629-644.
Flieger, J.C. 1991. Dreams come true for cowboys too. Tucson, AZ: Western Lore Press.
Fowler, J. 2000. Historic range livestock industry in New Mexico. In: Jemison, R.; Raish, C., eds. Livestock management in the American Southwest: ecology, society, and economics. Amsterdam, Netherlands: Elsevier Science: 419-444.
Fowler, J.M.; Rush, D.; Hawkes, J.M.; Darden, T.D. 1994. Economic characteristics of the western livestock industry. Range Improvement Task Force, Agricultural Experiment Station, Cooperative Extension Service, College of Agriculture and Home Economics Report 35. Las Cruces, NM: New Mexico State University.
Fredine, J.; Jones-Bartholomew, D.A.; Bowden, J.; Crollett, E.T.; Teigrob, R. 1999. Archaeological survey of 3,330 acres for the Mills Upland project, Cibola National Forest, Harding and Mora Counties, New Mexico. Albuquerque, NM: Lone Mountain Archaeological Services. Unpublished report 1999-03-007 on file at: USDA Forest Service, Cibola National Forest, Albuquerque, NM.
Gardner, R. 1970. Grito! Reies Tijerina and the New Mexico land grant war of 1967. Indianapolis, IN: Bobbs-Merril.
Gentry, H.S. 1998 (second printing of 1982 text). Agaves of continental North America. Tucson: University of Arizona Press. 670 p.
Gifford-Gonzalez, D.P.; Damrosch, D.B.; Damrosch, D.R.; Pryor, J.; Thunen, R.L. 1985. The third dimension in site structure: an experiment in trampling and vertical dispersal. American Antiquity. 50(4): 803-818.
Glassow, M.A. 1972. The evolution of early agricultural facilities systems in the northern Southwest. Los Angeles: University of California. Dissertation.
Gonzales, C. 2002. E-mail message to C. Raish. January 28. Message on file at: USDA Forest Service, Rocky Mountain Research Station, Albuquerque Lab, Albuquerque, NM.
Gonzales, N.L. 1969. The Spanish-Americans of New Mexico: a heritage of pride. Albuquerque: University of New Mexico Press.
Gregg, J. 1954. Commerce of the Plains. New York: Bobbs-Merrill (originally published 1849, New York: H.G. Langley).
Guess, C.A. 1999. The national movement for better land use: Valle Grande Grass Bank Demonstration Project: a case study of range restoration in northern New Mexico. Unpublished professional project on file at: University of New Mexico, School of Architecture and Planning, Albuquerque, NM.
Gunnerson, J.H. 1987. Archeology of the High Plains. Denver, CO: USDA Forest Service, Rocky Mountain Region.
Hadley, D.; Sheridan, T.E. 1995. Land use history of the San Rafael Valley, Arizona (1540-1960). Gen. Tech. Rep. RM-269. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.
Hall, S.A. 1985. Quaternary pollen analysis and vegetational history of the Southwest. In: Holloway, R.G., ed. Pollen records of late-quaternary North American sediments. Dallas, TX: American Association of Stratigraphic Palynologists Foundation: 95-123.
Hammond, G.P.; Rey, A. 1953. Don Juan de Onate, colonizer of New Mexico, 1595-1628 (1). Albuquerque: University of New Mexico Press.

Harper, A.G.; Cordova, A.R.; Oberg, K. 1943. Man and resources in the middle Rio Grande valley. Albuquerque: University of New Mexico Press.
Hassell, M.J. 1968. The people of northern New Mexico and the National Forests. Unpublished paper on file at: USDA Forest Service, Southwestern Region, Albuquerque, NM.
Hays, J.S.; Brooks, R.L.; Hofman, J.L. 1989. Historical Archaeology in the southern Great Plains. In: Hofman, J.L.; Brooks, R.L.; Hays, J.S.; Owsley, D.W.; Jantz, R.L.; Marks, M.K.;
Manhein, M.H., eds. From Clovis to Comanchero: archeological overview of the southern Great Plains. Arkansas Archeological Survey Research Series No. 35. Fayetteville: Arkansas Archeological Survey: 101-110.
