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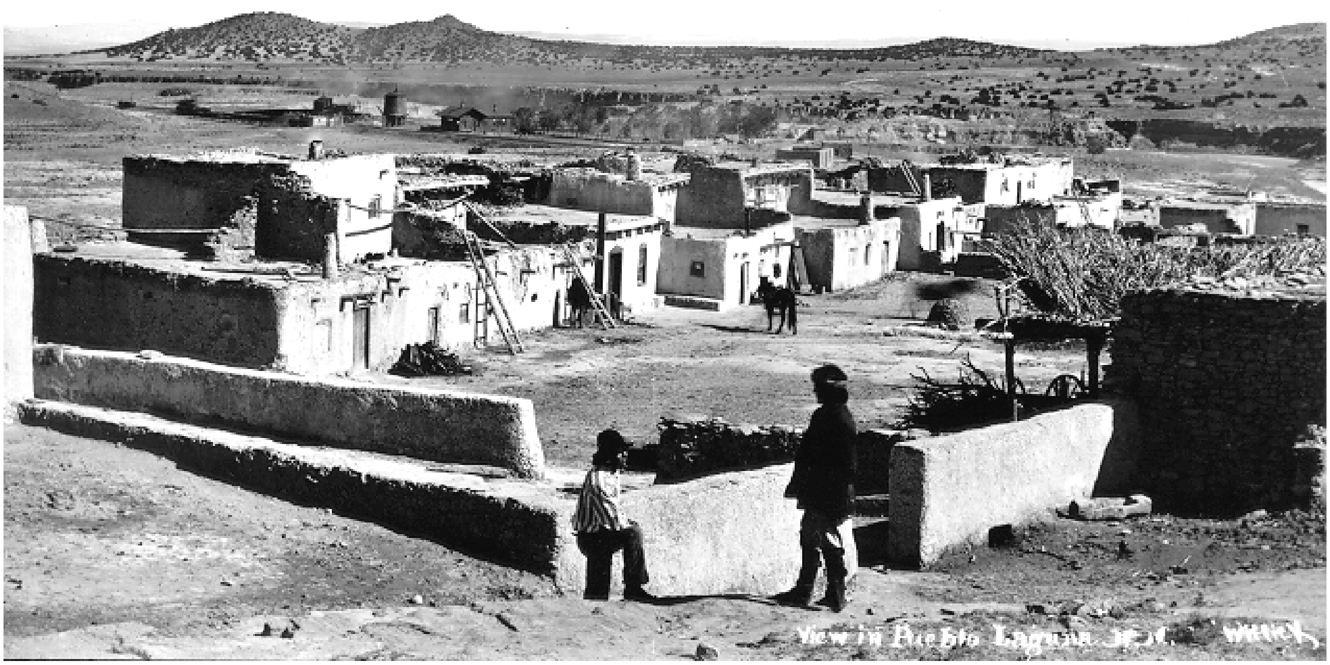
**General Technical Report
RMRS-GTR-5**

From the Rio to the Sierra: **An Environmental History of the Middle Rio Grande Basin**

Dan Scurlock



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Abstract

Various human groups have greatly affected the processes and evolution of Middle Rio Grande Basin ecosystems, especially riparian zones, from A.D. 1540 to the present. Overgrazing, clear-cutting, irrigation farming, fire suppression, intensive hunting, and introduction of exotic plants have combined with droughts and floods to bring about environmental and associated cultural changes in the Basin. As a result of these changes, public laws were passed and agencies created to rectify or mitigate various environmental problems in the region. Although restoration and remedial programs have improved the overall "health" of Basin ecosystems, most old and new environmental problems persist.

Keywords: environmental impact, environmental history, historic climate, historic fauna, historic flora, Rio Grande

Publisher's Note

 The author withheld diacritical marks from the Spanish words in text for consistency with English punctuation.

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Cover photo: View northeast of Laguna Pueblo and landscape. Ben Wittick photo, ca. 1883. Courtesy School of American Research and Museum of New Mexico, Santa Fe (negative no. 16051).

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From the Rio to the Sierra: An Environmental History of the Middle Rio Grande Basin

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MAPS

CHAPTER 1

INTRODUCTION

For more than 450 years the ecosystems of the Middle Rio Grande Basin have evolved dynamically with the interrelated vagaries of climate, land forms, soils, fauna, flora, and most importantly, human activities. Various land use practices have caused an array of environmental problems. Activities such as grazing, irrigation farming, logging, and constructing flood control features, combined with climatic fluctuations, have produced changes in stream flow-morphology, groundwater levels, topsoils, biotic communities, and individual species. Indigenous human populations have, in turn, been impacted by modifications in these resources. This report examines these processes, impacts, and changes in depth.

SCOPE OF THE PROJECT

This study of the environmental history of the Middle Rio Grande Basin, and to a lesser degree the Upper Basin (Fig. 1), was begun on June 1, 1994, and continued until February 15, 1996. This project is part of a multidisciplinary research program called "Ecology, Diversity, and Sustainability of Soil, Plant, Animal and Human Resources of the Rio Grande Basin" and was initiated by the U.S. Forest Service, Rocky Mountain Research Station, Albuquerque, in 1994. The larger 5-year study is focused on the retrieval, synthesis, and interpretation of extant and new data on the Middle Basin to better understand ecological processes, including not only the interrelationship of physical and biological components of ecosystems but also the human element. As the dominant force and agent of change, various human groups or eco-cultures[1] have impacted all Basin ecosystems for more than 10,000 years (Stuart 1986: a–c).

To address these interrelationships over time, the study team, under the direction of Deborah M. Finch, identified four areas of research: (1) responses of upland ecosystem components to "natural" as well as human perturbations and how these responses have affected or will affect the dynamics, stability, and productivity of these ecosystems; (2) interrelationships of lowland riparian and upland ecosystems of the past and present; (3) species responses to barriers in dispersal, migration, and reproduction along the Rio Grande and selected tributaries and identification of those plants or animals and their needs for sustainable management; and (4) environmental history of the Basin to better understand the kind and extent of human interactions with ecosystems and the sustainability of such traditional eco-cultural activities within regional ecosystems.

The focus and context of these research areas are interrelated and grounded in environmental history as they relate to human uses, impacts, and changes within a context of climate, fire, and other ecosystem dynamics. Further, environmental changes generated by various groups sometimes resulted in modification of their world views and economic systems. Without a better understanding of these historical processes and their end results, bioremediation and sustainability of Basin ecosystems, including traditional lifeways, will be difficult if not impossible to accomplish. This report on the environmental history of the Middle and Upper Rio Grande basins[2] provides data pertinent to all four research areas.

The Middle Basin includes the Rio Grande from Bandelier National Monument to the upper end of Elephant Butte Reservoir and seven major tributaries—Santa Fe River, Galisteo Creek, Jemez River, Las Huertas Creek, Rio Puerco, Rio San Jose, and Rio Salado. Within this region are three national forests—Carson, Santa Fe, and Cibola—in which lie the southern Sangre de Cristo, Jemez, Sandia, part of the Zuni and Datil, Manzano, Ladron, Los Pinos, Magdalena, and San Mateo mountains (Fig. 2).

The Upper Basin extends northward embracing the Espanola Basin, the Rio Chama, the Rio Grande Gorge, the uplands of the Carson National Forest, and the uppermost watershed of the river in southern Colorado (Figs. 1 and 3). This latter area includes the San Luis Basin, part of the northern Sangre de Cristo Mountains, and the eastern extension of the San Juan Mountains in the Rio Grande National Forest.

The Upper Basin is included in this study for several reasons. The Middle Valley ecosystem is first and foremost driven by water, and much of this resource comes

[1] *For these distinct groups interacting with and changing their environment, the term eco-cultures will be used in this report to reflect their ecological use of, impact on, and interaction with the resources and ecology of the area. Also, archeological remains of these groups will be referred to as eco-cultural resources. This term precludes the use of more cumbersome, and misleading, compound descriptors such as "cultures and environments" or "humans and nature."*

[2] *Collectively, these two basins will be referred to as the "study region." Use of the term "region" refers to the study region and adjacent areas.*

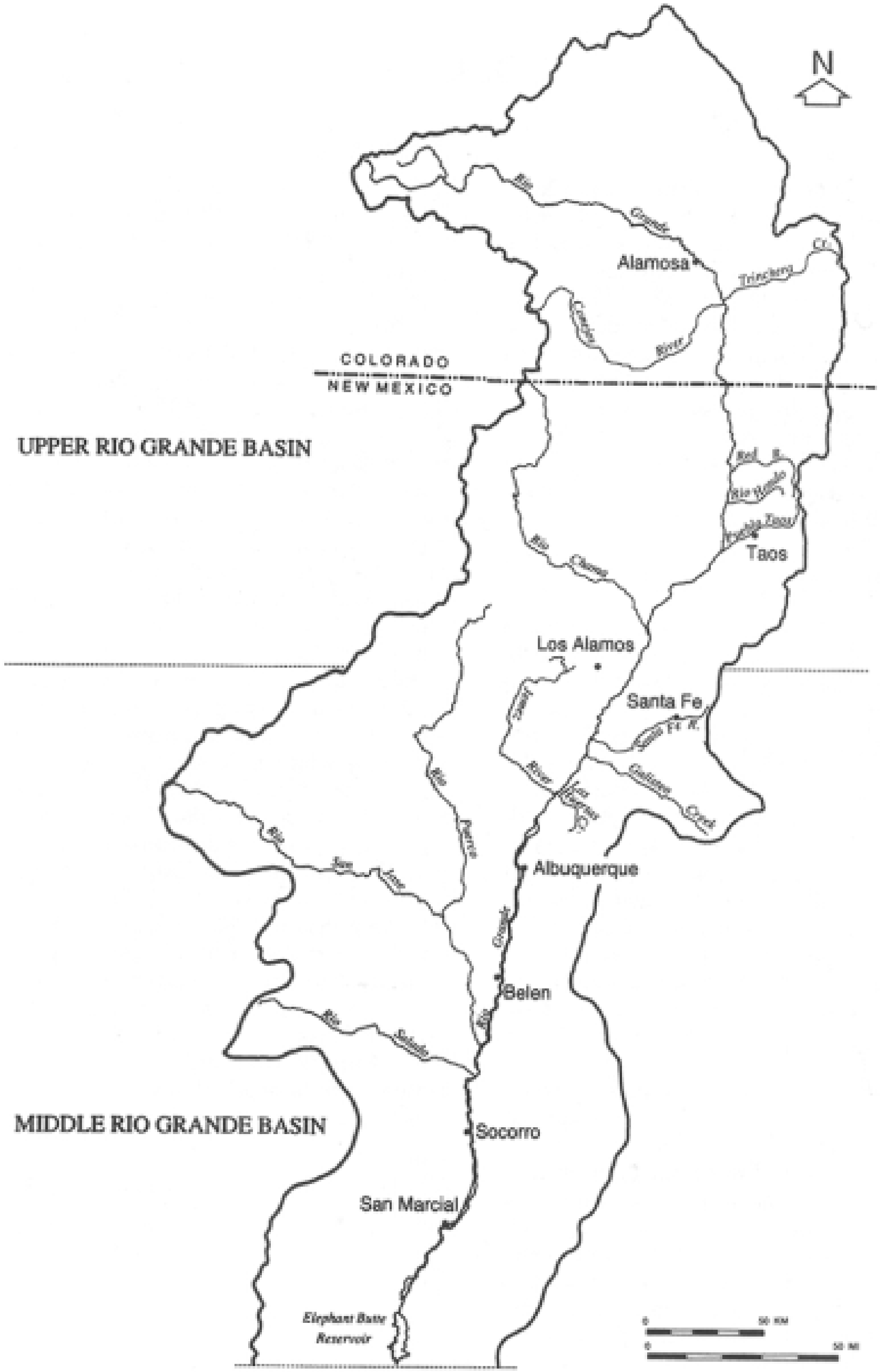

Figure 1—Study region.

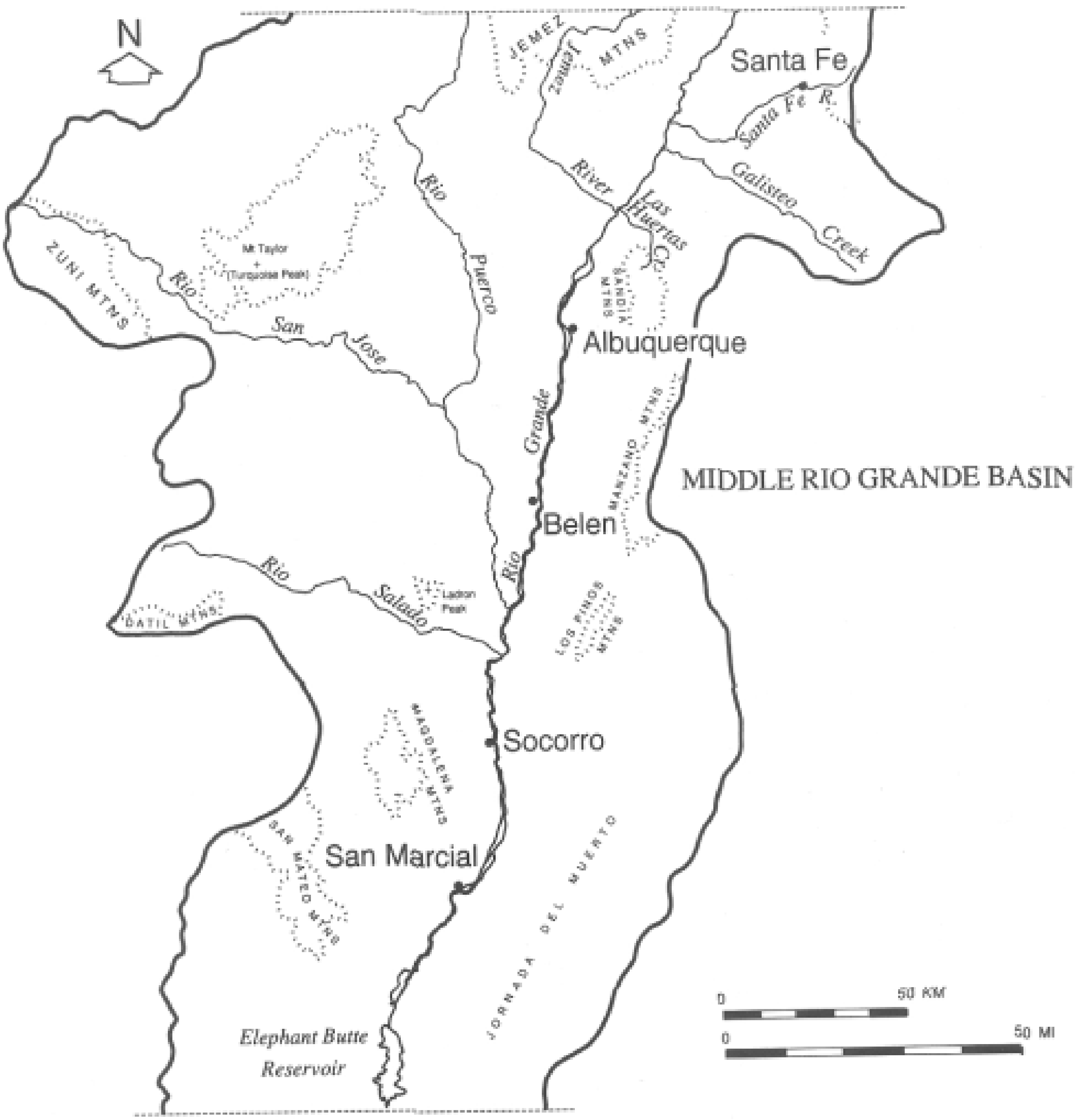

Figure 2—Middle Rio Grande Basin.

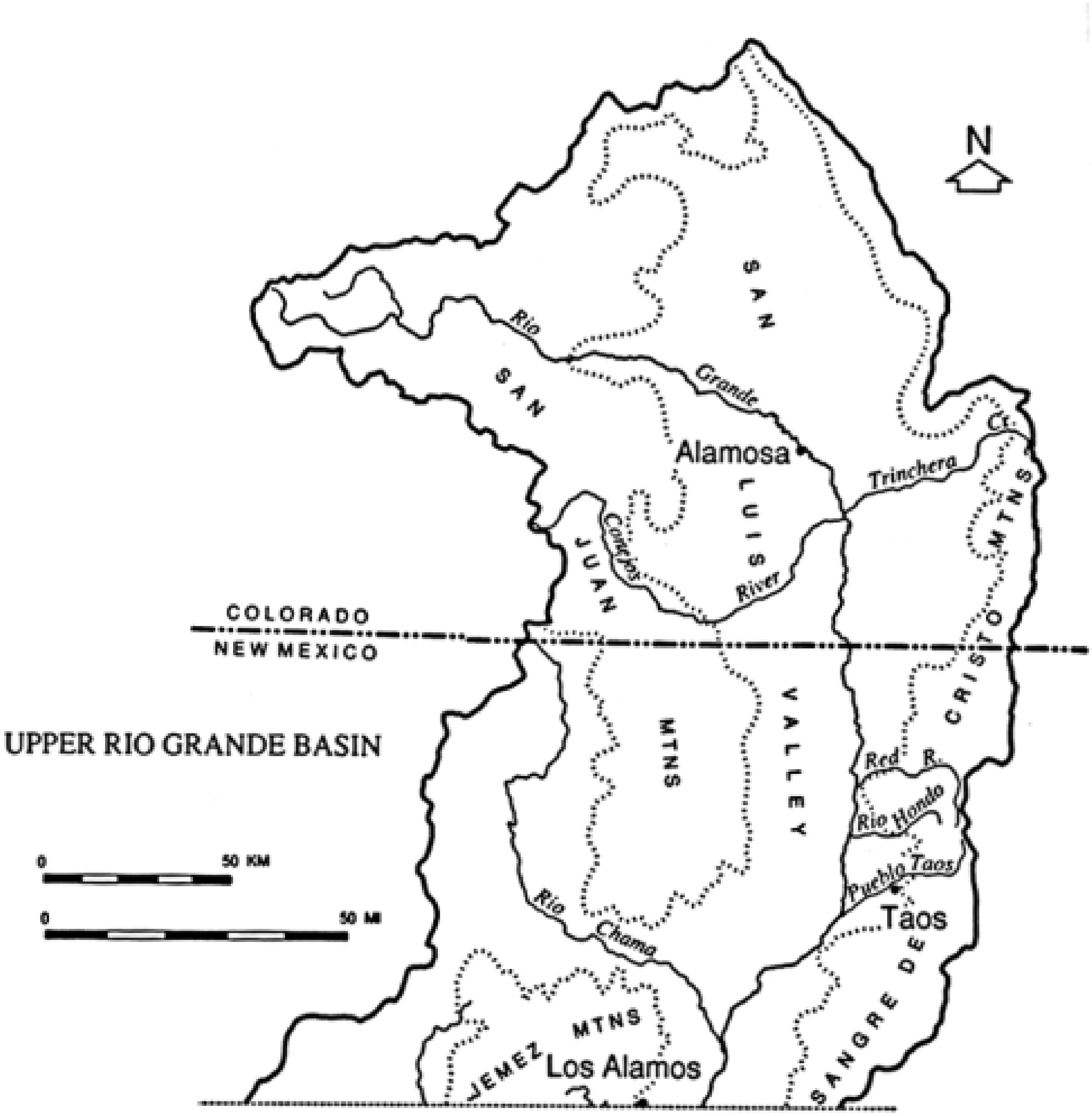

Figure 3—Upper Rio Grande Basin.

from the Upper Rio Grande and tributaries above the north boundary of the Middle Basin (Figs. 1 and 3). Floodwaters generated in the Upper Basin affected virtually all components of the middle one. Upper Basin droughts clearly affected the Middle Valley ecosystem in other ways. Further, some plant communities and animal populations also extend across this boundary, and various human groups moved from one basin to the other over time, impacting both basins with their activities. Sustainability of ecosystems, and their significant human component, clearly lies in studying and managing both basins as one.

APPROACH AND METHODOLOGY

Environmental history has been recognized only recently by the academic community as a viable and needed approach to better understanding human history by placing it in an environmental context. However, decades before this, several individuals, such as Aldo Leopold, James Malin, and Walter Prescott Webb, were developing and applying environmental history methodology and theory to understanding and describing human groups and their interrelationships with ecosystems. Although Leopold called for "an ecological interpretation of history" more than 50 years ago, environmental history was not a recognized academic discipline until the 1970s, following the dynamic and influential environmental movement of the late 1960s and early 1970s (Worster 1993: 2). The American Society of Environmental History was formed in the bicentennial year of 1976. Since then, this new field of study has embraced related fields such as climate history, fire history, landscape ecology, forest history, agricultural history, anthropology, ethnohistory, and history of conservation and science. Some specific topics addressed by environmental historians, and discussed in this study, include historic floods and droughts, hydrology and geomorphology of streams, the "Columbian exchange," environmental views of groups in a given area or region, environmental impact and change, and evolution of conservation and scientific research (Merchant 1993: vii–ix).

Aldo Leopold has been called the "father of wildlife management," and his prolific writings have significantly influenced the philosophy and methodology of environmental sciences. Leopold's published books, such as *A Sand County Almanac* (1944), and papers have also helped shape the view of many contemporary ecologists and environmental historians, such as Donald Worster of the University of Kansas. This influence is reflected in Worster's (1993: 4) definition of his own field of study: "[Environmental history] deals with the role and place of nature in human life. . . ." and "Its goal is to deepen our understanding of how humans have been affected by their natural environment through time, and conversely and perhaps more importantly in view of the present global predicament, how they have affected that environment and with what results."

Importantly, this discipline has not only expanded the view and "data base" for historians but has also provided pertinent data for biological scientists and resource managers to use in developing a more comprehensive approach to bioremediation, reconstruction of ecosystems, and determination of sustainability.

The ecosystem, or watershed, approach to study of areas or regions used by ecologists for some time is emulated by the bioregional approach that some environmental historians have used. This focus on a definable abiotic-biotic region in which various groups have employed distinctive adaptive and exploitive strategies was discussed by Dan Flores (1994: 8):

> . . . [A] given bioregion and its resources offer a range of possibilities, from which a given human culture makes economic and lifeway choices based upon the culture's technological ability and its ideological vision of how the landscape ought to be used and shaped to meet its definition of a good life.

The Middle and Upper Rio Grande basins, with a long history of human occupation, have been studied by archeologists and historians for more than a century. The region's prehistory and history, reconstructed from an array of physical and documentary evidence possibly as comprehensive and detailed as that of any region in the United States, lend themselves to the bioregional approach. The distribution of the protohistoric Pueblo groups was mainly limited to the Middle and Upper Rio Grande basins; the Zuni and Hopi Pueblos were the exceptions. Subsequent Spanish settlement was confined to the basins as well until the early 1800s. The Spanish also recognized the environmental distinction between the Upper and Lower basins, which they named the Rio Arriba and Rio Abajo, respectively, for purposes of administration. Further, early Anglo settlers almost exclusively occupied these two ecological units. Also found here are descendants of the two earlier eco-cultures, Native American and Hispanic, who still practice traditional lifeways to some degree, so there is a continuing historic record today.

In general, this study focuses on identifying and interpreting the roles of various human groups in affecting Basin ecosystems and their responses to the environmental changes that they and "nature" have produced. Although it was known that human groups had, over time, shaped all regional ecosystems from the Rio Grande to the tundra of the highest peaks, the processes of these transformations were poorly understood. This study examines in detail the interrelationships of various eco-cultures with their Middle Basin environments, with a special focus on how groups have viewed and exploited their environments. In addition, the general role and relationship of politics, economic institutions, and social organizations to resource exploitation and its resulting impacts on the environment are clarified. Finally, a number of specific environmental changes and their spatial and temporal occurrence, nature, and impacts were identified and are discussed.

Because an environmental history of this spatial and temporal magnitude has never been attempted in New Mexico, the first priority was to review and integrate the readily available, pertinent data on human prehistory (late) and history with data from the physical and biological sciences. Important sources of this type of information were published works on local environmental histories within the study region, such as *Man and Resources in the Middle Rio Grande Valley* by Harper et al. (1943) and *Enchantment and Exploitation* (Sangre Cristo Mountains) by deBuys (1985). Publications dealing totally or in part with the historical use of specific environmental components, such as the *Climate of New Mexico* by Tuan et al. (1973), *Water in New Mexico* by Clark (1987), *Birds of New Mexico* by Ligon (1961), and *Fishes of New Mexico* by Sublette et al. (1990), were also helpful in providing general context, as well as more specific data on topics of special interest. Recent comprehensive studies on the ecology of the study region, such as the *Middle Rio Grande Biological Survey* by Ohmart and Hink (1984) and the *Middle Rio Grande Ecosystem: Bosque Biological Management Plan* by Crawford et al. (1993), provided a sound basis for understanding the interrelationships of the river and the various biotic components of the Middle Basin. Most of the allocated research and analysis time was devoted to review of these and other pertinent published books, reports, papers, and documents. Unpublished manuscripts, maps, and photographs were consulted as time permitted. Data from selected oral interviews conducted by me and other researchers were also reviewed. There is a huge body of archival material in various state and regional depositories that was not researched during this project owing to time constraints but should be included in future regional or local environmental history projects.

Early in the project, 10 research problems requiring environmental history data were identified for inclusion in the study: (1) effects of climatic phenomena, such as droughts, on human views of and responses to the environment; (2) effects of human activities on changing local, regional, or global climatic components and regimes; (3) effects of the temporal occurrence and magnitude of flooding on historic land use activities; (4) effects of grazing on different ecosystem components such as plant communities; (5) effects of erosion on fauna, flora, and other components; (6) effects of various water control structures on riparian fauna and flora; (7) effects of fragmentation of the Rio Grande bosque on riparian ecosystems; (8) effects of introduced plants and animals on ecosystems; (9) effects of past resource management by various agencies on these same ecosystems and their traditional resident eco-cultures; and (10) effects of environmental impacts on human responses, specifically attitudes, to these perturbations. These 10 problems guided the research presented in this report. Four spatial-temporal models of impact and change in the Middle Rio Grande Valley were also developed for "testing" during the study.

ORGANIZATION OF THE REPORT

Chapters 2 through 6 describe and reconstruct the history of occupation and use of the study region by various human groups, the historic environmental conditions in the basins, and the impact on and modification of abiotic and biotic components of Middle Rio Grande ecosystems by natural and human events over the last 455 years. These chapters include historic and recent climates (Chapter 2), human settlement and land use (Chapter 3), historical descriptions and reconstruction (Chapter 4), impacts and changes (Chapter 5), and the origin and development of a conservation ethic and related land management agencies and organizations (Chapter 6). A chronology of pertinent events is provided at the end of each of these chapters. The final chapter (7) is a synthesis of the information presented in the previous chapters, with conclusions and considerations for using the data from this report in future research studies and management programs.

BENEFICIARIES OF RESEARCH

In addition to potential data uses by various public resource management agency personnel at all levels, this study should be useful to a myriad of other Basin communities and organizations—Pueblos, Hispanic land grant associations, the Middle Rio Grande Conservancy District, universities and schools, environmental groups, and private contractors and individuals involved in Middle Rio Grande Basin research. Potential uses include evaluating current resource use and management, planning for bioremediation of environmental problems at specific locales or areas, evaluating sustainability of past and current land use practices, locating field trip and study area sites for schools, and identifying, and hopefully resolving, critical environmental issues.

CHAPTER 2

MODERN AND HISTORICAL CLIMATE

Climatic elements such as precipitation types and patterns, temperature patterns, wind, solar radiation, frosts-freezes, and evaporation affect human activity and health positively or negatively. Effects of intense rain, drought, floods, deep snow, hail, freezes, lightning, intense heat, and so forth on such endeavors as hunting, fishing, gathering, farming, ranching, mining, travel, and recreation have been a long-time interest of archaeologists, climatologists, and environmental historians working in the Southwest. The siting of dwellings, fields, villages, livestock facilities, mining operations, trails, and roads were generally related, at least in part, to one or more climatological elements (Calvin 1948; Hambidge 1941; Upham 1986).

Precipitation and other weather phenomena are also major influences on formation and maintenance of plant communities, availability of wild plant foods, and dynamics of wildlife populations. Variations within these elements, coupled with human activities, have led to serious environmental problems such as intensive flooding, fluctuations or exhaustions of water supplies, and soil erosion.

The following sections of this chapter include discussions on various climatic elements. Coverage of interrelationships of climatic events and human activities are presented in Chapters 4 and 5. Also following in this chapter are sections on climatic stations and records, recent climate, reconstruction of the region's historic climate, climatic impacts on human populations, historic droughts and floods, historic snowfall, and a chronology of climatic events.

CLIMATIC RECORDS

Evidence of the earliest climate patterns and changes for the region has been derived from tree-ring chronologies from various prehistoric archeological sites. These chronologies provide indications of relative dry or wet periods over a specific period. For the historic period, these fluctuating patterns appear to generally correlate with historical observations and, after 1846, scientifically collected data.

The earliest written historical observations of weather were made by Spanish explorers, missionaries, government personnel, and settlers. In general, Spaniards who came to New Mexico thought the climate was similar to that of Spain, except for the Rio Arriba, which they found to be colder (Tuan et al. 1973: 4–5). All historical accounts, of course, have to be evaluated for their accuracy, as personal views of untrained observers were sometimes exaggerated or otherwise inaccurate.

The first scientific climatic records were collected by a few Anglo-American explorers in the first half of the 19th century, followed by those recorded by U.S. Army personnel beginning in 1849. Observers were either military doctors at various military posts or volunteers, who reported their recordings to the Smithsonian Institution until 1870. In that year, Congress authorized the Chief Signal Officer of the Army to record climatic data; this program continued until July 1, 1891, when the Weather Bureau was created in the U.S. Department of Agriculture. From about 1892 to 1931 weather observations were made by Cooperative Observers. First Order Weather Stations, such as that at Albuquerque, were first established in 1931 (Bradley 1976: 11–12; Taft 1980: 1; Table 1, Fig. 4).

Precipitation and temperature were the primary data recorded in the early decades of record keeping. However, due to personnel changes and the closing of recording stations, records are generally noncontiguous, spotty, or of short duration. Only Santa Fe, Albuquerque, and Socorro have reliable scientific records that extend back continuously for more than a century; these include precipitation and temperature (Bradley 1976: 11–13; Tuan et al. 1973: 11–12; Table 1).

Scientifically recorded snowpack measurements in the Upper Rio Grande basin (Colorado and New Mexico) were begun in 1936–37. Since that time, these measuring stations have been operated by the Soil Conservation Service (now the Natural Resources Conservation Service). From 11 stations established in the 1930s, the total number has grown to 63 stations, with 31 in Colorado and 32 in New Mexico. Of these, eight in Colorado and seven in New Mexico were selected for their distribution across the Upper Basin, and for continuous annual records that generally predate 1940, although three date only to 1950 (Fig. 5). Data from these stations were compared with runoff, flood, drought, and other precipitation records, and these data are summarized in the following sections.

CLIMATIC REGIME

The Middle Rio Grande Basin ecosystem has evolved with, and is basically driven by, the regional climate. Especially important to the hydrologic regime, as well as to plants, animals, and human activity, is the availability of moisture from rain or snowfall, which varies widely diurnally, seasonally, annually and over longer periods.

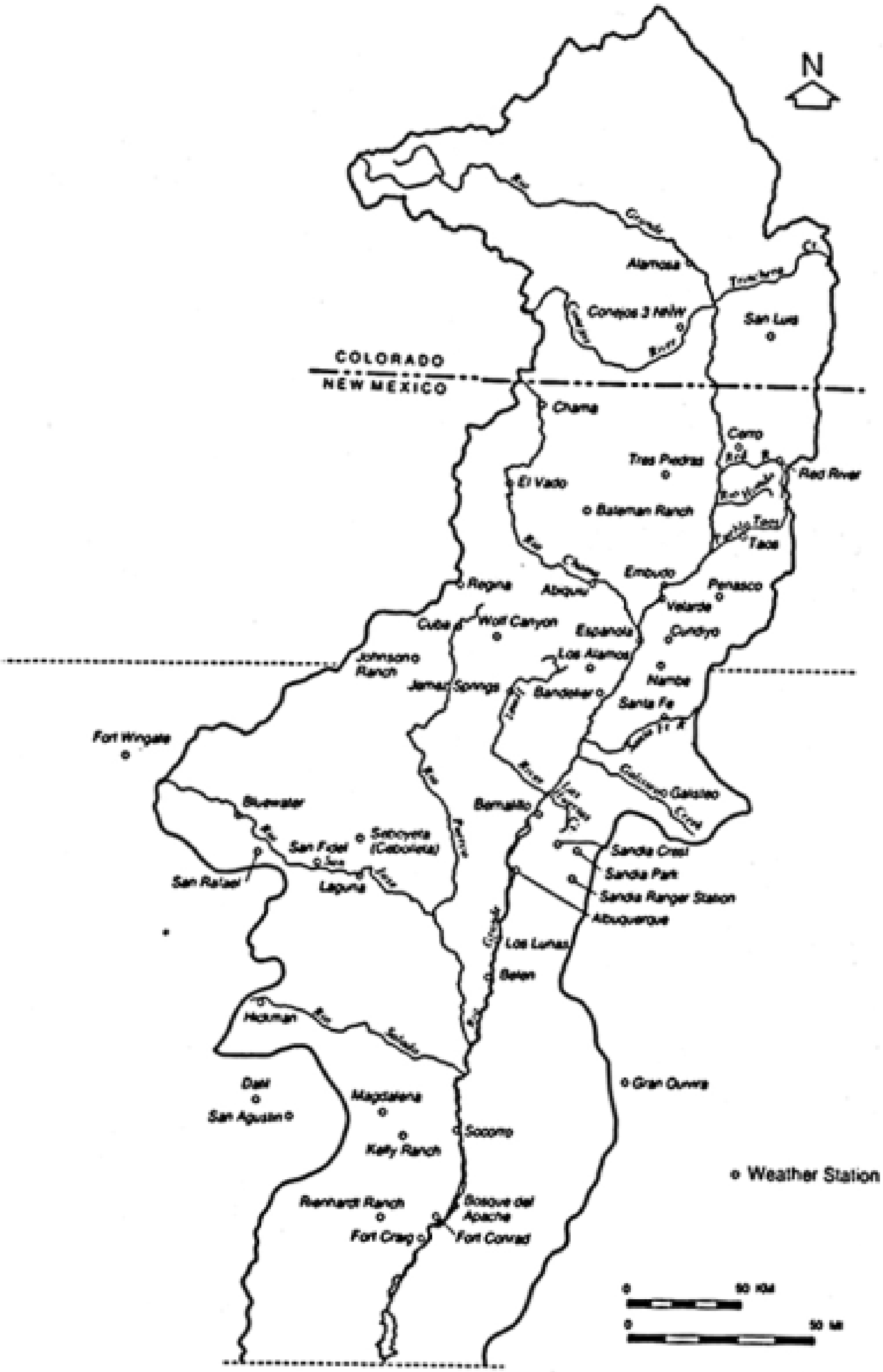

Figure 4—Historic weather stations, 1849–1994.

Table 1—Historic weather stations, 1849–1994.

Location	Temperature	Precipitation
County: Bernalillo		
Stations: 4		
Albuquerque	1850–1867	1893–1975
	1878–1879	
	1889–1994	
Sandia Crest	1953–1975	1953–1975
Sandia Park	1939–1994	1939–1994
Sandia Ranger Station	1910–1994	1915–1994
County: Catron		
Stations: 2		
Datil	1905–1908	1905–1908
	1916–1951	1920–1951
Hickman	1944–1994	1957–1994
County: Cibola		
Stations: 6		
Bluewater 3WSW	1896–1903	1896–1903
	1908–1919	1908–1919
	1925–1959	1925–1959
Cebolleta	Jan. 1894?	
Laguna	1850–1851	1905–1921
	1905–1915	1927–1994
	1919–1921	
	1924	
	1927–1994	
Prewitt Ranch	1887–1894	
San Fidel	1920–1976	1920–1975
San Rafael	1904–1915	
County: Los Alamos		
Stations: 1		
Los Alamos	1910–1994	1919–1994
County: McKinley		
Stations: 1		
Fort Wingate	1864–1911	1897–1911
	1940–1966	1940–1966
County: Rio Arriba		
Stations: 9		
Abiquiu (Near)	1940–1948	
Abiquiu Dam	1957–1994	1957–1994
Bateman Ranch	1909–1970	
Chama	1889–1897	1889–1897
	1905–1994	1905–1994
El Vado Dam	1906–1907	1906–1907
	1936–1994	1936–1994
El Vado Dam (Near)		1923–1927
Embudo	1889–1893	1893
Espanola	1895–1929	1895–1902
	1938–1975	1905–1929
		1938–1975
Velarde	1940–1948	
County: Sandoval		
Stations: 7		
Bandelier National Monument	1924–1975	1937–1975
Bernalillo	1889–1892	1895–1901
Bernalillo	1948–1982	1948–1982
Cuba	1938–1994	1938–1994
Jemez Springs	1910–1994	1910–1994
Johnson Ranch	1944–1994	
Regina	1914–1969	1914–1969
Wolf Canyon (Senorita, Selsor Ranch)	1912–1994	1912–1994
County: Santa Fe		
Stations: 6		
Cundiyo	1909–1923	
Fort Marcy	Jan. 1849–1890?	
Galisteo	1894–1903	
Nambe #1	1889–1892	1930–1931
	1930–1931	
	1947–1974	
Nambe #2	1940–1950	
Santa Fe	1850–1994	1874–1994
County: Socorro		
Stations: 15		
Augustine	1926–1939	1926–1939
	1959–1973	1959–1972
Augustine 2E	1939–1959	1939–1959
	1973–1994	1973–1994
Bosque del Apache	1851–1862	1894–1945
	1865–1881	1950–1994
	1884	
	1889–1891	
	1894–1945	
	1950–1994	
Bosque del Apache A	1945–1950	1945–1950
Fort Conrad	1851–1854	
Fort Craig	1940–1950?	
Gran Quivira National Monument	1905–1906	1940–1994
	1929	
	1938–1994	
Gran Quivira National Monument A	1929–1938	1930–1934
Kelly Ranch	1945–1975	
Magdalena	1889–1890	1906–1915
	1905–1993	1918–1975
Rienhardt Ranch	1951–1994	
Rosedale	1905–1932	1906–1932
Rosedale A	1927–1928	1927–1928
Socorro	1850–1851	1850–1851
	1879–1881	1879–1881
	1891–1994	1891–1994
Socorro Post	1849–1851	
County: Taos		
Stations: 6		
Cerro	1910–1920	1911–1920
	1932–1966	1932–1966
Cerro 5NE	1920–1931	1920–1931
	1966–1994	1966–1994
Penasco Ranger Station	1929–1976	
Red River	1906–1994	1909–1994
Taos	1889–1897	1889–1896
	1901–1994	1901–1994
Tres Piedras	1905–1995	1905–1995
County: Valencia		
Stations: 3		
Los Lunas	1889–1941	1889–1941
Los Lunas A	1944–1958	1944–1958
Los Lunas 3SSW	1957–1994	1957–1994
Belen	1948–1976	1962–1994
Bernardo	1962–1994	1962–1994

Total counties: 10; total stations: 63
Sources: Gabin and Lesperance 1977: 11–34; Kann et al. 1995

Figure 5—Snow survey data sites, Colorado and New Mexico.