Hecht, M.E.; Reeves, R.W. 1981. Atlas of Arizona. Tucson: University of Arizona, Office of Arid Lands Studies.
Heimlich, R.E.; Anderson, W.D. 2001. Development at the urban fringe and beyond: impacts on agriculture and rural land. ERS Agricultural Economic Report No. 803. Washington, DC: Government Printing Office.
Hess, K., Jr. 1990. The wilderness experience: New Mexico ranches on National Forest wilderness. Special Report No. 7. Las Cruces: New Mexico Department of Agriculture.
Hofman, J.L. 1989. Protohistoric culture history. In: Hofman, J.L.; Brooks, R.L.; Hays, J.S.; Owsley, D.W.; Jantz, R.L.; Marks, M.K.; Manhein, M.H., eds. From Clovis to Comanchero: archeological overview of the southern Great Plains. Arkansas Archeological Survey Research Series No. 35. Fayetteville: Arkansas Archeological Survey: 91-100.
Holechek, J. 2001. A growing population, rangelands and the future. Rangelands. 23(6): 39-43.
Holechek, J.L.; Pieper, R.D.; Herbel, C.H. 1998. Range management: principles and practices. Englewood Cliffs, NJ: Prentice-Hall.
Huckell, B.B. 1995. Of marshes and maize. Anthropological Papers of the University of Arizona No. 59. Tucson: University of Arizona Press.
Hughes, J.T. 1991. Prehistoric cultural developments on the Texas High Plains. Bulletin of the Texas Archeological Society. 60: 1-56.
Hughes, S. 1980. Chuck wagon cookin'. Tucson: University of Arizona Press.
Hyder, D.N. 1972. Defoliation in relation to vegetative growth. In: Younger, V.B.; McKell, C.M., eds. The biology and utilization of grasses. New York: Academic Press: 304-317.
Joyce, L.A. 1993. The life cycle of the range condition concept. Journal of Range Management. 46: 132-138.
Kennedy, J.J.; Fox, B.L.; Osen, T.D. 1995. Changing social values and images of public rangeland management. Rangelands. 17(4): 127-132.
Kiowa and Rita Blanca National Grasslands. 1999. Kiowa and Rita Blanca National Grasslands geographic area assessments, version 1. Unpublished report on file at: USDA Forest Service, Southwestern Region, Albuquerque, NM.
Knight, R.L. 2002. The ecology of ranching. In: Knight, R.L.; Gilgert, W.C.; Marston, E., eds. Ranching west of the 100th meridian. Washington, DC: Island Press: 123–144.
Knowlton, C.S. 1967. Land grant problems among the state's Spanish-Americans. New Mexico Business. 20:1-13.
Knowlton, C.S. 1980. The town of Las Vegas community land grant: an Anglo American coup d=état. Journal of the West. 19(3): 12-21.
Knowlton, C.S. 1985. Reies L. Tijerina and the Alianza Federal de Mercedes: seekers after justice. Wisconsin Sociologist. 22(4): 133-144.
Knudson, R. 1979. Inference and imposition in lithic analysis. In: Hayden, B., ed. Lithic use-wear analysis. New York: Academic Press: 269-281.
Kreutz, K.J.; Mayewski, P.A.; Meeker, M.S.; Twickler, S.I.; Whitlow, I.P. 1997. Bipolar changes in atmospheric circulation during the Little Ice Age. Science. 277: 1294-1296.
Kruse, W.H.; Jemison, R. 2000. Grazing systems of the Southwest. In: Jemison, R.; Raish, C., eds. Livestock management in the American Southwest: ecology, society, and economics. Amsterdam, Netherlands: Elsevier Science: 27-52.
Kuchler, A.W. 1964. Potential natural vegetation of the coterminous United States. Special Publication 36. New York: American Geographical Society.
Kutsche, P.; Van Ness, J.R. 1981. Cañones: values, crisis, and survival in a northern New Mexico village. Albuquerque: University of New Mexico Press.
Le Blanc, S.A. 1985. History and environments in the Mimbres Valley. Masterkey. 59(1): 18-24.
Lee, K.N. 1993. Compass and gyroscope: integrating science and politics for the environment. Covelo, CA: Island Press.
Leopold, A. 1924. Grass, brush, timber, and fire in southern Arizona. Journal of Forestry. 22: 1-10.
Lewis, M. 1989. National grasslands in the Dust Bowl. The Geographical Review 79(2).
Linden, M. 2001. (Personal communication). August 16. Albuquerque, NM: USDA Forest Service, Southwestern Region.
Loftin, S.R.; Bock, C.E.; Bock, J.H.; Brantley, S.L. 2000. Desert grasslands. In: Jemison, R.; Raish, C., eds. Livestock management in the American Southwest: ecology, society, and economics. Amsterdam, Netherlands: Elsevier Science: 53-96.
Macon, D. 1998. What will become of the West? Rangelands. 20(4): 4-5.
Maestas, J.D.; Knight, R.L.; Gilgert, W.C. 2002. Holy cow! Biodiversity on ranches, developments, and protected areas in the "New West." Quivira Coalition. 5(1): 1, 23-30.
Mattison, R.H. 1946. Early Spanish and Mexican settlements in Arizona. New Mexico Historical Review. 21: 273-327.
McCarty, K. 1976. Desert documentary: the Spanish years, 1776-1821. Historical Monograph No. 4. Tucson: Arizona Historical Society.
McCormick, R.C. 1865. Arizona: Its resources and prospects. Tucson, AZ: Territorial Press (reprint 1968).
McQueen, R.E. 2000. World population growth, distribution and demographics and their implications on food production. Canadian Journal of Animal Science. 80: 229-234.
McSweeney, A.M. 1995. Views on land and nature: conversations with northern New Mexico ranchers. Las Cruces, NM: New Mexico State University. M.S.Thesis.
Medina, A.L. 1996. The Santa Rita Experimental Range: annotated bibliography (1903-1988). Gen. Tech. Rep. RM-GTR-276. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.
Melville, E.G.K. 1994. A plague of sheep: environmental consequences of the conquest of Mexico. Cambridge: Cambridge University Press.
Menning, N.; Raish, C. 2000. From ranchers to recreationists, loggers to environmentalists: collaborative decision making in the New West. In: Schneider, I.E.; Chavez, D.; Borrie, B.; James, K., eds. The third symposium on social aspects and recreation research: diverse challenges of our times: people, products, places. Tempe: Arizona State University: 103-111.
Mitchell, J.E. 2000. Rangeland resource trends in the United States: a technical document supporting the 2000 USDA Forest Service RPA Assessment. Gen. Tech. Rep. RMRS-GTR-68. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station.
Mitchell, J.E.; Fletcher, R. 1996. Perceptions of grazing on Forest Service land. USDA Forest Service, Forestry Research West.
Moir, W. 2003. Personal communication. Flagstaff, AZ: USDA Forest Service, Rocky Mountain Research Station (Retired).
Mortensen, D.R. 1978. The deterioration of forest grazing land: a wider context of the effects of World War I. Journal of Forest History. 22: 224-225.
Nabhan, G.P. 1985. Gathering the desert. Tucson: University of Arizona Press. 209 p.
Nabhan, G.P. 1989.Enduring seeds, Native American agriculture and wild plant conservation.Berkele, CA: North Point Press.
NatureWatch. 1996. NatureWatch: an economic engine: 1996 national survey of fishing, hunting, and wildlife-associated recreation. USDI Fish and Wildlife Service. Unpublished information on file at: USDA Forest Service, Southwestern Region, Albuquerque, NM.
Officer, J.E. 1987. Hispanic Arizona, 1536-1856. Tucson, AZ: University of Arizona Press.
Osborn, A.; Vetter, S; Hartley, R.; Walsh, L.; Brown, J. 1987. Impacts of domestic livestock grazing on the archeological resources of Capitol Reef National Park, Utah. Midwest Archeological Center Occasional Studies in Anthropology No. 20. Lincoln, NE: USDI National Park Service, Midwest Archeological Center.

Paul, R.W. 1963. Mining frontiers of the far west: 1848-1880. New York: Holt, Rinehart and Winston.
Payne, G.F.; Foster, J.W.; Leininger, W.C. 1983. Vehicle impacts of northern Great Plains range vegetation. Journal of Range Management. 36: 327-331.