Temperature has fluctuated widely over time and, along with precipitation, is a major determinant of vegetation types, their distributions, and surface water amounts. These two elements have also, of course, impacted human activities in various ways (Tuan et al. 1973: 185).

The continental climate of the study region is characterized by light precipitation, a wide range of diurnal and annual temperatures, abundant sunshine, low relative humidities, and high evaporation over water surfaces. These characteristics are determined by New Mexico's location relative to the moderating influences of the Pacific Ocean and Gulf of Mexico, distance from the equator, and topography, including ranges in elevation (Tuan et al. 1973: 185–186, 188; Von Eschen 1961: 1).

The Middle Rio Grande Basin lies within three climatic subtypes: arid, of the valley reach and lowlands (below 5,000 feet) from Bernalillo to Elephant Butte Reservoir; semi-arid, of the adjacent uplands (to 9,000 feet) to the east, west, and north of Albuquerque; and sub-humid, of the mountains above 9,000 feet (Tuan et al. 1973: 186–187; Fig. 6).

In the arid areas temperatures and evaporation are high, and annual precipitation is below 10 inches. The frost-free season ranges from 180 to 210 days (Tuan et al. 1973: 189–190).

The semi-arid portions of the study region, sometimes referred to as grassland or steppe, have average temperatures in the warmest months in the 70s° F and in the coolest months around 32° F. Annual precipitation ranges from near 11 to 18 inches; the average is 15 inches. The semi-arid climate extends over most of the region. Temperatures are somewhat lower than in the arid subtype. The annual moisture deficiency is between 10 and 21 inches. Winter cyclonic storms, with snow, are more common here, although they are of relatively short duration. Spring winds with blowing dust are annual events (Tuan et al. 1973: 191–192; Fig. 6).

The sub-humid areas are the locations of greatest annual precipitation and the chief sources of water for the state. Precipitation averages 20 to 30 inches annually in the higher ranges, with a great annual range of variability. Temperatures generally decrease 5° F for every 1,000 feet in elevation gain. Higher peaks, of course, have many nights when temperatures fall below freezing. The general frost-free season is 60 to 90 days (Bennett 1986: 47; Tuan et al. 1973: 192, 194–195; Fig. 6).

For the study region, precipitation falls during two distinct periods—winter and summer (early July to late September). The principal sources of moisture for this precipitation are the Gulf of Mexico and the Pacific Ocean. About 43 to 54 percent of the annual precipitation falls in summer from thunderstorms, which are uplifted over high mountains by convection-heated air. Snow falls mostly from cyclonic storms of moist Pacific air masses, generally moving eastward over the mountains. The least amounts of precipitation fall in November and May or June (Tuan et al. 1973: 20–34).

From north to south, precipitation generally decreases and temperature increases over the study region. Also, the variability of precipitation in the southern half of the study region has a greater range than the northern half (Tuan et al. 1973: 56; Fig.6). Average annual precipitation in the Upper Basin varies from 19.01 inches at Chama to 9.42 inches at Espanola. In the Middle Basin it varies from 25.43 inches at Jemez Springs to 8.84 inches at Bosque del Apache National Wildlife Refuge (NWR) (Table 2). About 50 percent of the annual precipitation in the region falls from moist, unstable air invading the region from the Gulf of Mexico from early July to late September. The summer thunderstorms are generally intense but brief and local in extent. Lesser amounts of precipitation occur in spring and fall, but these rains are sometimes longer in duration and produce moderate to severe flash floods (Bennett 1986: 44–45, 52–54; Crawford et al. 1993: 8–9; Tuan et al. 1973: 188–193).

Most snowfall in lower elevations occurs from December through February, with larger amounts occurring in higher elevations for this period and into March and April. These snows generally result from moist, eastward-moving storms originating over the Pacific Ocean (Bennett 1986: 52–54). Average annual precipitation and snowfall for 14 selected weather stations in the study region are shown in Tables 2, 3, 4, and 5.

The correlation between precipitation and streamflow depends mainly on geographical and seasonal conditions. The mean annual runoff in the arid Southwest is 0.25 to 10 inches per year or 1–40 percent of annual precipitation. Mean annual streamflow in cfs (cubic feet per second) per square mile "... is very low, often less than 0.1 CSM" (de Wiest 1965: 62). Various mean discharges at nine selected stations between the years 1895 and 1994 are listed in Table 6).

Table 2—Average annual precipitation at selected stations, 1951–1980.

Location	Inches
Chama	19.01
Taos	13.42
Santa Fe	14.22
Espanola	9.42
Cuba	13.06
Jemez Springs	25.43
Bernalillo	8.19
Albuquerque	8.12
Laguna	9.45
Grants	10.26
Gran Quivira	14.25
Socorro	8.63
Bosque del Apache	8.84

Sources: Bennett 1986: 43, 45; Gabin and Lesperance 1977

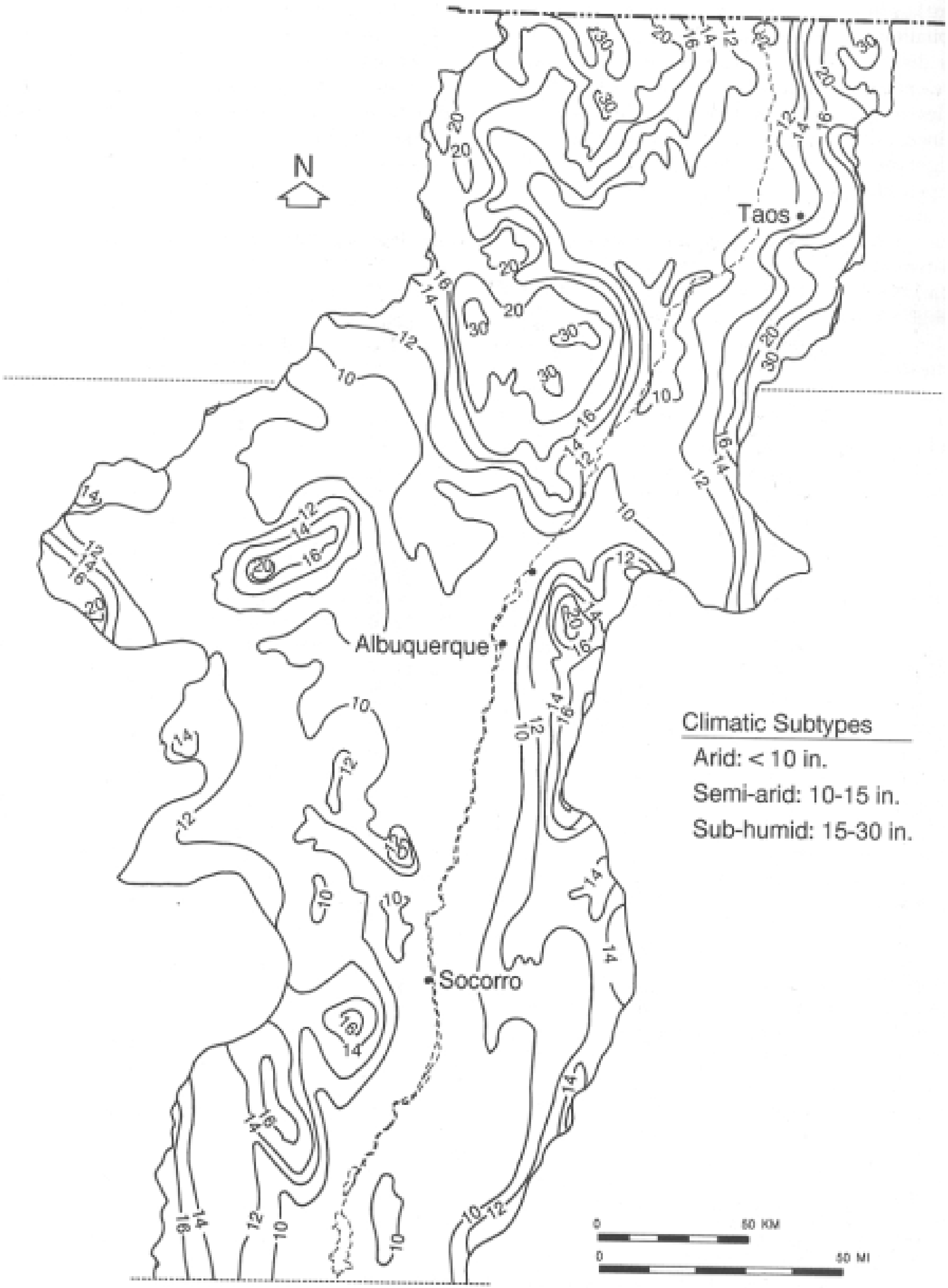

Figure 6—Climatic subtype areas and precipitation isolines in the New Mexico Rio Grande Basin.

In general, there is a correlation between high snowpack levels and spring floods caused by large runoff on the Rio Grande and major tributaries, such as the Rio Chama, Jemez River, and Rio Puerco for the period from 1936 to 1970. For the period 1890–1935, the May volume of runoff is the highest monthly flow; winter is the lowest (Table 7).

The 3 years of greatest measured snowfall for the eight stations in the Upper Rio Grande Basin in Colorado were, in decreasing amounts, 1952, 1941, and 1957 (Table 3). In New Mexico, 1941, 1952, and 1937 were the years of greatest snow depths recorded (Table 4). El Nino (wet) conditions occurred in 1941 and 1952, and above-normal precipitation was recorded in 1937 and 1957.

Table 3—Mean historic snow depths (inches) at selected Upper Rio Grande stations (Colorado).

Year	Cochetopa Pass (elev. 10,000 feet)	Santa Maria (elev. 9,600 feet)	Upper Rio Grande (elev. 9,400 feet)	Wolf Creek Pass (elev. 10,320 feet)	La Veta Pass (elev. 9,440 feet)	Silver Lakes (elev. 9,500 feet)	Culebra (elev. 10,500 feet)	Cumbres Pass (elev. 10,022 feet)
1936			9.50	58.00				45.50
1937			23.00	96.33		17.67		78.33
1938			19.00	85.33	19.50	17.67		63.30
1939		8.00	9.75	56.33	22.33	12.67		50.00
1940		5.00	7.75	37.25	16.25	6.75	24.75	36.25
1941		23.00	32.00	89.25	34.25	25.00	49.75	87.75
1942		12.50	12.00	69.75	24.50	13.25	37.00	56.00
1943		16.50	16.75	62.25	17.00	15.75	14.25	52.50
1944		25.00	35.25	90.25	28.50	25.50	35.25	65.00
1945		11.25	16.00	72.50	29.25	15.00	41.50	71.50
1946		1.75	7.75	36.50	12.00	10.00	12.25	25.50
1947		10.75	17.25	56.50	23.50	16.75	35.25	38.75
1948		20.75	36.75	82.00	32.25	23.75	33.50	49.50
1949	25.00	23.75	37.25	95.00	25.00	26.75	37.00	63.75
1950	9.25	11.25	19.00	73.50	12.00	15.75	17.50	42.00
1951	17.75	8.50	34.50	68.00	16.00	11.75	19.25	42.75
1952	24.50	28.00	13.50	114.25	38.00	34.50	55.00	60.25
1953	12.00	8.75	14.50	48.75	16.00	7.75	29.50	36.25
1954	9.50	7.00	17.50	50.50	16.75	8.00	22.50	24.00
1955	16.00	10.50	16.00	54.00	12.75	9.25	15.75	25.00
1956	20.00	13.75	20.75	76.25	17.00	22.50	17.75	41.75
1957	29.50	20.50	29.50	104.50	31.00	29.00	37.75	66.75
1958	23.75	19.25	30.00	69.50	19.25	20.00	42.33	53.00
1959	17.50	9.75	17.75	41.25	17.50	9.25	15.67	31.75
1960	18.50	15.25	24.25	71.00	19.25	16.25	24.00	52.25
1961	21.50	9.50	19.75	56.75	21.75	18.50	25.25	44.75
1962	21.75	22.00	34.00	83.75	23.25	25.33	28.25	63.50
1963	13.25	6.75	12.75	45.25	13.50	8.00	19.25	29.70
1964	18.50	10.75	14.75	55.00	23.75	19.00	19.00	36.00
1965	26.75	24.33	35.75	99.25	33.75	28.50	32.50	73.00
1966	14.25	18.25	23.00	61.00	19.75	13.67	29.50	46.50
1967	5.50	11.00	14.25	82.00	11.25	9.50	15.50	1.00
1968	22.75	20.75	23.83	80.25	25.00	23.25	28.25	47.25
1969	18.00	14.50	26.25	80.00	21.50	23.25	26.50	70.25
1970	34.50	5.40	14.50	58.75	20.25	9.00	25.25	35.25
Avg. mean	19.09	14.19	21.03	70.31	21.62	17.31	27.96	48.76

Note: Months snow depths recorded.
Cochetopa Pass: Feb.–May
Santa Maria: Feb.–May
Upper Rio Grande: Feb.–May; except 1936, April–May; 1937–38, Mar.–May
Wolf Creek Pass: Feb.–May
La Veta Pass: Feb.–May
Silver Lakes: Feb.–May; except 1937–39, Mar.–May; 1965, April–May; 1966, Mar.–May
Culebra: Feb.–May; except 1958–59, Mar.–May
Cumbres Pass: Feb.–May

The 3 years of least snow depth for Colorado, in decreasing amounts, were 1946, 1967, and 1951 and in New Mexico were 1967, 1951, and 1955. All four of these years (1946, 1951, 1955, and 1967) were substantially below normal in annual precipitation, as recorded at the nearest weather stations (U.S. Soil Conservation Service 1994).

Seasonal, annual, and decadal precipitation in New Mexico vary greatly, resulting in dry or drought periods, which may last a season, a year, or longer. The year 1956 was a dry, or La Nina, year. In fact, 1956 was the driest year since the advent of scientifically recorded annual precipitation in New Mexico. In Santa Fe the mean precipitation for 1916–17 was 4.5 inches below normal. In the summer of 1929, during an El Nino year, Santa Fe recorded 8 inches above normal. Drought years often occurred in "swarms," while wet periods generally lasted only a year or, more rarely, a few years. Wet years tend to follow an extended drought. For example, Chama experienced its

Table 4—Mean historic snow depths (inches) at selected Upper Rio Grande stations (New Mexico)

Year	Chama Divide (elev. 7,820 feet)	Red River (elev. 9,850 feet)	Bateman (elev. 9,300 feet)	Taos Cany. (elev. 9,100 feet)	Tres Ritos (elev. 8,600 feet)	Quemazon (elev. 9,500 feet)	Elk Cabin (elev. 8,250 feet)
1937		40.50		30.50			
1938		24.00		12.00	6.0		
1939		15.00		13.00	19.7		
1940	22.0	19.67		16.00	16.3		
1941	25.3	35.33		35.70	32.3		
1942	16.7	25.67		20.30	27.7		
1943	12.7	20.67		13.70	15.0		
1944	17.0	31.67		24.00	26.3		
1945	20.3	36.33		29.30	27.0		
1946	6.5	8.67		10.70	10.3		
1947	8.3	20.67		21.70	17.7		
1948	12.0	25.67		24.30	30.7		20.0
1949	26.6	27.67		14.30	24.0		15.0
1950	5.7	18.33	32.7	12.30	10.3	23.3	4.0
1951	7.0	12.33	20.7	7.70	10.0	19.7	2.3
1952	14.7	38.33	53.0	24.70	26.3	42.5	9.0
1953	11.3	7.00	31.7	13.00	16.3	29.0	8.3
1954	8.7	14.33	34.7	10.00	10.7	26.5	3.7
1955	9.0	11.67	26.3	12.00	12.3	12.5	6.7
1956	13.7	15.33	39.7	12.00	11.7	22.0	8.7
1957	13.7	31.67	45.7	16.70	19.3	31.0	4.0
1958	15.0	17.66	53.0	17.00	23.7	49.0	16.0
1959	2.7	9.33	29.5	10.00	13.7	25.0	4.7
1960	18.0	21.33	39.5	18.00	20.7	41.3	18.0
1961	14.0	22.67	35.5	14.30	21.0	39.0	9.7
1962	13.7	29.33	49.0	17.30	19.3	40.7	11.3
1963	5.0	17.00	35.5	9.70	15.3	25.0	10.0
1964	2.7	13.10	33.0	13.00	19.3	20.7	10.3
1965	22.0	29.67	48.5	18.25	28.0	39.0	13.7
1966	13.3	21.00	35.5	15.00	12.7	30.0	9.3
1967	6.0	11.67	29.5	7.70	5.0	14.7	1.7
1968	9.3	24.00	38.5	16.70	19.3	30.3	15.3
1969	20.3	21.67	47.5	23.70	17.3	32.7	8.3
1970	0.0	17.00	30.7	10.70	10.7	27.3	4.3
Avg. Mean	12.7	21.65	37.6	16.63	18.1	29.6	9.3

Note: *Months snow depths recorded.*
Chama Divide: 1940–62, Feb.–April; 1963–70, Feb.–May
Red River Pass No. 2:1937–39, Mar.–April; 1940, 1945–51, 1953–64, 1966–70, Feb.–April; 1941–44, 1952, 1965, Feb.–May
Bateman: 1950–57, Feb.–April; 1958–69, Mar.–April; 1970, Feb.–April
Taos Canyon: 1937–39, Mar.–April; 1940–70, Feb.–April
Tres Ritos: 1938, Mar.–April; 1939–70, Feb.–April
Quemazon: 1950–51, Feb.–April; 1952–59, Mar.–April; 1960–70, Feb.–April
Elk Cabin: 1948–70, Feb.–May

driest period in 1951–55 and its driest year ever in 1956, recording only 8.7 inches. For the next year, 1957, this community measured its greatest ever annual precipitation of 31.4 inches (Bennett 1986: 42; Tuan et al. 1973: 50, 52).

New Mexico experiences a wide range of temperatures, primarily due to its elevation range and latitude. For each degree of latitude change from south to north in the region, the temperature decreases 1.5º to 2.5º F. For every 1,000-foot gain in elevation, there is a decrease of about 5º F. The topographic configuration of the region affects temperature as well (Tuan et al. 1973: 65–67). Slope and exposure, or aspect, as primary determinants of temperature are relatively well understood. One cited example is temperature readings taken at Frijoles Canyon in Bandelier National Monument on October 28, 1962. In mid afternoon, temperatures at the north-facing wall of the canyon, in shade, were from 8º–13º F lower than those at the south-facing wall, in sunshine (Tuan et al. 1973: 68). Similar differences in temperatures, which determine vegeta-

Table 5—Average annual snowfall at selected stations, 1931–1983.

Location	Inches
Chama	102
Taos	38
Santa Fe	36
Espanola	18
Cuba	39
Jemez Springs	35
Bernalillo	9
Albuquerque	11
Grants	18
Gran Quivira	29
Socorro	6
Bosque del Apache	6
Truth or Consequences	7

Source: Bennett 1986: 52

Table 6—Daily and annual mean discharges at selected USGS gauging stations: Upper and Middle Rio Grande drainages, 1895–1993.