Peplow, E.H., Jr. 1958. History of Arizona (2). New York, NY: Lewis Historical Publishing.
Periman, R.D. 2001. The changing cultural landscapes of New Mexico's Rio del Oso valley. Albuquerque, NM: University of New Mexico. Dissertation.
Periman, R.D.; Kelly, J.F. 2000. The dynamic environmental history of Southwest Willow Flycatcher habitat: a survey of changing riparian conditions through time. In: Finch, D.M.; Stoleson, S.H., eds. Status, ecology, and conservation of the Southwestern Willow Flycatcher. Gen. Tech. Rep. RMRS-GTR-60. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station: 25-42.
Pilles, P.J. 2002. E-mail message to C. Raish. March 6. Message on file at: USDA Forest Service, Rocky Mountain Research Station, Albuquerque Lab, Albuquerque, NM.
Pyne, S.J. 1982. Fire in America. Princeton, NJ: Princeton University Press.
Raish, C. 2000a. Environmentalism, the Forest Service, and the Hispano communities of northern New Mexico. Society and Natural Resources. 13(5): 489-508.
Raish, C. 2000b. Lessons for restoration in traditions of stewardship: sustainable land management in northern New Mexico. In: Gobster, P.H.; Hull, R.B., eds. Restoring nature: perspectives from the social sciences and humanities. Washington DC; Covelo, CA: Island Press: 281-297.
Raish, C. 2000c. Ranching in the American Southwest: conflict and compromise. In: Jemison, R.; Raish, C., eds. Livestock management in the American Southwest: ecology, society, and economics. Amsterdam, Netherlands: Elsevier Science: 373-378.
Raish C.; McSweeney A. 2001. Livestock ranching and traditional culture in northern New Mexico. Natural Resources Journal. 41(3): 1-18.
Raish, C.; Yong, W.; Marzluff, J. 1997. Contemporary human use of Southwestern ponderosa pine forests. In: Block, W.M.; Finch, D.M., eds. Songbird ecology in Southwestern ponderosa pine forests: a literature review. Gen. Tech. Rep. RM-292. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 28-42.
Rapport, D.J.; Regier, H.A.; Hutchinson, T.C. 1985. Ecosystem behavior under stress. The American Naturalist. 125: 617-640.
Rasmussen, D.I. 1941. Biotic communities of the Kaibab Plateau, Arizona. Ecological Mongographs. 11: 229-275.
Reher, C.A. 1977. Adaptive processes on the shortgrass Plains. In: Binford, L.R., ed. For theory building in archaeology. New York, NY: Academic Press: 13-40.
Riebsame, W.E.; Gosnell, H.; Theobold, D.M. 1996. Land use and landscape change in the Colorado mountains I: theory, scale, and pattern. Mountain Research and Development. 16: 395-405.
Riebsame, W.E., gen. ed.; Robb, J.J., dir. cart.; Gosnell, H.; Theobold, D.M.; Breding, P.; Hanson, C.; Rokoske, K. 1997. Atlas of the New West: portrait of a changing region. New York: W.W. Norton and Company.
Roberts, P.H. 1963. Hoofprints on forest ranges: the early years of National Forest range administration. San Antonio, TX: Naylor.
Robertson, F.D. 1992. Riparian management—a leadership challenge. Unnumbered pamphlet. Washington, DC: USDA Forest Service.
Robinson, G.O. 1975. The Forest Service: a study in public land management. Baltimore, MD; London: The Johns Hopkins University Press.
Rome, A. 2001. The bulldozer in the countryside: suburban sprawl and the rise of American environmentalism. New York, NY: Cambridge University Press.
Rosenbaum, R.J. 1981. Mexicano resistance in the Southwest. Austin: University of Texas Press.
Roth, D. 1997. The National Forests and the campaign for wilderness legislation. In: Miller, C., ed. American forests: nature, culture, and politics. Lawrence: University Press of Kansas: 229-246.
Rothman, H. 1989. Cultural and environmental change on the Pajarito Plateau. New Mexico Historical Review. 64(2): 185-211.
Rowley, W.D. 1985. U.S. Forest Service grazing and rangelands: a history. College Station, TX: Texas A & M University Press.