Station	Discharge (cfs)
Red River near Questa	
Years: 1910, 11, 12–24, 25, 26–93	
Annual mean discharge (1966–93)	41.9
Highest annual mean (1979)	87.6
Lowest annual mean (1971)	11.8
Highest daily mean (June 9, 1979)	557.0
Lowest daily mean (January 6, 1971)	2.5
Rio Pueblo de Taos	
Years: 1911–16, 40–51, 52–93	
Annual mean	29.8
Highest annual mean (1979):	72.3
Lowest annual mean (1972)	7.7
Highest daily mean (May 26, 1979)	926.0
Lowest daily mean (January 27, 1950)	0.2
Rio Chama near Chamita	
Years: 1912–93	
Annual mean	588.0
Highest annual mean (1987)	923.0
Lowest annual mean (1972)	234.0
Highest daily mean (May 5, 1985)	3,570.0
Lowest daily mean (September 16, 1971)	1.2
Rio Grande at Otowi Bridge	
Years: 1895–1905, 1909–93	
Annual mean	1,559.0
Highest annual mean (1987)	2,764.0
Lowest annual mean (1977)	602.0
Highest daily mean (May 11, 1985)	12,000.0
Lowest daily mean (August 4, 1977)	195.0
Santa Fe River near Santa Fe	
Years: 1910, 13–93	
Annual mean	8.18
Highest annual mean (1919)	26.20
Santa Fe River near Santa Fe (continued)	
Lowest annual mean (1951)	1.90
Highest daily mean (September 23, 1929)	3.80
Lowest daily mean (February 7, 1927)	0.10
Jemez River below Jemez Canyon Dam	
Years: 1936–38, 43–93	
Annual mean	58.9
Highest annual mean (1973)	17.8
Lowest annual mean (1953)	10.6
Highest daily mean (January 19, 1958)	3,640.0
Lowest daily mean (May 24, 1943)	0.0
Rio Grande at Albuquerque	
Years: 1942–74, 75–93	
Annual mean	1,440.0
Highest annual mean (1987)	2,486.0
Lowest annual mean (1977)	356.0
Highest daily mean (1985)	8,650.0
Lowest daily mean (1977)	0.0
Rio Puerco near Bernardo	
Years: 1939–93	
Annual mean	44.1
Highest annual mean (1941)	171.0
Lowest annual mean (1978)	5.5
Highest daily mean (May 5, 1941)	5,980.0
Lowest daily mean (November 1, 1939)	0.0
Rio San Jose at Grants	
Years: 1912–26, 49–66, 68–93	
Annual mean	0.8
Highest annual mean (1980)	8.1
Lowest annual mean (1978)	0.0
Highest daily mean (April 21, 1980)	355.0
Lowest daily mean (June 1, 1968)	0.0

Source: USGS 1994

Table 7—Average monthly distribution of annual runoff (acre-feet) at two Middle Rio Grande gauging stations, 1890–1935.

Month	Otowi Bridge	San Marcial
January	37,900	37,900
February	41,000	41,600
March	77,000	63,400
April	185,800	138,500
May	379,300	318,200
June	275,100	230,800
July	94,700	81,700
August	60,400	48,900
September	51,400	41,200
October	62,900	52,700
November	46,700	34,400
December	40,800	38,400
Total	1,353,000	1,127,700

Source: National Resources Committee 1938: 29

Table 8—Average annual temperatures (°F) for New Mexico, 1991.

Location	January	July	Annual
Chama	18.6	61.5	40.4
Taos	20.3	67.0	45.7
Santa Fe (Santa Fe 2)	28.7	67.9	49.2
Espanola	31.9	72.4	52.7
Cuba	n.d.	66.5	n.d.
Jemez Springs	31.0	69.7	51.1
Bernalillo	n.d.	n.d.	n.d.
Albuquerque	35.7	76.9	56.8
Laguna	n.d.	73.5	n.d.
Grants	27.3	71.2	50.5
Gran Quivira	34.3	71.3	53.7
Socorro	36.3	74.7	57.1
Bosque del Apache	38.8	77.3	58.3

n.d. = No data available.
Source: National Oceanic and Atmospheric Administration 1991

tion type, can be observed on east versus west sides of north-south trending mountain ranges.

Like precipitation, temperatures vary greatly for diurnal, seasonal, annual, and longer periods. Average maximum temperatures, which usually occur in late June or early July, range from 69° F at Cochiti Dam to 76° F at the Bosque del Apache NWR. For the coldest month, January, the average annual temperature for Espanola is 31.9° F, while at the Bosque del Apache NWR, it is 38.8° F (Bennett 1986: 37; Crawford et al. 1993: 8–9; Table 8).

Another effect of topography is air movement or drainage. Cooler air warmed during the morning begins to rise upslope or up canyon, usually by mid morning. Conversely, warm mountain air cools in the evening and night, producing a downslope drainage or movement of cooler air into valleys or onto canyon floors (Tuan et al. 1973: 69–70).

July is normally the warmest month in the study region, with average temperatures in the 70s° F, and January is the coldest month, averaging in the 50s° F (Table 8). Mean monthly temperatures, however, vary far less from year to year than does average monthly precipitation. Daily temperature ranges average 30°–34° F. Summer thunderstorms usually mitigate afternoon temperatures, and rapid cooling, due to high elevations, occurs over much of the region. Humidity averages less than 30 percent during the heat of the day, making even high summer temperatures relatively comfortable in the shade (Bennett 1987: 34–36; Tuan et al. 1973: 69–72). Average annual temperatures and maximum-minimum of temperatures for some representative stations in the study region for 1991 and 1951–80 are shown in Tables 8 and 9.

Two kinds of frost, radiation and advection, occur in New Mexico. The former, which occurs almost entirely at night, is the most common, while the latter is more rare,

Table 9—Average high and low temperatures (°F), 1951–1980.

Location	High	Low
Chama	88.8	–17.7
Taos	94.0	–14.5
Santa Fe	93.7	–4.4
Espanola	98.6	–9.0
Cuba	94.4	–14.8
Jemez Springs	96.3	–2.1
Bernalillo	102.4	–2.9
Albuquerque	100.8	3.6
Laguna	n.d.	n.d.
Grants	n.d.	n.d.
Gran Quivira	97.0	–2.4
Socorro	101.3	2.6
Bosque del Apache	103.3	1.7

n.d. = No data available.
Source: Bennett 1986: 38

but can occur any time and is the most dangerous. Radiation frost generally occurs on clear, windless, or nearly so, nights when the air is dry. Cold air drainage into low areas then can produce frost, causing damage to crops and other vegetation. Duration is usually just a few hours (Bennett 1987: 46–47).

Advection frost results from an unseasonable invasion of cold, polar air masses, usually accompanied by strong winds. Temperatures may remain low for many hours or even a few days. Frost damage can be severe and widespread (Bennett 1987: 47).

In the Upper Basin the average frost-free, or growing, period extends from early June to early September. To the south, in the Socorro area of the Middle Basin, the frost-free period generally extends from late April to late October (Bennett 1986: 46–47; Crawford et al. 1993: 9). The av-

Table 10—Average annual number of frost-free days, 1951–1980.

Location	Days
Chama	100
Taos	139
Santa Fe	164
Espanola	170
Cuba	120
Jemez Springs	173
Bernalillo	180
Albuquerque	191
Laguna	180
Grants	140
Gran Quivira	160
Socorro	195
Bosque del Apache	200
Truth or Consequences	228

Sources: Bennett 1986: 47; Tuan et al. 1973: 86–98

erage annual number of frost-free days for 1951–80 are shown in Table 10.

That central and northern New Mexico are part of the "sun belt" is common knowledge. Insolation, or solar radiation, the total radiant energy from the sun that reaches the ground, has significant effects on the environment and human activity. The intensity of sunshine is greatest at higher altitudes and in atmospheres of low humidity and pollution levels. The region receives 70 to 80 percent of possible sunshine, except in the higher mountains (Tuan et al. 1973: 99–101). Plant growth, species distribution, evaporation, solar heating of structures, and human health are some of the environmental and cultural aspects determined or influenced by solar radiation.

Potential evaporation is two to five times greater than precipitation amounts. This evaporation varies from 40 to more than 80 inches of water; the areas with the least precipitation have the highest rates. Loss of water through actual evaporation, less than that of potential evaporation, adversely impacts native vegetation, crops, runoff, stream flows, lake levels, and ground water. Losses through evaporation are obviously larger in summer than in winter. Evaporation is influenced by many environmental factors, including solar radiation, air temperature, relative humidity, wind, water turbidity, water temperature, soil texture, depth of water table, and vegetation (Bennett 1987: 48–49; Tuan et al. 1973: 112–115).

Wind, which constantly changes speed and direction, is the least stable climatic element. Continental air masses, local air drainage, ground cooling or heating, configurations of the terrain, and human structures affect surface wind speed and direction. Convection heating usually reaches its peak in the afternoon, causing the highest winds. Average wind speeds for the region are 9.8 mph. Although wind direction is highly variable, southeast winds in summer and west winds in winter generally predominate (Bennett 1987: 50–51).

When winds reach 14 to 18 mph, small amounts of dust, called dust streams, are picked up from the ground. Higher winds of 20–30 mph result in mild dust storms. Sustained winds of more than 45 mph may carry dust more than 12,000 feet above the ground, with visibility decreasing to a range of three-quarters to 2 miles. Spring dust storms are more frequent than those of the other three seasons; an average of five occur in April. Over a 16-year period (1945–60) Albuquerque experienced a total of 364 days with some blowing dust, for an average of almost 23 occurrences per year (Tuan et al. 1973: 105–111).

CLIMATOLOGICAL HISTORY OF ALBUQUERQUE: A CASE STUDY

Introduction

To document the variability and extreme ranges of the Middle Rio Grande Basin's historical and modern climate, and to provide a "model" for researchers working with the region's eco-cultural resources, a somewhat detailed discussion of Albuquerque's climate, past and present, is presented here. In addition to the references cited, a relatively large collection of documents on the city's weather may be found at the National Weather Service, National Oceanic and Atmospheric Administration, Albuquerque International Airport.

Albuquerque's climate has been heralded, like that of most of New Mexico, as one of its major attractions. Sizable populations of Native Americans adapted to the vagaries of the area's climate in various ways, and the Pueblo population in the Middle Rio Grande Valley at first European contact was higher than that of any other part of the region at the time. This concentration was due in part to available surface water for runoff and irrigation ditch farming.

The Duke City's abundant sunshine and low humidity, extolled by journalists, promotionalists, and public officials, attracted thousands of midwesterners and easterners to farm, ranch, retire, or be cured of various illnesses, primarily respiratory, from the 1880s to the 1930s. Tuberculosis, especially, brought many patients to the city's sanitariums or convalescent homes during this period (Simmons 1982: 343–346). The local climate has continued to be a major factor in attracting tourists and new residents from out of state.

Albuquerque, located on the east side of the Rio Grande, about halfway between the Colorado-New Mexico state line and Elephant Butte Dam, has perhaps the best climatic documentation of any location in the study region. Located on the Camino Real-Chihuahua Trail and a long used east-west trail, Albuquerque was frequented by an array of travelers, before and after European settlement in 1706. Some of these individuals kept diaries or journals from which historical climatic information can be gleaned. In 1850, a U.S. Army post was established here, and military personnel recorded precipitation data for the years 1850–67, 1878–79, and 1889–90. Precipitation records were kept by various cooperative observers in the community from 1892 to January 1919; temperature recordings were begun in 1893. From September 1918 through March 1931 precipitation and temperature data were collected at the University of New Mexico. Subsequently, a "First Order Station" was established at the Kimo Building, then moved to the TWA West Mesa Airport on January 23, 1933, where a variety of weather observations were made until July 1939. From here, the weather station was moved to the Albuquerque municipal airport (now international), where it has been maintained to date (Gabin and Lesperance 1977: 11; Taft 1980: 1; Tuan et al. 1973: 11).

Additional climatic information for the historic period is represented by area tree-ring and Middle Rio Grande streamflow data. Recent tree-ring work in the Sandias and Manzanos has added valuable data to information previously collected in the area (Baisan 1993, 1994). Streamflow records for the river and tributaries also provide some information, although the first gauging station in the Middle Basin dates only to 1925 (USGS 1994).

Climatic Regime

Albuquerque's climate has been characterized as continental plateau desert, with moderate temperatures and arid to semi-arid precipitation ranges. Skies are generally clear, solar radiation is high, precipitation and relative humidity are low, and evaporation over water surfaces is high. Diurnal-nocturnal and season-to-season temperature ranges are wide (Taft 1980: 1; Tuan et al. 1973: 185). Its weather is determined largely by air mass movements from outside the state and local topography. The invasion of air masses affects Albuquerque's weather on a day-to-day, as well as a seasonal, basis. These occur as cold, dry, polar continental air masses from Canada; cool, moist, polar Pacific (north) air masses; hot, dry, tropical, continental air masses from Mexico and the far southwestern United States; warm, moist, tropical air masses from the Gulf of Mexico and Caribbean; or warm, moist, tropical Pacific (south) air masses (Anderson 1961: 63–64). Vertical and horizontal air movement, radiation heating, and precipitation between the Rio Grande Valley and the Sandia Mountains is dynamic, causing rather dramatic variations and differences in local climate.

Most of the winter and spring moisture comes from the north Pacific Ocean, while the summer moisture originates in the Gulf of Mexico. The air masses from Mexico and the extreme southwestern part of the United States usually result in warm, dry weather. Extended cold periods are brought by the cold, polar continental masses; some snow can result if warm, moist air is replaced. Moist air from the tropical Pacific usually contributes little to annual precipitation, although heavy rains of limited duration may result (Anderson 1961: 63–64).

Precipitation Variability

The amount of precipitation has been the most important climatic element affecting historic human activities in and around Albuquerque. Precipitation may have been higher during various periods in the first 250 years of the historic period. Since 1890, precipitation has remained relatively stable (Fig. 7). Extreme, long droughts occurred in the Albuquerque area, however, during these earlier periods, as well as in this century. Forty-five percent of the year's total moisture, or about 3.8 inches of moisture, falls from early July to late September in thunderstorms, which covers most of the growing season. For the remainder of this critical agricultural period, May through June, farmers have generally depended on runoff from mountain snowpack upstream, which, even in some drought years, was substantial enough to produce adequate crop harvests through irrigation. An average snowfall of 11 inches, or 1.6 inches of moisture, has been recorded at local weather stations for the winters of 1850–1994. Only a trace of snow was recorded in the years 1896 and 1950 (Bennett 1986: 52; Environmental Data Service 1977: 1; Liles 1994: 35, 41; Von Eschen 1961: 5).

At the Tijeras Ranger Station, about 15 miles east of Albuquerque, the annual mean precipitation is about 15 inches. At Sandia Crest, more than a mile above the weather station at the airport, the average precipitation has been about 25 inches. The greatest 24-hour snowfall, some 30 inches, was recorded there on December 29, 1958 (Environmental Data Service 1977: 1; Taft 1980: 10, 20).

Of Albuquerque's 12 wettest months, five occurred between 1852 and 1900, five between 1905 and 1933, and two since this 1933. Seven of the 10 snowiest winters for the period 1893–1994 occurred after 1957–58. The month with the highest recorded snowfall was December 1959, when 14.7 inches fell. The worst blizzard on record occurred March 22–25, 1957. The wettest 6-month period was March-August 1858, when 14.4 inches of precipitation were recorded. The wettest spring was 1941, with 5.27 inches, and the wettest month ever, with 8.15 inches, occurred in June 1852 (Liles 1994: 6, 32, 41; Fig. 7).

November and January are the two driest months in Albuquerque. Droughts in 1698–1704, 1714–34, 1748–57, 1770s, and 1805–13 had severe adverse impacts on the area. There were crop failures, loss of livestock, and general hardship for the community and outlying ranches and farms. For example, the dry conditions in spring 1862, which resulted from below-normal precipitation over the preceding 2 years, presented invading Union and Con-

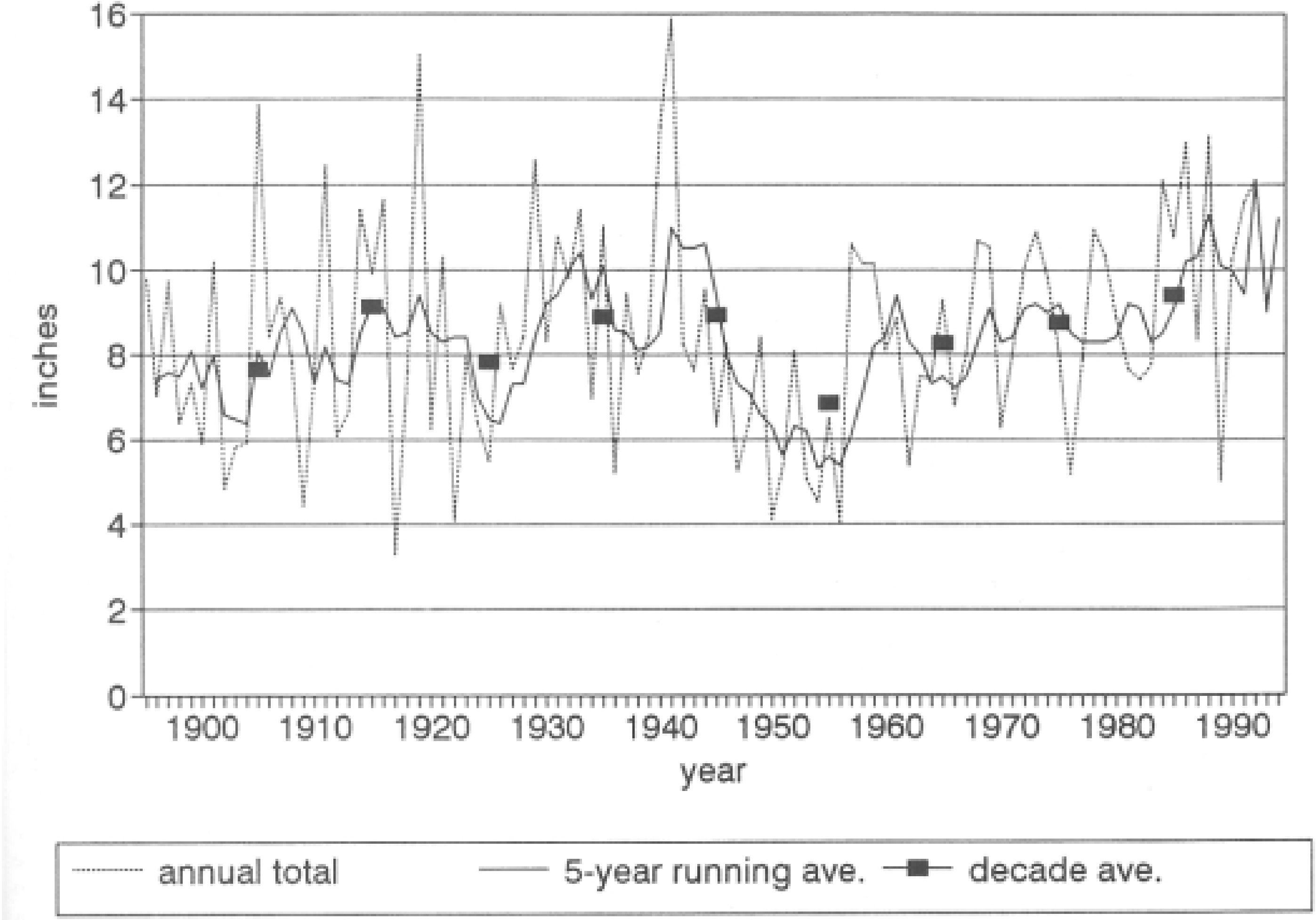

Figure 7—Annual precipitation in Albuquerque, 1896–1994.

federate armies with the problems of finding food and water and keeping their horses and mules fit (Abert 1962: 71; Calvin 1968: 60, 70, 79; Simmons 1982: 85, 111, 179).

Droughts in the late 1800s-early 1900s, coupled with increasing diversions of water from the Rio Grande, caused water shortage problems for irrigation farmers in the Albuquerque area. When the droughts "broke," intense rainy periods usually followed, eroding the parched and overgrazed ranges even more and causing destructive flash flooding. These events resulted in increasing sedimentation in the river and its tributaries and waterlogging of floodplain soils (Harper et al. 1943: 31–39).

The driest 30-year period recorded for Albuquerque was 1941–70, when the annual mean was 7.77 inches. The average annual precipitation from 1892 to 1938 was 8.23 inches, and from 1892 to 1994 it was 8.46 inches (Liles 1994:9; Taft 1980: 1; Von Eschen 1961: 5; Fig. 7).

The 10 driest years for Albuquerque are shown in Table 11. Seven of these years occurred since 1900, and three were recorded in the 1950–57 drought, the most severe dry period in this century. The longest period of no measurable precipitation was September 22, 1903, to January 9, 1904, or 110 days. The second longest was 109 days, from January 31, 1902, to May 19, 1902. No precipitation was recorded in the fall of 1858, the driest fall on record. March 1956, was the driest month ever recorded for Albuquerque; November and January, however, are gener-

Table 11—Ten driest years, Albuquerque, 1850–1994.

Year	Precipitation (inches)
1917	3.29
1860	3.78
1861	3.81
1956	4.06
1922	4.09
1950	4.10
1856	4.15
1909	4.43
1954	4.51
1902	4.82

Source: Liles 1994: 9

ally the two driest months (Liles 1994: 9; Taft 1980: 1; Tuan et al. 1973: 107).

Relative humidity at Albuquerque is generally low, averaging about 43 percent annually. Diurnal range normally varies from 58 percent in the cool morning hours to 30 percent during the highest temperatures during the day. On abnormally hot days and in the spring and fall, relative humidity usually falls well below 20 percent. May and June are the least humid months, averaging about 29 percent (Environmental Data Service 1977: 1; Taft 1980: 1; Von Eschen 1961: 1).

Temperature Variability

As noted above, Albuquerque temperatures are characteristic of high altitude, arid, continental climates. In addition to warm or cold air masses, Albuquerque's temperature is affected by its varied topography, ranging from about 4,900 feet elevation at the river valley to 10,678 feet at Sandia Crest. Temperature inversion, cold or warm air movement, and nocturnal radiation cooling are common climatic phenomena experienced in the Albuquerque area (Tuan et al. 1973: 69).

Seasonal temperature variations are distinct, with large annual and diurnal temperature ranges, which are characteristic of the type of climate. Above-normal temperatures are associated with the drought periods. Tree-ring data indicate that warming periods occurred during the droughts in the 1780s–1790s and in 1815–22, for example (Fritts 1991: 126, 152). There were also periods that were cooler than 20th century temperature norms, such as the period from 1833 to 1842 (Fritts 1991: 125).

Albuquerque's average annual temperature for 1893–1994 was 55.95° F; the average mean by decades for this period is shown in Table 12. Summer temperatures are moderate, and winter readings are relatively mild. Since 1893 the average spring temperature has been 55.2° F, the summer 75.5° F, the fall 56.3° F, and the winter 36.7° F. The hottest month, July, is the only month with an average high temperature above 90° F. From June through August, however, about 2 out of 3 days will have maximum temperatures of 90° F or higher. The average high temperature in July at Sandia Crest is only 66° F (Environmental Data Service 1977: 1; Liles 1994: 2, 53, 67–70; Von Eschen 1961: 5).

Daytime temperatures usually reach the mid 40s° F in January, the coldest month, and at night they usually fall to the low 20s° F (Von Eschen 1961: 5). The mean temperature in January is 34.7° F. The lowest temperature on record, –17° F, occurred on January 7, 1971 (Taft 1980: 9). Of the 10 coldest years since 1892, all occurred between 1911 and 1933. The coldest was in 1912, with a mean temperature of 51.6° F, and the tenth coldest was in 1933, with 54.2° F, the same as the ninth coldest year in 1918 (Table 13).

Normally, the coldest period for Albuquerque is December 28-January 16 (Liles 1994: 53, 70; Taft 1980: 7). The average last freeze date in the spring is April 20, and the first in the fall occurs on October 20. The average frost-free period is 203 days (Tuan et al. 1973: 88–89).

Albuquerque's temperature trend since 1880, and probably from the beginning of the historic period, has been upward (Table 12 and Fig. 8). The warmest year on record, 1954, had an average temperature of 55.9° F. The 1980s were the hottest decade on record (Liles 1994: 52–53).

Five of the 10 warmest years for Albuquerque occurred after 1977 (Liles 1994: 53). The longest severe heat wave of 90° F or more occurred over 64 consecutive days in the summer of 1980. There were nine consecutive days with temperatures of 100°F or more during this period and a total of 28 days on which the temperature reached or exceeded the century mark. The latest occurrence of a 100° F day in a year was on September 5, 1979 (Taft 1979: 3). The highest temperature ever recorded for Albuquerque was 107° F, which occurred on June 27, 1994. Only 10 days with 100° F or more occurred from 1893 to 1933. From 1934 to the present, Albuquerque has recorded 201 such days, and more than half, 128 days, have occurred since 1972. The second highest temperature recorded was 105° F on June 28, 1974 (Liles 1994: 1, 52, 83; Taft 1980: 13; Fig. 8).

Table 12—Average decadal temperatures, Albuquerque, 1893–1994.

Decade	°F
1893–99	55.08
1900–09	55.80
1910–19	53.75
1920–29	55.40
1930–39	55.24
1940–49	56.53
1950–59	57.74
1960–69	56.06
1970–79	55.96
1980–89	56.75
1990–94	57.20
Average	55.95

Source: Liles 1994: 53

Table 13—Ten coldest years, Albuquerque, 1893–1994.

Years	°F
1912	51.6
1913	51.8
1915	53.0
1917	53.4
1914	53.8
1930	53.8
1919	53.9
1929	54.0
1918	54.2
1933	54.2

Source: Liles 1994:53

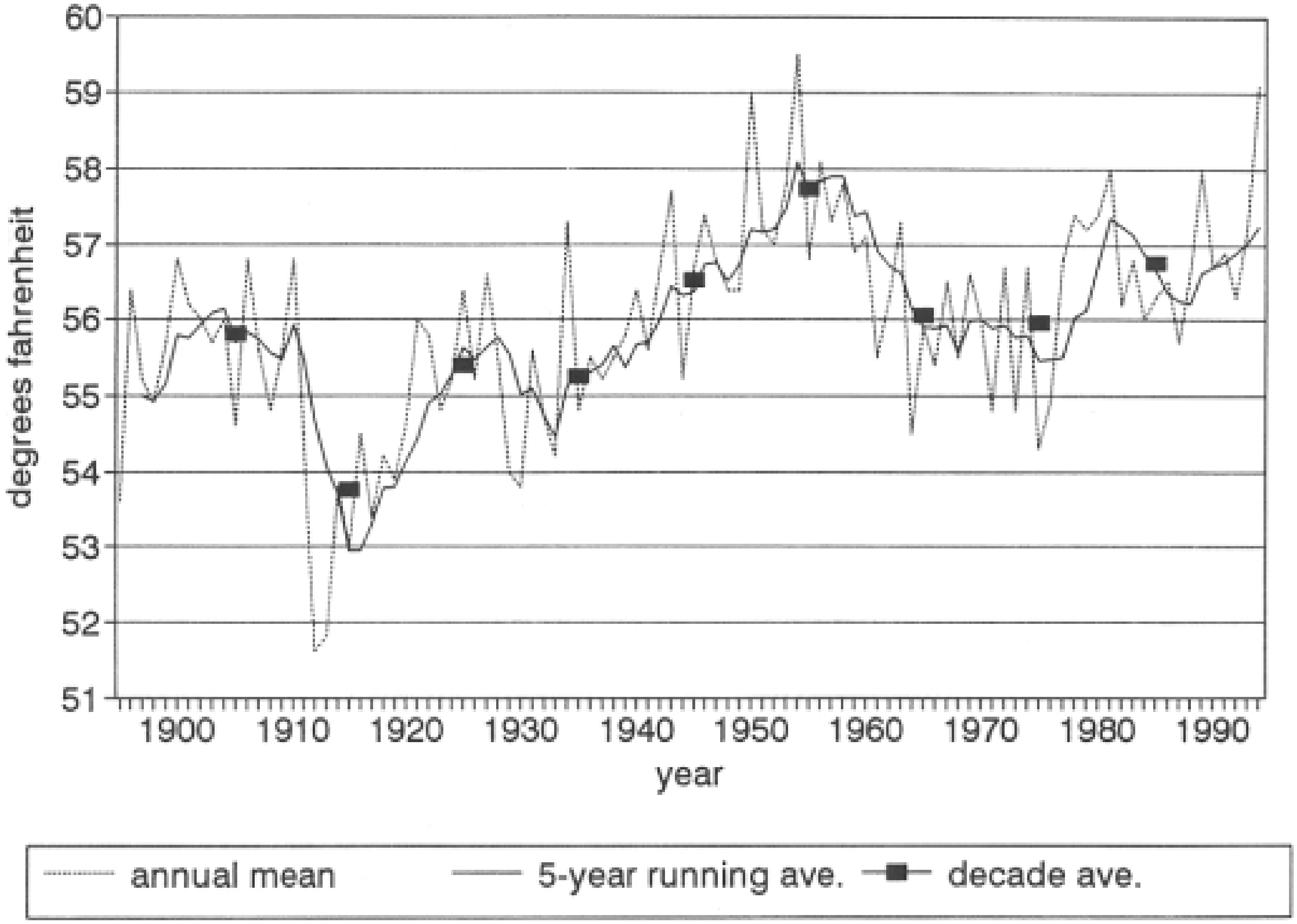

Figure 8—Annual mean temperatures in Albuquerque, 1896–1994.

Wind Direction and Speed

Wind direction and speed at Albuquerque are locally affected by cool air drainage from the Sandias into the valley and from higher mountains and mesas to the north, down the valley. Warming of the air during the day causes upslope winds along the west face of the range (Tuan et al. 1973: 69). Local winds, which are sometimes turbulent, are common during summer thunderstorm activity.

Annually, measurable wind blows from the northwest quadrant (i.e., west, northwest, or north) 42.1 percent of the time and from the southeast quadrant, (southeast or east) 41.9 percent of the time. Albuquerque's winds blow less than 8 mph 53.1 percent of the time, from 8 to 12 mph 26.4 percent of the time, from 13 to 18 mph 13.1 percent of the time, and from 19 to 47+ mph 7.4 percent of the time (Bennett 1986: 51).

Spring winds and dust storms are generally perceived as Albuquerque's only adverse climatic features. An average of five of these events occurs in April, the highest for a month, but those in March last longer. These strong, turbulent winds blow from the west across an area generally with scant or no vegetative cover, picking up soil particles and transporting them through westside developments and across the Rio Grande to older neighborhoods in the city. Severe dust storms occur with the passage of a cyclone with a sharp, cold front. These develop gradually during daylight hours, reaching speeds of 45 mph or higher by 3:00 to 4:00 p.m. Dust may be carried to 12,000 feet above the ground surface, reducing visibility to three-quarters of a mile (Bennett 1986: 50; Tuan et al. 1973: 105–107).

The worst such storms occur during hot, dry springs, such as those of March and April 1862, when the activities of Confederate and Union troops were hampered by blowing sand (Hall 1960: 121; Simmons 1982: 188). W.H.H. Davis (1982: 53) described springs in Albuquerque as sometimes having prevailing high winds, "when the sun is almost obscured by the clouds of fine dust. . . ."

In more recent history, two substantial dust storms occurring over 3 days struck Albuquerque in mid March 1963. These storms preceded passage of a cold front; strong, warm windy conditions existed. Winds of 30–40 mph with peak gusts of 50 mph and a high temperature of 66° F were recorded at the weather service station on March 15th, while winds on the Sandia Crest attained speeds of 80 mph, with gusts exceeding 100 mph. With passage of the cold front, the next day was clear and cool. In the early afternoon of the following day, March 17th, the temperature rose sharply, and the winds again gusted to 30–40 mph, replicating meteorologically the storm of March 15th (Tuan et al. 1973: 109).

Fall and early winter are the periods of least blowing dust, with September having the fewest dust storms (Tuan et al. 1973: 111). The strongest wind gusts have been recorded in the winter. On December 9, 1943, wind velocity from the southeast at Albuquerque peaked at 90 mph. The highest wind gust ever recorded occurred December 12–13, 1987, 44 years later, at the base of the Sandia tramway. Gusts up to 98 mph were measured in the city on January 18, 1990 (Liles 1994: 3; Taft 1980: 1). Dust storms recorded for Albuquerque for 1945–60 are listed by month and severity in Table 14.

Solar Radiation

Solar radiation or "sunshine" directly affects temperature and produces in part some precipitation, snowmelt, plant growth, evaporation, and wind. Sunshine also affects human health and tourism. Receiving about 76 percent of the potential insolation, Albuquerque is exposed to a significant amount of solar radiation (Keen 1987: 150; Taft 1980: 15). From December 1961 to February 1964, some sunshine was recorded every day (Tuan et al. 1973: 100). This kind of solar exposure at Albuquerque's mid latitude and high elevation has resulted historically in a relatively high incidence of skin and eye diseases. Melanoma and other skin cancers have increased sharply in recent decades.

The maximum daily potential in hours of possible solar radiation varies from a low of 8.78 on winter solstice to a high of 14.5 on summer solstice (Table 15).

Besides clouds, slope aspect determines the amount of solar insolation reaching the ground, especially for north-south oriented mountain ranges and deep valleys or canyons. For example, temperature differences between the north and south slopes of the Sandia Mountains or Embudo Canyon can be considerable. Prehistorically and historically, this phenomenon was many times a determinant in the siting of communities, camp sites, houses, and agricultural fields in this area (Scurlock 1982: 27–28, 41, 44, 100–101; Tuan et al. 1973: 68–69).

Table 14—Dust storms in Albuquerque, 1945–1960.

Month	Total number of days with blowing dust	Storms classified		
		Severe[a]	Moderate[b]	Light[c]
January	14	4	3	7
February	26	7	11	8
March	44	15	12	17
April	75	18	21	36
May	55	2	8	45
June	56	5	6	45
July	38	1	2	35
August	10	0	1	9
September	8	0	2	6
October	15	0	5	10
November	13	1	2	10
December	10	3	3	4
Total	364	56	76	232
Average year	23	3	5	15

[a] *Severe: Continuous blowing dust for 3 hours or more with visibility restricted to 1 mile or less at some time during the storm.*
[b] *Moderate: Continuous blowing dust for 2 hours or with visibility 4 miles or less during the storm.*
[c] *Light: All other dust storms during which visibility was restricted to 6 miles or less.*
Source: Tuan et al. 1973: 109, 111

HISTORIC CLIMATE: OVERVIEW AND RECONSTRUCTION, 1540–1980

Over the last 6 centuries the climatic regime of the Middle Rio Grande Basin has remained relatively stable, with no major changes in the various components that make up weather. Episodic droughts and wet years characterize the variability of the region's historic weather. However, there were minor, but noticeable, climatic changes that occurred between about 1450 and 1850, when average temperature ranges were a few degrees below post–1850 averages and snowfall somewhat greater. A number of early explorers, priests, and Hispanic settlers,

Table 15—Sunrise and sunset at or near equinoxes and solstices.[a]

Date	Time
March 21 (spring equinox)	
Sunrise	7:15 a.m.
Sunset	5:06 p.m.
June 21 (summer solstice)	
Sunrise	4:53 a.m.
Sunset	7:24 p.m.
September 21 (autumn equinox)	
Sunrise	5:53 a.m.
Sunset	6:05 p.m.
December 21 (winter solstice)	
Sunrise	7:11 a.m.
Sunset	4:58 p.m.

[a] *Actual dates can fall on the 22nd or 23rd as well.*
Source: Taft 1980: 18

as well as a few early Anglo Americans in New Mexico, wrote about the long, cold winters of this period. This generally colder period, known as the "Little Ice Age," was a worldwide event (Crawford et al. 1993: 15; Lamb 1977: 454–473; Swan 1977: 29–36). For example, Fray Benavides in 1630 observed that the winters were "very rigorous" and with "so many snows, frosts, and cold," causing the rivers and other surface waters to freeze solid. Interestingly, he found the summer heat more "intolerable," however, than the winter cold (Ayer 1965: 37, 39).

In 1844, near the end of this period, Josiah Gregg (1966, I: 146–147) wrote the following about the weather:

> Salubrity of climate is decidedly the most interesting feature in the character of New Mexico. Nowhere, not even under the much boasted Sicilian skies, can a purer or a more wholesome atmosphere be found.

From the late 19th century to today there has been a general warming of a few degrees Fahrenheit over the study region, making the dry climate even more attractive to a variety of residents and visitors, especially those with respiratory ailments. In 1903 a University of New Mexico climatological researcher (Weinzirl 1903: 9) expressed his view of New Mexico's weather as related to human health:

> That more equable climates can be found than that of New Mexico is certain. That warmer climates or cooler summer climates are available is equally true. But it will indeed be difficult to find an all-around, all-year climate which at the same time affords so many of the desirable factors required by the invalid, viz., an abundance of sunshine, a dry atmosphere, plenty of pure air, and a considerable altitude.

The following overview, a chronological reconstruction of the historical climate for the Middle and Upper Rio Grande basins, is based on tree-ring and stream runoff data, scientific weather records, and anecdotal observations. Dendrochronology for the region is reasonably good, but there are few or no data available for many specific locations. In some instances anecdotal data have been combined with local or regional dendrochronology sites to interpret the seasonal or annual weather for a particular location. Weather data recorded by scientific instruments began in late 1849, but this collected information varies in reliability until late in the century. Many early recording stations were forts or military garrisons and were abandoned, so continuous records to the present do not exist. A few locales, such as Santa Fe and Albuquerque, have reliable, continuous records extending for more than a century (table 1). Stream-flow records for regional rivers began in 1888, when the U.S. Geological Survey (USGS) established the first such station at Embudo. Most of the continuous records are from post 1900. The most reliable reconstruction of the historical climate is therefore from 1888 to the present.

Early Colonial, 1540–1680

When the first Spaniards, led by Francisco Vasquez de Coronado, arrived in the Middle Rio Grande Valley in December 1540, the region was in the grips of what some researchers have called the Little Ice Age. This generally cold period began about 1430–50 and lasted until the mid 1800s, and was periodically marked by temperatures 1.8 to 3.6° F below 20th century means (Fritts 1991: 175, 189–192; Lamb 1977: 454–473; Swan 1977: 29–36). Some investigators (Fritts 1991; Jones and Bradley 1992) suggested that the term Little Ice Age is misleading, in that there is little evidence of abnormally colder temperatures during this period.