Ruyle, G.B.; Tronstad, R.; Hadley, D.W.; Heilman, P.; King, D.A. 2000. Commercial livestock operations in Arizona. In: Jemison, R.; Raish, C., eds. Livestock management in the American Southwest: ecology, society, and economics. Amsterdam, Netherlands: Elsevier Science: 379-417.
Schickedanz, J.G. 1980. History of grazing in the southwest. In: McDaniel, K.C.; Allison, C., eds. Grazing management systems for southwest rangelands: a symposium. Albuquerque, NM: The Range Improvement Task Force: 1-9.
Schlesinger, A.B. 1971. Las gorras blancas, 1889-1891. Journal of Mexican American History. 1(2): 87-143.
Schlesinger, W.H.; Reynolds, J.F.; Cunningham, G.L.; Huenneke, L.F.; Jarrell, W.M.; Ross, V.A.; Whetford, W.G. 1990. Biological feedbacks in global desertification. Science. 247: 1043-1048.
Scurlock, D. 1995a. Environmental history. In: Finch, D.M.; Tainter, J.A., eds. Ecology, diversity, and sustainability of the middle Rio Grande basin. Gen. Tech. Rep. RM-268. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 12-28.
Scurlock, D. 1995b. Middle Rio Grande basin environmental history: an overview of resource management and conservation, 1846-1980. Unpublished paper on file at: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station (now Rocky Mountain Research Station), Albuquerque Lab, Albuquerque, NM.
Scurlock, D. 1998. From the rio to the sierra: an environmental history of the middle Rio Grande basin. Gen. Tech. Rep. RMRS-GTR-5. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station.
Sebastian, L.; Levine, F. 1989a. The Mexican and American Historical Periods. In: Sebastian, L.; Larralde, S., eds. Living on the land: 11,000 years of human adaptation in southeastern New Mexico, an overview of cultural resources in the Roswell District. Roswell, NM: USDI Bureau of Land Management, Roswell District: 105-126.
Sebastian, L.; Levine, F. 1989b. The Protohistoric and Spanish Colonial Periods. In: Sebastian, L.; Larralde, S., eds. Living on the land: 11,000 years of human adaptation in southeastern New Mexico, an overview of cultural resources in the Roswell District. Roswell, NM: USDI Bureau of Land Management, Roswell District: 93-104.
Secretary of Agriculture. 1936. The western range. Senate Document 199. Washington, DC: U.S. Government Printing Office.
Seescholtz, D. 2000. (Personal communication). September 27. Taos, NM: USDA Forest Service, Carson National Forest.
Seperich, G.J., Ward, W.B.; Woolverton, M.W. 1995. A survey of Arizona ranch industry cost and return estimates. A Grazing Land Valuation Commission Study, April 1995.
Sheridan, T.E. 2001. Cows, condos, and the contested commons: the political ecology of ranching on the Arizona-Sonora borderlands. Human Organization. 60(2): 141-152.
Simmons, M. 1979. History of Pueblo-Spanish relations to 1821. In: Ortiz, A., ed. Handbook of North American Indians: Southwest (9). Washington, DC: Smithsonian Institution: 178-193.
Simpson, S.; Wilcox, S.; Holmes, R.D.; Acklen, J.C. 1998. Cultural resource inventory of the Washita 3-D seismic project, Roger Mills County, Oklahoma. Albuquerque, NM: TRC Companies. Unpublished report 1998-03-011 on file at: USDA Forest Service, Cibola National Forest, Albuquerque, NM.
Smith, A.H.; Martin, W.E. 1972. Socioeconomic behavior of cattle ranchers with implications for rural community development in the West. American Journal of Agricultural Economics. 54: 217-225.
Steen, H.K. 1976. The U.S. Forest Service: a history. Seattle, WA; London: University of Washington Press.
Steen, H.K. 1998. Forest Service research: finding answers to conservation's questions. Durham, NC: Forest History Society.
Stephens, A.R.; Holmes, W.M. 1989. Historical atlas of Texas. Norman: University of Oklahoma Press.

Stout, J.A., Jr.; Faulk, O.B. 1974. A short history of the American West. New York: Harper and Row.
Sullins, M.J.; Theobold, D.T.; Jones, J.R.; Burgess, L.M. 2002. Lay of the land: ranch land and ranching.In: Knight, R.L.; Gilgert, W.C.; Marston, E., eds. Ranching west of the 100th meridian. Washington, DC: Island Press: 25-31.
Sullivan, A.P., III. 1996. Risk, anthropogenic environments, and Western Anasazi subsistence. In: Tainter, J.A.; Tainter, B.B., eds. Evolving complexity and environmental risk in the prehistoric Southwest: Proceedings of the workshop on resource stress, economic uncertainty, and human response in the prehistoric Southwest; 1992 February 25-29; Santa Fe, NM. Proceedings Volume 24, Santa Fe Institute Studies in the Sciences of Complexity. Reading, MA: Addison-Wesley: 145-167.
Swanson, L. 2001. The West's forest lands: magnets for new migrants and part-time residents. Changing Landscape. 2: 16–25.
Tainter, J.A.; Tainter, B.B. 1996. Riverine settlement in the evolution of prehistoric land-use systems in the middle Rio Grande valley, New Mexico. In: Shaw, D.W.; Finch, D.M., tech. coords. Desired future conditions for Southwestern riparian ecosystems: bringing interests and concerns together; 1995 September 18-22; Albuquerque, NM. Gen. Tech. Rep. RM-GTR-272. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 22-32.
Task Group on Unity in Concepts and Terminology. 1995. New concepts for assessment of rangeland condition. Journal of Range Management. 48: 271-282.
Tellman, B.; Yarde, R.; Wallace, M.G. 1997. Arizona's changing rivers: how people have affected the rivers. Water Resources Research Center, Issue Paper No. 19. Tucson, AZ: University of Arizona.
Terrestrial Ecosystem Survey (TES) Handbook. 1986. FSH R3 2509.14. Albuquerque, NM: USDA Forest Service, Southwestern Region. Pp. 137.
Thakali, R.; Lesko, L. 1998. Wisdom of the ages: traditional knowledge and forest ecosystems. Unpublished paper on file at: USDA Forest Service, Kaibab National Forest, Williams, AZ.
Theobald, D.M. 2000. Fragmentation by inholdings and exurban development. In: Knight, R.L.; Smith, F.H.; Buskirk, S.W.; Romme, W.H.; Baker, W.L., eds. Forest fragmentation in the Southern Rocky Mountains. Boulder: University Press of Colorado: 155–174.
Torell, L.A.; Hawkes, J.M.; Stromei, T.D. 1998. Range livestock cost and return estimates for
New Mexico, 1996. Agricultural Experiment Station Research Report 726. Las Cruces: New Mexico State University.
Trimble, M. 1989. Arizona: a cavalcade of history. Tucson, AZ: Treasure Chest Publications.
Tucker, E.A., comp. 1989. The early days: a sourcebook of Southwestern Region history (1). Cultural Resources Management Report No. 7. Albuquerque, NM: USDA Forest Service, Southwestern Region.
Tucker, E.A., comp. 1992. The early days: a sourcebook of Southwestern Region history (3). Cultural Resources Management Report No. 12. Albuquerque, NM: USDA Forest Service, Southwestern Region.
Udall, S.L. 1995. Majestic journey: Coronado's inland empire. Santa Fe: Museum of New Mexico Press.
United Nations. 1998. World population projections to 2150. New York: United Nations Secretariat, Population Division of the Department of Economic and Social Affairs.
U.S. Department of Agriculture, Forest Service. 2000. Fiscal Year 2000 financial report, Region 3, oil and gas leases. Unpublished information on file at: USDA Forest Service, Southwestern Region, Albuquerque, NM.
U.S. Department of Agriculture, Forest Service, Range Management. 1997. Grazing statistical summary, FY 1996. Washington, DC: USDA Forest Service, Range Management.
U.S. Department of Agriculture, Forest Service, Range Management. 1998. Grazing statistical summary, FY 1997. Washington, DC: USDA Forest Service, Range Management.
U.S. Department of Agriculture, Forest Service, Range Management. 1999.Grazing statistical summary, FY 1998. Washington, DC: USDA Forest Service, Range Management.