An increase in moisture, perhaps from long winter snowfalls, in the first 2 decades of the 15th century is indicated by various tree-ring studies. This factor probably favored Pueblo populations, primarily dependent on corn, beans, and squash as staples, but floods caused by runoff from deep snowpacks and periodic droughts forced the abandonment of some villages, with relocation to higher sites with new farmlands (D'Arrigo and Jacoby 1991: 95, 98; Gunnerson 1974: 132; Schoenwetter and Dittert 1968: 46; Stuart 1985: 96). During periods of lower temperatures, shortened growing seasons may have resulted in diminished crop harvests.

Periodic droughts, accompanied by warmer temperatures, did occur, of course, over these 3 centuries, as they have over the last 146 years. Just prior to the Spanish arrival, droughts struck in 1525 and 1533–35. These dry years have recently been termed "La Nina." An "El Nino " year, or an exceptionally wet period, occurred in 1531–32; such years are caused by the early winter appearance of anomalously warm surface water along the coast of Ecuador and Peru (Table 16). This warm water apparently interacts with the atmosphere to produce increased moisture content. Associated with this event is a west-to-east flow of this moist air over North America known as the Southern Oscillation. In La Nina years, the opposite effects occur (Ellis 1974: 231; Leighly 1963: 67–68; Quinn et al. 1987: 14449–14450, 14453).

The heavy snowfall of late 1540, which caused suffering among the Coronado expedition members, actually began in late October near Zuni Pueblo. Snowfall accumulations resulted in depths of 18 inches from there to the Tiguex villages in the Bernalillo area. Snowfall occurred at Taos Pueblo for six consecutive months in 1540–41, and snow fell almost every day in January and February at the Tiguex villages. The surface of the Rio Grande

Table 16—El Nino years.

Year	Year	Year	Year
1525–26	1660	1791	1906–07
1531–32	1671	1803–04	1911–12
1539–41	1681	1814	1915
1552	1687–88	1815–16	1917
1567–68	1701	1828	1925–26
1574	1714–15	1844–45	1932
1578	1717–18	1864–65	1937
1591–92	1720	1871	1940–41
1607	1728	1877–78	1952
1614	1746	1884	1958
1618–19	1747	1886 winter	1972–73
1624	1761	1891	1982–83
1634	1775	1899–1900	1985
1652	1785–86	1905 winter	1986–87

Sources: Crawford et al. 1993: 16; Quinn et al. 1987: 14450–14451

was frozen solid and remained so until May. Runoff from the deep snowpack caused severe flooding in the late spring-early summer (Bancroft 1989: 56, 59; Bolton 1964: 204–205, 213–214, 216; Hodge 1946: 204–211, 316).

Tree-ring data indicate that a drought occurred in 1542, probably in the summer. Apparently summers were generally dry, but winters remained long and cold throughout the remainder of the century. The 1550s generally were wet, with above-average precipitation. Precipitation was below normal for the period 1560–93; the years 1552, 1567–68, 1574, and 1578 were exceptionally wet (Bradley 1976: 216–217; Ellis 1974: 231–232; Fritts 1965: 432; Ladurie 1971: 30–31, 285; Quinn et al. 1987: 14450; Reher 1972: 216–217; Schroeder 1972: 48).

During this period, some Pueblo villages were abandoned along the Rio Grande, Rio Chama, and Galisteo basin, and populations moved to higher elevations in some instances. Severe winters no doubt had an adverse effect on the Pueblos, as they did on the Spanish entradas of January 1581 and the winters of 1581–82, January-March 1583, and the winter of 1590–91. Deep snows, below-normal temperatures, and frozen streams were the main problems experienced by Spaniards on these expeditions (Bolton 1946: 178; Hammond and Rey 1966: 62, 106–107, 137, 170, 206, 284; Sanchez 1987: 34, 38, 46–47; Schroeder and Matson 1965: 73, 103, 110, 123, 124, 145, 148, 152, 154; Fig. 8). Santo Domingo Pueblo was flooded in the spring of 1591, no doubt due to high runoff from the melting of the deep snowpack (White 1935: 12).

The winter of 1597–98 and the summer of 1598 were dry, followed by another severe winter, both of which adversely affected the first Spanish colonists of New Mexico as they were led up the Rio Grande from El Paso to San Juan Pueblo by Juan de Onate. By late October, area snows began, and this and the next two winters were long and severe (Baisan 1994: 2). One of Onate's soldiers commented, "The cold is so intense that the rivers freeze over, and it snows most of the time during the winter, which lasts eight long months" (Baisan 1994: 2; Simmons 1991: 101–105, 109, 111, 118, 125, 127, 158). Partly due to the dry summers and harsh winters of the next few years, Apaches and Navajos began to raid the Pueblo and Spanish villages for food. The Jemez, Keres, and Tewa pueblos were forced to move to more environmentally advantageous sites (Schroeder 1968: 298, 1972: 48).

Precipitation was below normal and temperatures above normal from 1602 to 1609, except for the El Nino year of 1607. Probably due to environmental stress caused by this extended drought, the Querechos (Apaches?) raided from their mountain strongholds in the basin. The next decade was wet; 1614 and 1618–19 were El Nino years. The following decade, 1620–1629, was a dry period, as was the next, except for 1634, an El Nino year. Famine among the Pueblos was widespread, especially in the Salinas Province. Apache raids, also caused in part by the severe drought, which extended onto the Southern Plains, were frequent and intense. Hostilities between the Jemez Pueblos and Navajos and Apaches also ensued. And as in the early part of the century, winters were harsh. Custos Alonso Benavides wrote about New Mexico's weather in 1630:

> The temperature is by extremes: for the winter is very rigorous and of so many snows, frosts and cold [snaps] that all the rivers, sloughs, and even the Rio del Norte freeze. . . . And so every winter many Indians are frozen in the country, and many Spaniards have their ears, feet, and hands frozen. And on the contrary, in summer the heat is more intolerable than the cold in winter (Ayer 1965: 39).

Another priest also noted that winters in the 1610s–1620s brought deep snows and very cold temperatures. Fray Salmeron described these seasons as "cold and healthful," but noted the heat "is more intolerable than the cold" in the summer. Tree-ring evidence for warmer summers has been collected (Ayer 1965: 39; Fritts 1991: 133, 141, 190; Hackett 1937: 109, 119–120; Milich 1966: 55, 57; Quinn et al. 1987: 14450; Schroeder 1968: 298; Vivian 1964: 153).

The years 1641–50 brought increased rainfall and perhaps the lowest temperatures of the Little Ice Age, but the heat and dryness returned after 1650 (Eddy 1976: 1189, 1199; Ladurie 1971: 30, 32; Fritts 1991: 190). By 1658 drought-generated famine had impacted the Pueblos, and the Piro began to abandon villages from below modern Belen to San Marcial. Again, the plains and mountain Apaches were stressed by drought conditions, and they brought their own children and slaves to the pueblos to trade. By the summer of 1659 the Pueblos and Spaniards were forced to eat grass seeds, herbs, bran, "spinach" (quelites?), and green barley. The severe aridness and heat extended into the next decade, resulting in more nomadic raids, starvation, and an increased death rate, resulting in an estimated population decline from 40,000 Native Americans in 1638 to 17,000 in 1671 (Forbes 1960: 151, 159–161; Gutierrez 1991: 119; Hackett 1937: 17, 142, 162; John 1975: 92; Loomis and Nasatir 1967: 17; Reeve 1957: 48–50; Vivian 1964: 153).

The drought continued through the 1660s, bringing more starvation and unrest. Salinas Province was the hardest hit, while drought conditions in the Santa Fe-Pecos area were not so severe (Fairchild-Parks et al. 1995: 10). Compounding the suffering and loss of Native American and Spanish lives was the outbreak of an epidemic in the region (Forbes 1960: 159, 161: Hackett 1937: 17; John 1975: 92; Reeve 1957: 48; Schroeder 1968: 297; Simmons 1979: 184; Vivian 1964: 3, 153). By 1670 the Piro and Salinas pueblos were experiencing possibly the worst drought in the Spanish Colonial period (Fairchild-Parks et al. 1995: 10).

Perhaps by this time the Pueblos began to believe that Catholicism did not ensure an orderly and productive progression of the seasons with attendant precipitation, as their own religion did. "Sorcery" and other native rituals may have increased at this time. Attempted suppression of native religion, ongoing since early Spanish colonization, was increased. Some 47 "Pueblo witches" were apprehended at San Juan Pueblo in 1675; a few were hanged and others were flogged. One of those flogged was Pope, a major leader in the revolt that occurred 5 years later (Anderson 1985: 369; deBuys 1985: 51; Sando 1992: 63; Tainter and Levine 1987: 86).

The ongoing drought and interrelated famine and raids were a major cause of the Pueblo Revolt of August 1680 (Loomis and Nasatir 1967: 17; Schroeder 1968: 297). An epidemic made the situation worse in the early 1670s, and the Apache and Navajo raids continued at an intense level. Tompiro and Piro pueblos were depopulated and before the end of the decade totally abandoned (Fig. 9). Punitive raids by the Spanish against the raiders exacer-

Figure 9—Cochiti Pueblo in snow. Photo by T.H. Parkhurst, courtesy Museum of New Mexico (negative no. 12311).

bated the general decline of the Pueblo-Apache-Navajo relationship.

Climate played a crucial role in the revolt. Pope and other Pueblo leaders noted that the winter snowfall of late 1679-early 1680 on the mountains of the Upper Rio Grande Basin was heavy. They also observed that spring temperatures were cool, delaying snowpack melt until the summer. These factors, they believed, would result in an abnormally major and late flood, which would delay the arrival of the supply caravan at the El Paso del Norte crossing of the river. So they set the date of the revolt in early August. These planners were proved to be correct in their predictions of this environmental event. The supply train was not only delayed in August but also until Spanish refugees fleeing from the revolt made their way downriver to the ford in mid September (Bailey 1980: 58–59; Correll 1976: 16; Forbes 1960: 167–168; Grinde and Johansen 1995: 67–68, 72; Gunnerson 1974: 98; Gutierrez 1991: 130; Hackett 1937: 17; Kessell 1979: 212; Reeve 1957: 48). The revolt of 1680 temporarily ended the Spanish oppression, as they were driven south to El Paso.

Middle-Late Colonial, 1681–1821

A flood along the lower Rio Grande resulted from a heavy snowpack to the north during the summer of the revolt, but drought once again appeared the following year and persisted until the El Nino of 1687–88. The customary elevated temperatures accompanied the drier conditions (Baisan 1994: 2; Ellis 1974: 233; Quinn et al. 1987: 14450). Due partly to the stress of the drought, the Pueblo alliance of 1680 disintegrated, and the Spaniards and their allies at El Paso suffered as well. The now familiar pattern of nomadic raids against Indian and Spanish farm villages in the area resumed. Winters remained severe, with heavy snows and very cold temperatures (Bancroft 1889: 184–185; Beck 1962: 82, 85; Ellis 1956: 29; Espinosa 1940: 170; Folsom 1989: 121; Fritts 1991: 125; Gutierrez 1991: 139; Hackett and Shelby 1942: 321, 337, 351, 354, 362–365; Quinn et al. 1987: 14450; Simmons 1977: 73).

An extended winter storm in late 1681 indicates how severe the weather was at the time, hampering the activities of the Spanish army under Governor Otermin. Rain, snow, and high winds struck the area from Isleta to Alameda on the morning of December 10, and then snow fell all day. On the night of the 11th there was an intense sleet storm, and temperatures were low. This bitter cold continued on December 12 and through the morning of the 13th. At this time a "fierce storm of large hail" accompanied by strong winds occurred. On the 14th, rain and snow fell, with a continuance of cold temperatures and high winds. The snow persisted through the night and into the next morning, "the earth being everywhere invisible and much snow still falling." The weather moderated some later in the day, and on the 17th the sky cleared. A cold, north wind blew, however, on the 18th of December (Hackett and Shelby 1942: 22–224, 227–231).

Diego de Vargas assumed command of the Spanish military and colonists at El Paso in early 1691, and he found them in deplorable condition. When he led a reconquest expedition up the Rio Grande in October of the next year, his army was hampered by rain and snow, which made bad roads even worse. Vargas described New Mexico's climate as "so very cold with abundant snow and rain and such heavy frost and freezes..." (Kessell et al. 1995: 110).

Campaigning again from El Paso against the northern Pueblos in December 1693, Vargas and his troops suffered in the deep snow and cold temperatures. In late 1694 and 1696, campaigns by Vargas again were hampered by snow and cold. In the latter year, drought conditions returned, and crop and livestock losses were high; an infestation of worms adversely affected the harvest as well. Most of the northern Pueblos revolted during this year, and some Rio Grande Pueblo residents sought refuge from the weather at Acoma and Laguna. Tree-ring data indicate a cooler period over most of the decade (Bailey 1940: 95; Bancroft 1889: 214–215; Beck 1962: 88; Ellis 1974: 397; Espinosa 1942: 151–154; Fritts 1991: 125; Simmons 1982: 85; Twitchell 1963, I: 391).

Drought continued from 1698 into the first decade of the 18th century. Conditions among the Pueblos and Spanish were again worsened by epidemic diseases and raiding by Apaches and Navajo, partly due to the drought. Precipitation fell mainly in the form of snow in winter and as rain in the El Nino year of 1701. The harsh winters of 1704 and 1706 and the drought of 1707 caused suffering among the Spanish and Pueblos. Navajos began to raid settlements in 1707. Travel was again hindered by winter snows during this period (Adams 1954: 47, 65, 105; Baxter 1987: 21; Brugge 1979: 113–114; Ellis 1974: 397; Fritts 1991: 125, 127; Hackett 1937: 375; Kelley 1952: 384; Minge 1976: 32; Quinn et al. 1987: 14450; Simmons 1980: 194).

An El Nino year was experienced in 1714–15 according to one source, but another suggests a dry period occurred in 1714–17 (Ellis 1974: 234; Quinn et al. 1987: 14450). At least one crop failure took place, and forest fire frequency was above normal. In the late years of the decade, wetter conditions and warmer temperatures prevailed, except for below-normal rainfall in the summer. An El Nino year occurred in 1720 (Baisan 1994: 3; Fritts 1991: 127, 148, 190; Simmons 1982: 111; Swetnam and Betancourt 1990: 1019).

The decade of the 1720s was generally dry, except for the El Nino year of 1728. Warmer temperatures continued until about 1726. What the specific weather conditions were throughout the late 1720s and early 1730s is not known, however, dry conditions probably prevailed. Tree-ring data indicate that precipitation was below normal from 1734 to 1739. Tree-ring data from the Sevilleta National Wildlife Refuge indicate that the 1730s–40s was the worst drought period since the late 1500s (Fairchild-Park et al. 1995: 8). A Rio Grande flood, which destroyed the church of upper Bernalillo in 1735, may have been the result of runoff from a deep snowpack to the north or an intense local rain. At this time and place, the Rio Grande channel began to move westward (Ellis 1974: 234; Fritts 1991: 134; Quinn et al. 1987: 14450; Snow 1976: 172–175).

A major flood occurred along the Rio Grande in 1741, and floods on the north bank of the Chama in the Abiquiu area forced Spanish settlers to move to the south bank. Precipitation was above normal in 1745–47, with an occurrence of an El Nino in 1747. The following year a severe drought began, and wildfires were much above normal. In 1752 the Rio Grande was dry for its entire reach in the region. Temperatures were moderately warmer during this period, especially in the drought years of 1755–57 (Adams 1954: 43, 71; Baisan 1993: 3; Fritts 1991: 127, 134; Pattie 1966: 268; Tuan et al. 1973: 56).

The Rio Grande flooded almost every year from 1753 to 1760. The river topped its banks several times in 1760 and ran "full" throughout the year. The following year was an El Nino year. Several severe floods occurred along the river, especially in the Santa Fe, Belen, and Tome areas; the Rio Grande channel moved eastward at the latter two settlements. Temperatures for the entire decade were below normal (Adams 1954: 43, 71; Fritts 1991: 126, 150; Gerald 1974: 151–152; Kessell 1980: 150; Quinn et al. 1987: 14450; Snow 1976: 172–175; Tuan et al. 1973: 56).

One of the severest droughts of the colonial period struck the region from 1772 until about 1785. There was general crop failure and a marked decrease in wild plant and animal populations. Navajo, Apache, and Comanche raids increased sharply because of the environmental stress. El Nino rains fell in 1775, and crop harvests were good at Taos Pueblo. Drought conditions returned for the last half of the decade; springs and creeks reportedly ceased flowing. Some residents ate cow and oxen hides, leather shoes, and saddles. A smallpox epidemic struck the region in 1780, which, combined with the drought, killed some 5,025 Pueblo Indians. A number of Pueblo and nomadic Indians moved into other Pueblo or Spanish villages (Adams and Chavez 1956: 112, 175, 194, 213, 215, 217; Bodine 1979: 256; D'Arrigo and Jacoby 1991: 95, 97–98; Fritts 1991: 127; Gutierrez 1991: 372; Hewett et al. 1913: 48; Hodge 1929: 26; John 1975: 474; Jones 1966: 133–134, 150–156; Kenner 1969: 48–49; Kessell 1979: 347; Simmons 1979: 190; Workers of the Writer's Program 1940: 69).

Although the drought persisted, an above-normal spring runoff, probably due to a heavy snowpack in the Rio Grande headwaters, caused flooding at San Felipe and other Rio Grande pueblos in 1780–81. The lake near Laguna Pueblo was dry for most of the year in 1782, except in the spring, when it filled with runoff water from the San Mateo Mountains. By 1785 forest fire frequency in the region was above normal due to dry conditions, but these changed later in the year due to an El Nino event. Temperatures generally were warm over the decade (Fritts 1991: 126, 151; Kessell 1980: 132; Quinn et al. 1987: 14450; Swetnam and Betancourt 1990: 1019; Thomas 1932: 103).

In 1791 there were El Nino conditions; the winter of 1792–93 was also wet. Temperatures over the next 20 years continued generally warm. High temperatures caused the deaths of some horses in 1801. Irrigation water saved crops during the drought year of 1803; an El Nino year followed, temporarily ending the drought. Dry conditions returned, however, and persisted until 1813. An El Nino year followed in 1814, and severe, long winters began in this year and extended over the next few years. The remainder of the decade and into the early 1820s were dry, causing hardship for people and their livestock. Wildfires were common in 1818–19 and 1822 (Baisan 1994: 3; Bancroft 1889: 302; Baxter 1987: 77; Denevan 1967: 701; Ellis 1974: 235; Fritts 1991: 128, 151–152; Gunnerson 1974: 284; Quinn et al. 1987: 14450; Simmons 1983: 6–8; 1991: 70–71).

Mexican-Territorial, 1821–1912

In 1822–23, at the end of the drought, major flooding occurred along the Rio Grande from Bernalillo to El Paso (Bowden 1971: 94; Carter 1953: 4, 19). A major flood on the river, perhaps due to deep snowpack, occurred in 1823 (Lange et al. 1975: 73). Rainfall was below normal in 1824–25. Precipitation increased, beginning in 1827; an El Nino year occurred in 1828. Perhaps the largest flood on the Rio Grande during the historic period, estimated at 100,000 cfs, inundated the entire valley below Albuquerque in 1828. Among the widespread flood damage was the destruction of the church at Socorro. Temperatures were abnormally cold during this period; one source noted that New Mexicans had to spend 6 months of every year indoors due to the cold. Tree-ring data in the northern part of the region indicate below-normal precipitation (Baisan 1994: 3; Burrus 1984: 148; Carroll and Haggard 1942: 40; Fritts 1991: 154; Ellis 1974: 235; Quinn et al. 1987: 14450).

In 1830 another major flood occurred along the Rio Grande, destroying property in the region. The decade was not only a wet one, but also temperatures were the coldest in the historic period. The winters of 1831 and 1832 were bitterly cold with deep snows. One source reported that loaded wagons could cross over ice on streams. There was some loss of human life and major losses of livestock (Bailey and Carroll 1942: 24–25; Barreiro 1928: 11–12; D'Arrigo and Jacoby 1992: 243, 251; Fritts 1991: 128–129, 154; Gregg 1966, I: 147–148). Forest and grass fires were below normal, probably due to the above-normal precipitation (Swetnam and Betancourt 1990: 1019).

Drier conditions began in 1841 and prevailed into the early 1850s. Probably as a result of this drought, nomadic groups increased their raiding on villages, herds, and fields along the Rio Grande (Bayer et al. 1994: 115–116). The El Nino year of 1844–45 brought some relief, but the drought returned. The years 1845–47 were perhaps the driest period in the last 5 centuries. In 1847 forest fire frequency was above normal, as was the case in 1851. Streams dried up, there were dust storms, and temperatures were above normal over much of the period. Nomadic Indian raiding intensified in 1852–53, both dry years (Horgan 1954, I: 831). Heavy snow and cold temperatures occurred in northern New Mexico in the winter of 1846–47 (Abert 1962: 141–148; Bloom 1914: 37–38; Denevan 1967: 701; Ellis 1974: 235; Fritts 1965: 438–442; 1991: 128, 129, 134, 155; Quinn et al. 1987: 14451; Schroeder 1963: 12; Swann 1977: 31; Swetnam and Betancourt 1990: 1019; Tiller 1992: 43).

Precipitation was substantially above normal in 1854–55, causing disastrous flooding over much of the region. The Rio Abajo and Rio Arriba experienced relatively severe property damage. A major sandstorm struck Casa Colorado in early May 1855, and there was a relatively heavy snowfall and cold temperatures in the Algodones-Santa Fe area in the late fall-early winter of 1856. Floods also occurred in 1856 and 1857. An extended drought hit the region in 1859–65. A major flood in 1862, probably caused by runoff from a deep snowpack, inundated much of the Rio Grande Valley from Albuquerque south; structures and crops were damaged or destroyed (Barbour 1990: 95, 97, 105, 106–107, 109, 115; Baisan 1994: 3; Beadle 1973: 514–515; Davis 1982: 298–299, 359–360; Espinosa and Chavez n.d.: 146; Fritts 1991: 156; Heyman 1951: 49–50; Lange and Riley 1970: 14; Loew 1875: 133; Sonnichsen 1980: 9; Tuan et al. 1973: 57). Cold winter weather was experienced in January and February 1861, and March brought at least one severe dust storm. Later in the year, the Rio Grande was dry from Socorro to below El Paso.

Continuing drought conditions caused the Navajo to raid Acoma and other pueblos for agricultural produce in the early 1860s. The dry conditions and warm temperatures continued, and a severe winter in 1863–64 caused hardship for the Navajos, who had been continually beleaguered by the U.S. Army. Some 8,000 surrendered during this period. Snowfall was heavy in the El Nino year of 1864. The next winter was also snowy and cold; late spring frosts killed the buds and flowers of fruit trees regionwide. Floods caused by snowmelt runoff resulted in major flooding from Bernalillo south, destroying crops and forcing valley residents to move to higher ground. Above-normal precipitation caused more flooding in 1866–70; the Rio Grande shifted its channel in some Rio Abajo locations at this time. Winters continued to be cold, causing hardship and some deaths (Armstrong 1988: 60–63; Browne 1973: 70–71; Carter 1953: 64; Ellis 1974: 235; Fritts 1991: 134, 191; Keleher 1982: 382–383; McKeta 1982: 56–57; Miller 1989: 95, 201, 217–218; Quinn et al. 1987: 14451; Scurlock 1982: 12; Simmons 1982: 179, 194, 195; Sonnichsen 1980: 9, 182; Tiller 1992: 71, 73; Wozniak 1987).

The years 1870–71 were wet; the latter was an El Nino year. Generally dry conditions prevailed in southern New Mexico in 1871 and from 1873 to 1880 across the entire region. Floods occurred in the Middle Valley in the springs of 1871 and 1872 and on the Chama and Rio Grande in the spring and summer of 1874, due to spring runoff from the northern snowpack. The summer of 1877 was one of below-normal rainfall. An El Nino year occurred in late 1877–78, and heavy snowfalls in the winter caused the loss of more than 20 percent of the sheep in the region. Below-normal precipitation followed for 2 years, according to tree-ring data. Drought severely impacted the livestock and railroad industries during this time, and forest fires were above normal in 1879. Temperatures generally were above average. The combination of drought, intense local rains, and overgrazing probably caused severe erosion (Baisan 1994: 3; Bancroft 1889: 739–740, 768; Biebel 1988, I: 138; Carter 1953: 9–10, 44, 73; Denevan 1967: 701; Eisenstadt 1980: 13; Fergusson 1951: 356; Fritts 1991: 129, 157; Gordon et al. 1974: 98; Miller 1989: 100–101, 103; Nanninga 1982: 99; Quinn et al. 1987: 14451; Simmons 1982: 204, 208; Swetnam and Betancourt 1990: 1019; Fig. 10).

The summer of 1880 was rainy in northern New Mexico, but drought prevailed elsewhere. The Rio Puerco flooded, and 2 years later the lower Santa Fe River flooded on July 13 (Lange and Riley 1966: 339; Quinn et al. 1987: 14451; USGS 1994). Dry conditions generally continued over the region until 1891, causing losses for ranchers and farmers. Due to the drought and increased upstream use of water, flow of the Rio Grande became more intermittent. Overstocking and severe winters contributed to these losses, and associated heavy snowfall produced major runoff flooding in the springs of 1884, 1885, and 1886; a flood also occurred in late summer 1886. Damage to villages, fields and crops, and the railroad was generally extensive (Adams and Chavez 1956: 131, 137; Bancroft 1889: 768; Barry and Bradley 1972: 295; Batchen 1972: 69; Baydo 1970: 134; Brugge 1980: 92, 94, 104; Carter 1953: 16–21, 29–31, 117, 187, 228; Chappell 1969: 15; Clark 1978: 89; Denevan 1967: 701; Ensign 1888: 142, 145, 147; Follett 1898: 3; Gordon et al. 1974: 93–95, 98; Kessell 1980: 92, 130–131, 183; Lange and Riley 1966: 248, 316, 331–332; Minge 1976: 71; Oppenheimer 1962: 30–31, 33, 36; Rothman 1989: 200–202; Sonnichsen 1980: 20; Taylor 1989: 4).

Drought conditions continued into the early 1890s according to several sources, but other sources indicate 1891 was a wet year (Brown 1983: 41; Minge 1976: 72; Quinn et al. 1987: 14451). A May flood damaged parts of Valencia and Los Lunas. The generally dry weather during the period adversely impacted the ranching, farming, and railroad industries. Below-average precipitation was recorded for the mid to late 1890s as well, except for the Middle Rio Grande Valley in 1897, which was wet. The river was intermittently dry during this period (Fig. 10). Due to the drought, an embargo on permitting new irrigation in the Upper Rio Grande was imposed by the Territorial Engineer. A moderate flood did occur on the lower Jemez River (Baisan 1994: 3; Baydo 1970: 224–228; Carter

1953: 315–316, 331; Cooper 1960: 135; D'Arrigo and Jacoby 1991: 95, 97; Ellis 1974: 235; Follett 1898: 90; Fritts 1991: 157; Gatewood et al. 1964: B13; Humphrey 1987: 420; Thomas 1963a: H16; Thomas et al. 1963: D4; Tiller 1992: 130; Tuan et al. 1973: 58; USGS 1994; Westphall 1965: 92–93).

The drought continued into the early years of the 20th century. Extremely dry conditions caused starvation among cattle herds in New Mexico (Branson 1985: 16). Flooding was experienced at Alameda in 1903, however, due to snowpack runoff or intense local rain. The year 1904 was a La Nina year, but western and northern New Mexico were hit with heavy rains in late September 1904, resulting in widespread flooding. A major flood occurred at this time along the Rio Grande, destroying almost all of the field crops, vineyards, and orchards. Another Rio Grande flood, this one less serious, occurred in 1905; it probably was caused by a heavy winter snowpack. Topsoil losses were generally severe during this period. Precipitation was above normal in 1906 and part of 1907, followed by a major drought in central New Mexico in late 1907–10. Regionally, however, based on tree-ring evidence, 1907–16 were wet and cool. Weather records showed precipitation to be below normal for 1910 (Anonymous 1905: 1; Barker 1953: 191–193; Beal and Gold 1987: 99; Clark 1987: 171, 205; Crawford et al. 1993: 18; Fritts 1991: 159–160; Grubbs 1961: 287–288; Manthey 1972: 8; Murphy 1905: 149; Sargeant 1987: 36; Sargeant and Davis 1986: 105–106; Simmons 1988: 12; Tuan et al. 1973: 57–59; Workers of the Writer's Program 1940: 79).

Precipitation in 1911 was above average, and the average annual flow of the Rio Grande at the Otowi Bridge gauging station exceeded the high flows of 1897, 1904, and 1905. San Marcial property was damaged by a flood in 1911 (Beal and Gold 1987: 125; Calkins 1937: 7–8). Good crops were harvested statewide.

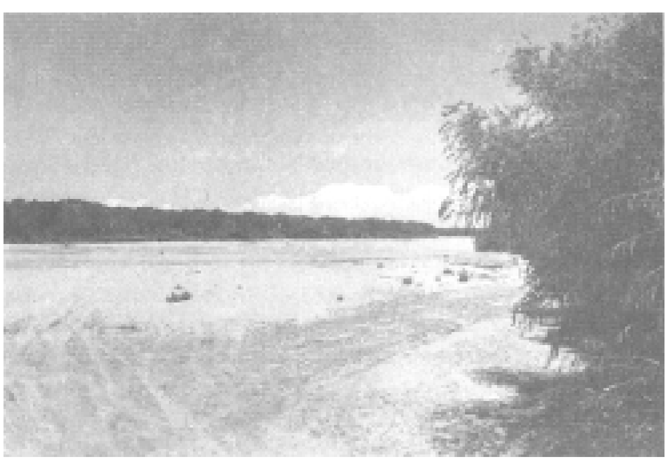

Figure 10—Dry Rio Grande riverbed near Los Lunas, 1987. Photo by author.

Statehood, 1912–1980

The first 3 years of this period, 1912–14, were also wet. The winter of 1914–15 was severe in the Jemez Mountains area; sheep ranchers suffered heavy losses. A heavy snowpack in the winter of 1915–16 resulted in above-average flows along the lower Rio Grande; 1915 was an El Nino year. The years 1917 and 1918 were dry and caused hardship for the livestock industry. Severe cold weather struck in the fall and winter of 1918, causing more losses in livestock. The next year, 1919, was one of the wettest years in this century. A major Rio Grande flood caused damage from Espanola to San Marcial in 1920 (Church and Church 1974: 12; Clark 1987: 147; Crawford et al. 1993: 18; Dahm and Moore 1994: 2; Grubbs 1961: 274–285, 287–288; Henderson 1983: 67; Kessell 1980: 152; Melzer 1982: 221; Pearson 1986: 124; Pynch 1911: 48; Tuan et al. 1993: 53, 58).

Dry conditions generally persisted across the region from 1920 into early 1925, adversely impacting the livestock industry (Hagy 1951: 29, 32–33; New Mexico Historical Records Survey 1940: 24). The Rio Grande flood of 100,000 cfs on June 3, 1921, was probably due to snowmelt runoff from the northern mountains. In contrast, the Rio Grande at San Marcial was dry for 150 days of the year. Precipitation was just above normal from late summer 1923 to February 1924 (Mortensen 1983: 16; Tuan et al. 1973: 58). A heavy snowpack was recorded on the Carson National Forest for the winter of 1924–25 (Tucker 1992: 7), but data on any related floods were not found. The drought was ended by the wet years of 1925–26 (Betancourt et al. 1993; Molles and Dahm 1990: 71); the wheat harvests of the 1926–27 winter were excellent. Production for the dry years of 1927–1928 was only about a third of normal, or about 150,000 bushels. Water shortages were a problem for Rio Puerco-of-the-East farmers in 1928. Severe winter weather in 1928 resulted in the loss of almost half of the sheep in northern New Mexico. The summer of 1928 was hot and dry; some ranchers moved their herds to better rangeland in Mexico. In August 1928 torrential rains on the Puerco and the Rio Salado watersheds in the Socorro area caused flooding of several downstream villages on the Rio Grande. In September 1929 heavy rains on the Upper and Middle Rio Grande caused major flooding, which virtually destroyed all of the region's crops and the villages of San Acacia, San Antonio, and San Marcial. Bernalillo was severely damaged. Many railroad bridges were washed out from Bernalillo to Guadalupe Canyon in the Jemez. Precipitation for July of the next year was the wettest ever recorded with instruments. Precipitation was above normal in 1929 and 1930. Temperatures for the decade were below normal, but summer temperatures for Albuquerque and Santa Fe began an upward trend (Bowen and Saca 1971: 53; Calkins 1937: 9–11; Calvin 1948: 25, 276; Church and Church 1974: 12; Clark 1987: 228; Davis 1986: 103; Garcia 1992: 101;

Glover 1990: 26; Harper et al. 1943: 33–34; Hedke 1925: 13; Maes and Fisher 1937: 20; Olson 1976: 73; Poulson and Fitzpatrick about 1930: 2–3; Rodey and Burkholder 1927: 16; Scurlock 1982: 13; Tuan et al. 1973: 58, 72, 76–77, 78, 145; Tucker 1992: 7; Wozniak 1987).

The frequent, intense flooding of the previous decade resulted in continuing waterlogging, a rising water table, and damage to dams and irrigation systems at the beginning of the 1930s. The winter of 1931–32 was marked by heavy snows and cold temperatures, causing loss of human lives and livestock. Intense rains in September 1931 and April-September 1932 caused flooding along the Rio Puerco and washed out the Santa Fe Northern Railroad in Sandoval County. The winter of 1932–33 was another severe season; almost 70 percent of the Jicarilla Apache sheep died. An extended drought began in late 1932, ending an El Nino year, and lasted until 1936; temperatures were above normal. There were severe losses of livestock, decimation of range vegetation, soil erosion by wind and water, and the spread of exotic plants such as tumbleweed (Fig. 11). Predation on livestock increased due to the dry conditions. Under the Drought Relief Service Program, the government began buying cattle on overgrazed, drought-stricken rangelands. The rains returned in 1937, washing out levees and irrigation facilities in a number of locations in the Middle Rio Grande Valley. Drier conditions, however, set in again in 1939-early 1940 (Bennett 1932: 27; Brown 1985: 157; Brugge 1980: 430; Calkins 1937: 13–18; Cooperrider and Hendricks 1937: 20, 76; Fritts 1991: 161, 189; Glover 1990: 56; Happ 1944: 4; Haughton 1978: 397; Limerick 1987: 88; Minge 1976: 90; Thomas et al. 1963: D4; Tiller 1983: 454; Tuan et al. 1973: 58, 72, 78; Weigle 1975: 115, 136, 145, 159).

The late winter of 1940 brought heavy precipitation; 14 inches of snow fell on Santa Fe in 5 hours. The snows continued to fall in the winter of 1940–41. Melting of the deep snowpack, and rain in the following spring, brought more flooding. Temperatures were substantially below average, and killing frosts were reported at many locations throughout the region. Heavy rains began to fall on the valley in the Cochiti Pueblo-Albuquerque area in late summer 1941, causing severe flooding. Local and regionwide records of high precipitation were set in this year. Some 62.45 inches fell at White Trail, Otero County; the statewide average was 28.24 inches. The annual runoff at Otowi Bridge in 1941 was the highest in this century; the flow for the next year was the third highest in the century. Perhaps the fewest acres to ever burn in the Southwest in recent history was due to this El Nino year (Liles 1994: 32; Quinn et al. 1987: 14451; Swetnam and Betancourt 1990: 11; Taft 1980: 12, 143; Tuan et al. 1973: 143–145).

Below-normal precipitation ensued from late 1942 to 1948, and 1943 was a La Nina year. Temperatures were elevated, and Albuquerque recorded a wind velocity of 90 mph. Livestock and wildlife suffered, there were municipal and agricultural water shortages, and forest fires occurred. Several heavy snows fell on the Pajarito Plateau in January 1948, but drought conditions prevailed regionwide. Precipitation was just above normal for 1949, but drought conditions once again returned the next year and persisted into the next decade. When rains did fall and following snow melts in the 1940s, runoff was greater due to denuded mountain slopes (Betancourt et al. 1993: 46; Calvin 1948: xv-xvi; Church 1960: 124, 132, 138, 144, 145; Clark 1987: 226–227; Crawford et al. 1993: 18; deBuys 1985: 229; Gatewood et al. 1964: B43-B44; Long 1975: 13–14; Manthey 1977: 8; Olson 1976: 73; Thomas 1963a: H18; Tuan et al. 1973: 58; USGS 1994).

A severe drought occurred over the first 6 years of the 1950s. This became the driest period since the scientific recording of weather data began in New Mexico. Surface and ground water were severely impacted, causing major losses for ranchers, farmers, and municipalities. Up to 60 percent of crops were lost; native trees such as junipers, usually drought resistant, were killed. Most farmers along the Rio Grande were able to continue farming, however, through development of irrigation wells. Water demands in the Middle Valley precluded delivery of scheduled water to Elephant Butte Reservoir. Streams dried up, and reservoirs were drawn down significantly. Intense dust storms, especially in 1956, were relatively common. Costilla, Santa Cruz, and El Vado reservoirs went dry. This was the driest year in New Mexico since the advent of scientifically recorded data. The drought finally broke with the El Nino of 1957–58. Floods occurred on the Santa Fe, Rio Puerco, and Jemez rivers in June 1958; in December the greatest 24-hour snowfall (30 inches) ever recorded in the state occurred at Sandia Crest. From late 1959 to the summer of 1963, precipitation in the region was below normal (Betancourt et al. 1993: 46; Burdett et al. 1990: 10; Gatewood et al. 1964: B43-B44; Molles and Dahm 1990: 71; Perrigo 1982: 198; Powell 1976: 91, 102; Taft 1980: 10; Tuan et al. 1973: 57, 107; USGS 1994; Welsh 1987: 132).

HISTORIC PRECIPITATION: VARIABILITY AND TRENDS

The variability of the region's climate has been alluded to previously. Historically, wet or normal years meant, in general, abundant to adequate irrigation water, native plant growth and germination, and in time, less soil erosion and few or no raids by nomadic Indians. Adverse impacts could include floods, shifts in stream channel, difficult road travel, and cultigen diseases. Droughts caused even more hardship, and even death, for humans as well as little native plant growth, decimation of wildlife, and soil erosion.