U.S. Department of Agriculture, National Agricultural Statistics Service. 1997. The cattle U.S. summary. Report 3050. Washington, DC: Agricultural Statistics Board.
U.S. Department of Agriculture, Natural Resources Conservation Service. 1995. Summary report 1992 National Resources Inventory. Revised edition. Ames, IA: Iowa State University, Statistical Laboratory.
U.S. Department of Agriculture, Soil Conservation Service. 1976. National range handbook. NRH-1. Washington, DC: USDA Soil Conservation Service.
U.S.Department of Agriculture, Soil Conservation Service. 1987. Basic statistics: 1982 National Resources Inventory. Statistical Bulletin 756. Ames: Iowa State University, Statistical Laboratory.
U.S. Department of Agriculture, Soil Conservation Service. 1990. The second RPA appraisal. Revised edition. USDA Miscellaneous Publication Number 1482. Washington, DC: U.S. Government Printing Office.
U.S. Department of Interior, Bureau of Land Management. 1984. Ecological site inventory. BLM Manual 4410; H-4410-1. Washington, DC: USDI Bureau of Land Management.
U.S. Department of Interior, Bureau of Land Management. 1991. Riparian-wetland initiative for the 1990's. BLM/WO/GI-91/001+4340. Washington, DC: USDI Bureau of Land Management.
U.S .Department of Interior, Bureau of Land Management. 1997. National rangeland inventory, monitoring, and evaluation report, fiscal year 1997. Denver, CO: USDI Bureau of Land Management, National Applied Sciences Center.
U.S. Department of Interior, Bureau of Land Management; U.S. Department of Agriculture, Forest Service, BLM/FS Rocky Mountain Regional Coordinating Committee. 1989. Surface operating standards for oil and gas exploration and development: "Gold Book." USDI Bureau of Land Management; USDA Forest Service, BLM/FS Rocky Mountain Regional Coordinating Committee.
U.S. Department of Interior, Bureau of Land Management; U.S. Department of Agriculture, Forest Service, BLM/FS Rocky Mountain Regional Coordinating Committee. 1989. Uniform format for oil and gas lease stipulations. USDI Bureau of Land Management; USDA Forest Service, BLM/FS Rocky Mountain Regional Coordinating Committee.
Van Ness, J.R. 1987. Hispanic land grants: ecology and subsistence in the uplands of northern New Mexico and southern Colorado. In: Briggs, C.L.; Van Ness, J.R., eds. Land, water, and culture: new perspectives on Hispanic land grants. Albuquerque, NM: University of New Mexico Press: 141-214.
Wang, K.M.; Hacker, R.B. 1997. Sustainability of rangeland pastoralism—a case study from the west Australian arid zone using stochastic optimal control theory. Journal of Environmental Management. 50: 147-170.
Weber, D.J. 1992. The Spanish frontier in North America. New Haven, CN: Yale University Press.
West, R. 1993.Sonora: its geographical personality. Austin: University of Texas Press.
Westoby, M.; Walker, B.; Noy-Meir, I. 1989. Opportunistic management for rangelands not at equilibrium. Journal of Range Management. 42: 266-274.
Westphall, V. 1965. The public domain in New Mexico, 1854-1891. Albuquerque: University of New Mexico Press.
Whittlesey, S.M.; Majewski, T.; Welch, J.R.; Bischoff, M.C.; Ciolek-Torrello, R. 1997. Euroamerican history, 1540 to the present. In: Whittlesey, S.M.; Ciolek-Torrello, R.; Altschul, J.H., eds. Vanishing river: landscapes and lives of the lower Verde valley: the lower Verde archaeological project: overview, synthesis, and conclusions. Tucson, AZ: SRI Press: 281-336.
Wildeman, G.; Brock, J.H. 2000. Grazing in the Southwest: history of land use and grazing since 1540. In: Jemison, R.; Raish, C., eds. Livestock management in the American Southwest: ecology, society, and economics. Amsterdam, Netherlands: Elsevier Science: 1-25.
Wozniak, F.E. 1995. Human ecology and ethnology. In: Finch, D.M., Tainter, J.A., tech. eds. Ecology, diversity, and sustainability of the middle Rio Grande basin. Gen. Tech. Rep. RM-GTR-268. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 29-51.