Extended, severe droughts have occurred relatively commonly in New Mexico over the past 500+ years. Examples include the drought of the late 16th-early 17th cen-

Figure 11—Although the study region never experienced these extreme Dust Bowl conditions of 1936 in western Oklahoma, dust clouds did appear over the Middle Rio Grande Basin. Photo by Arthur Rothstein, courtesy Museum of New Mexico Archives, Santa Fe (negative no. 66457).

tury, punctuated by long, heavy winter snowfalls, which is an unprecedented event of the period (Baisan 1994: 3; Thomas 1963a: H3). In addition to these periods, tree-ring evidence indicates that major dry periods occurred in the 1730s, late 1740s and 1750s, with 1755–57 being the driest years in the last 500+ years. Two decades later, one of the most severe, extended droughts struck the region, lasting from 1772 to 1785 (D'Arrigo and Jacoby 1991: 95, 97–98; Fritts 1991: 127; John 1975: 474).

Above-normal temperatures accompanied droughts, enhancing the dry conditions. Forest fires were also generally associated with these xeric periods (Swetnam and Betancourt 1990).

Since continuous, reliable weather records have been kept beginning in the late 19th century, annual precipitation in the region has continued to fluctuate cyclically, as have temperatures. The early to mid 1950s was the driest period in this century. Since the 1920s, there has been a general warming trend. The 1950s were warm, and the 1980s were the warmest decade of the century to date.

Characteristically, one or more El Nino years immediately followed these droughts. An unprecedented wet period, accompanied by very cold temperatures in winter, followed the drought of 1820–22. The heavy rains and deep snows, with major flooding, lasted until the 1840s (D'Arrigo and Jacoby 1992: 95, 98, 243, 251; Fritts 1991: 154; Quinn et al. 1987: 14450).

LIVING WITH THE RIVER: A BRIEF OVERVIEW OF HISTORICAL FLOODS IN THE MIDDLE RIO GRANDE VALLEY

Historically, periodic floods impacted the valleys of the Rio Grande and tributaries and their human users and occupants until major flood control structures were constructed in the 20th century. A minimum of 82 moderate to major floods occurred during the historic period, 1591–1942 (Table 17). These floods, which here are defined as having a flow of more than 10,000 cfs, were caused by three climatic phenomena. One type resulted in the spring from melting snow in the mountains within the Upper and Middle Rio Grande drainages. These runoff-generated floods occurred from late April to June and were characterized by a general rise in the river, then an extended flood period, followed by a gradual recession of flood waters. In 1776 one Spaniard observed

> This river is in flood from mid-April to the end of June. The force of the freshets depends upon whether the winter snows have been heavy or light, but they never fail, for it always snows more or less. In a very rainy year the flood season lasts a long time, and the longer it lasts, the greater the damage it does, whether to people or cattle who are drowned, or to farmlands that are swept away, or even to nearby houses that are carried off (Adams and Chavez 1956: 7–8).

Major flooding also resulted from extended, regional, summer rains over the drainage basin already saturated by the runoff of the snowpack and subsequent flooding. A third type of flood, of smaller scale, resulted from intense local rainstorms, which usually occurred between early July and the end of September.

When the first Spanish settlers reached New Mexico in the late 16th century, Pueblo Indians along the Rio Grande generally were living on slight rises in the floodplains or, perhaps more commonly, on elevated points of land along the edge of the valley. Situated above most flood levels, they farmed nearby plots on the lower portions of the floodplain using irrigation ditches or overflow waters from the river or its tributaries. Most of their villages and campsites were inundated periodically, however, causing the Pueblo residents to leave the area until the waters receded. Less frequently, they completely abandoned residential locations where inundation was too frequent or in instances of irreparable damage to homes or fields. Nevertheless, the Pueblos and the newly arrived Spanish settlers recognized the benefits of the floods—the deposition of nutrient-rich sediments for cultigens and native flora, the wetting of their farmlands, and perhaps even the flushing of salts from their fields and irrigation systems.

With European settlement, recording of adverse impacts due to severe flooding began, including personal injury and loss of human life; destruction of acequia systems, homes, churches, and crops; and loss of livestock. A number of floods have been documented by records research of the Colonial and Mexican periods (1598–1846). Relatively severe to major floods occurred in 1680, 1735, 1760, 1769, 1780, 1814, 1823, 1828, and 1830 (Table 17). Based on limited information, the 1828 flood was a mega event, with an estimated flow of 100,000 cfs. The entire valley was inundated from the Albuquerque area to El Paso (Carter 1953: 19; Peterson and Brown 1994: 43).

Flooding in the late 1600s–1735 was associated with a general westward shift of the Rio Grande channel. Residents of an "Upper Bernalillo" on the west bank of the river were forced to move to the east bank by this shift (Brown and Sacca 1971: 56–59; Snow 1976: 172–175). Alameda, too, was on the west bank in 1675, but sometime before 1710 the villagers were living on the "new" east bank of the Rio Grande. Albuquerque, founded in 1706, experienced some flooding when the river moved back and forth between an old chute, or channel, along the present North 2nd–4th streets and its more recent channel west of town. Dikes and berms, which date back to the Colonial Period, were sometimes breached by these flood-caused channel movements. Changes in the river are discussed in Chapters 4 and 5.

With the arrival of the first Anglo-Americans in 1846, use of the Middle and Upper Rio Grande drainage intensified. Clearing of upland forests, grazing, and more sophisticated farming contributed to increased runoffs with associated problems. Some 50 floods have been recorded for the main stem of the river from 1849 to 1942 (Table 17); these are relatively well documented as to extent and damage compared with those of the Colonial and Mexican periods. Major to moderate floods (10,000 cfs or more) in 1849, 1852, 1854, 1855, 1862, 1865, 1866, 1867, 1868, 1871, 1872, 1874, 1878, 1880, 1881, 1882, 1884 (two), 1885, 1886 (two), 1888, 1889, 1890, 1891, 1895, 1896, 1897 (two), 1902, 1903, 1904, 1905 (two), 1906, 1909, 1911 (two), 1912, 1916, 1920, 1921, 1924, 1929, 1937, 1940, 1941 (Fig. 12), and 1942 are documented for the Middle Rio Grande (Table 17). Floods of this magnitude occurred on an average of every 1.9 years during this period. There may have been other floods for which documentation has not been found.

Table 17—Historic Rio Grande floods, 1591–1942.

Date	Location	Impact	Source
1591	Santo Domingo to Puaray	Difficult or impossible to cross river	Hammond and Rey 1966: 292 White 1935: 12
1598 pre	Tewa village above San Juan	Village destroyed	Ellis 1987: 15–16
1665 spring–early summer	El Paso	Mission supply caravan delayed	Moorhead 1958: 35
1679 spring	El Paso	Created cienegas and esteros	Sonnichsen 1968: 32 Kessell 1979: 224
1680 August–September	Entire region	Deep snowpack and a late spring and intense summer rains caused flooding. Supply caravan at El Paso held up	Hackett and Shelby 1942: 229–230 Sonnichsen 1968: 31–32
1696 June	Upper Bernalillo (near present confluence of Jemez River and Rio Grande)	Village abandoned	Espinosa 1942: 255
1700	Bernalillo	Church destroyed, channel of Rio Grande began to shift westward	Bowen and Saca 1971: 56–59
1726 May	La Salineta ford, El Paso	Precluded crossing by conducta	Marshall 1990: 174
1735	Upper Bernalillo	Church destroyed, river began shifting channel westward	Snow 1976: 172–175 Bowen and Saca 1971: 56–59
1741	Rio Grande Valley	Major property damage and livestock loss	Beal and Gold 1988: 125
1700s mid	Entire region	Some humans and animals drowned, houses and fields damaged or destroyed; north bank of Chama River flooded; settlers moved to south bank	Adams and Chavez 1956: 8 Swadesh 1974: 37
1753–60	El Paso	May have flooded every year	Clark 1987: 14 Gerald 1974: 151–152
1756 ca.	Chama River valley	Santa Rosa church moved	McDonald 1985: 121
1750s late–1760s early	El Paso	Floods destroyed diversion dams virtually every year	Clark 1987: 14
1760 winter	Valley below Albuquerque	?	Adams 1954: 47
1760 July	Middle Rio Grande, Isleta, Tome	River could not be crossed	Adams 1954: 43, 56, 71 Tuan et al. 1973: 56
1760 all year	Entire region	River "ran full" all year	Adams 1954: 202–208
1763 post	Upper Bernalillo area	Residents forced to move to Algodones	Snow 1976: 172–175
1767	Santa Fe area	Property damage: Santa Fe River shifted into Rio Chiquito channel	Twitchell 1963, I: 447
1769	Tome – Belen	River shifted east and destroyed farmlands	Kessell 1980: 152
1780 spring	Santo Domingo, San Felipe, Sandia pueblos, Tome	Runoff caused severe flooding of villages and fields; courthouse damaged	Ellis 1955: 95 Kessell 1980: 132

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Table 17—Historic Rio Grande floods, 1591–1942 (continued).

Date	Location	Impact	Source
1782	Santa Ana Pueblo	Farmlands along Rio Grande and Jemez River destroyed	Thomas 1932: 98 White 1942: 27
1783	Albuquerque	Resident noted that flood left "a thick mud which serves (served) as manure for the land . . . a glutinous scum resembling lard"	Simmons 1983: 6
1798	El Paso	Bridge at lower ford washed out	Jones 1979: 145 Sonnichsen 1968: 89
1822	Bernalillo to Albuquerque	Major property damage; church destroyed	Carter 1953: 4 Chavez 1957: 3
1823	Cochiti to El Paso	Widespread damage	Bowden 1971: 94 Lang et al. 1975: 73
1828	Ranchito de Santa Ana to El Paso	Property destroyed, river shifted eastward at Ranchito de Santa Ana and cut new channel east of Peralta, flow estimated at 100,000 cfs; flood waters diverted away from Tome Plaza by a burro, or levee	Bayer et al. 1994: 114 Carter 1953: 19 Ellis and Baca 1957: 22 Peterson and Brown 1994: 43 U.S. Court of Private Land Claims 1899: 24–26
1829	Socorro	San Miguel Church destroyed	Burrus 1984: 148
1830	Entire Region	El Paso business district destroyed	Bowden 1971: 105 Lange et al. 1975: 73
1835	Upper or Middle Rio Grande	Two churches and convents destroyed	Lange et al. 1975: 73
1849 June 20	Albuquerque	Rio Grande ran "bank full in many places" with a "very swift" and "muddy or turbid" current	Bloom 1945: 146
1852 May to late July	Socorro to Isleta del Sur, Socorro	River above normal due to runoff from snowpack	Bowden 1971: 143 Hammond 1966: 24–25
1857 June or July	Tome to Fort Craig	River too high to cross at both places; estimated width at Fort Craig 1/2 mile	Browne 1973: 59
1850s	Corrales	River channel shifted and church destroyed	Eisenstadt 1980: 6
1860 ca.–1885	Chamberino, Santa Ana County	Several floods forced residents to move to higher ground	Johansen 1948: 54
1862 August	Albuquerque to Mesilla	Damage of buildings and crops; Mesilla Valley settlers moved to Tularosa Valley; Mesilla was an "almost inaccessible community" due to flood waters	Carter 1953: 4 Couchman 1990: 155 Schneider-Hector 1993: 42
1864	El Paso	Major damage	Peterson and Brown 1994: 43
1865 spring	Mesilla Valley	Village of Santo Tome destroyed; river channel shifted west	Wozniak 1987
1865 June	Cochiti to Sabinal	Evacuation of communities; crops and structures severely damaged	Carter 1953: 5, 64
1865	South of Rincon	Destruction of grain crop	Miller 1989: 95
1866	San Marcial	San Marcial was "wiped out"	Pearce 1965: 146

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Table 17—Historic Rio Grande floods, 1591–1942 (continued).

Date	Location	Impact	Source
1867 summer	Los Lentes Pueblitos to Bosque de Belen	Homes destroyed	Miller 1989: 100
1868 July 5–11	Corrales to Albuquerque	Corrales church destroyed; river could not be crossed	Armstrong 1988: 60 Simmons 1982: 194
1871 May-June	Middle Valley	Four persons drowned, little property damage	Carter 1953: 44
1872 late May–early June	Albuquerque to El Paso	Most of floodplain inundated by runoff from snowmelt in basin; flow peaked at an estimated 100,000 cfs	Beadle 1973: 490 Larson 1968: 112 Nanninga 1982: 99 Peterson and Brown 1994: 43
1874 May–June	Confluence of Rio Chama and Rio Grande to El Paso	Neither river could be crossed safely; widespread damage	Carter 1953: 9–10, 73 Kelley 1969: 17 Peterson and Brown 1994: 43
1878	"In the territory"	"There were many destructive floods..."	Bancroft 1889: 768
1878	Placitas, Dona Ana County	Residents forced to move to a mesa above Rio Grande	Johansen 1948: 54
1880 summer	San Juan Pueblo	Rear of church nearly washed away	Kessell 1980: 92
1880	Alameda	Various damages	Carter 1953: 13
1880–1930s late	Albuquerque	Town experienced "a considerable number of floods"; semi-permanent lakes bordered town on north and south, drained by Middle Rio Grande Conservancy District	Oppenheimer 1962: 33
1881	Jemez Pueblo Santo Domingo Pueblo area	Roof of Jemez church collapsed under heavy summer rains; new houses constructed on higher ground; levees constructed to channel the river away from Santo Domingo during flood stages	Kessel 1980: 130–131, 183 Lange and Riley 1966: 98
1882	Cochiti Santo Domingo	Bridge destroyed; Rio Grande was cutting into Cochiti farmlands; residents distraught; bridge damaged	Lange 1959: 37 Lange and Riley 1966: 248
1884 May–June	Del Norte to El Paso	Residents of Del Norte Valley reported that river flow was the largest they had experienced; runoff from heavy winter snowpack; flood damaged virtually every village from Albuquerque to El Paso; several people killed; extensive damage to buildings and crop fields; river cut through acequia and into old river bed near Peralta; flow estimated at 100,00 cfs; Tome church destroyed; Valencia totally abandoned; property damage between Alamillo and Lemitar; lower sections of Socorro under observed to be encroaching "upon its western bank" but cutting eastward above Alamillo	Carter 1953: 16–21, 117 Follett 1898: 90 Kight 1981: n.p. Lange and Riley 1970: 332 Peterson and Brown 1994: 43 Simmons 1982: 298–299 Taylor 1989: 4 U.S. Court of Private Land Claims 1899: 24–26
1884 July 2	Santo Domingo to El Paso	Extensive damage; interruption of work and social activities	Kessell 1980: 131 Lange and Riley 1970: 332 Peterson and Brown 1994: 43
1885	Entire region	Extensive damage, almost as severe as June 1884 flood	Carter 1953: 187 Follett 1898: 90 Simmons 1982: 301

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Table 17—Historic Rio Grande floods, 1591–1942 (continued).

Date	Location	Impact	Source
1886 June	Espanola to Isleta Pueblo	Bridges destroyed; Santo Domingo church destroyed	Lange et al. 1975:169 Yeo 1943: 23–25
1886 September	Valencia to Mesilla	Large number of houses washed away or damaged; hail damage at Belen; railroad and bridges washed out at Rio Salado and Rio Puerco–of–the–East; homes, fields, and bridges damaged, less severe than May flood; San Marcial and Bowling Green destroyed; homes, fields, and bridges damaged, less severe than May Flood; railroad tracks, cemetery, houses washed out at Chamberina and entire Mesilla Valley; Long Lake formed, remained for a number of years	Carter 1953: 31, 228, 232–233 Follett 1898: 90 Want 1964: 175–177
1888 late April–early May	Socorro	Part of the community was inundated	Carter 1953: 32–33
1889 ca.	Isleta Pueblo to El Paso	Destroyed most fields below pueblo and on west side of river	Peterson and Brown 1994: 43 Poore 1894: 113
1890	Santo Domingo Pueblo to Socorro	Pueblo buildings and fields damaged by flooding, and residents would not plant in the floodplain due to their concern for more high water; washouts of rail line at two valley locations and some bank cutting at Barelas	Carter 1953: 36 White 1935: 20–21
1891 May	Albuquerque to El Paso	Bridge washed away at Albuquerque; Isleta and Valencia attempted to "boom and dike" the river, but flood wiped out their work; homes destroyed at Valencia, new 500–yard–wide channel cut with water 5 feet deep flowing through village; new bridge over river destroyed; considerable, widespread damage	Carter 1953: 315–316, 328 Peterson and Brown 1994: 43 Poore 1894: 113
1895 late July	La Joya to Socorro	At least seven persons killed; property damage; runoff from thunderstorm in Blue Canyon west of Socorro flooded town, causing severe property damage and loss of life; in lower section of town water reached a height of 4 feet	Conron 1980: 31 Marshall and Walt 1984: 264 Yeo 1943: 26–27
1896	Near San Marcial	USGS gauging station washed away	Follansbee and Dean 1915: 41
1897 May	Embudo to El Paso	Widespread damage; flow at Buckman peaked at 15,300 cfs and San Marcial 21,750 cfs	Cooperrider and Hendricks 1937: 31 Sullivan 1924: 11–12 Yeo 1943: 27–29
1897 October	Near San Marcial	Flow from fall rain peaked at 15,500 cfs	Cooperrider and Hendricks 1937: 31
1897	Otowi Bridge	Total annual flow at this gauging station far exceeded the norm	Crawford et al. 1993: 18
1902	Alameda to Albuquerque	Dike and levees breached at Alameda; agricultural fields damaged	Simmons 1982: 301–302
1903 May 15	Lower Chama River to Otowi Bridge	Peak flow of 10,900 cfs	Yeo 1943: 29
1903 June	Otowi Bridge to Socorro	A flood of 19,300 cfs broke through Alameda dike, flooding valley and destroying the settlement; agricultural fields and buildings destroyed	Sargeant 1987: 36 Steele 1983: 29 Sullivan 1924: 11–12

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Table 17—Historic Rio Grande floods, 1591–1942 (continued).

Date	Location	Impact	Source
1904 Sept. 29 to Oct. 8	Buckman to San Marcial	Rain runoff peaked at 17,700 cfs at Buckman and 33,000 cfs at San Marcial; almost all agricultural fields, most of the houses at Corrales, Ranchos de Albuquerque, and Corrales bridge destroyed; fields and houses destroyed or damaged to south; highway near Tome became an arroyo	Cooperrider and Hendricks 1937: 31 Eisenstadt 1980: 5–6 Ellis and Baca 1957 Murphy 1905: 149 Sargeant and Davis 1985: 105–106
1904	Otowi Bridge Gauging Station	Annual Rio Grande flow was considerably above average	Crawford et al. 1993: 18
1905 May	Buckman to Tome	Flow at Buckman was 19,500 cfs; inundated Tome and washed out Los Lunas–Valencia bridge; widespread damage; peak flow at San Marcial was 29,000 cfs	Ellis and Baca 1957: 17 Bureau of Agricultural Economics 1941: 22 Cooperrider and Hendricks 1937: 31 Sullivan 1924: 12 Yeo 1943: 37–40
1905 winter	Entire region	Rains averaged 20 inches, damage?	Tuan et al 1973: 57–59
1906 early May to mid June	Lobatos to San Marcial	Intense, widespread rains in northern and central New Mexico caused moderate flooding; peak flow at Lobatos was 8,000 cfs and more than 10,000 cfs at San Marcial	Yeo 1943: 44
1911 May 8 to June 2	Otowi Bridge to San Marcial	Flow peaked at 10,800 cfs at Buckman and 15,270 at San Marcial; average annual flow at Otowi station exceeded high flows of 1897, 1904, and 1905	Crawford et al. 1983: 18 Yeo 1943: 50–51
1911 October 4–11	Del Norte, Colorado to San Marcial	Another flood peaked at 18,000 cfs at the first location and 11,530 cfs at the second	Yeo 1943: 51–52
1911 October	Otowi Bridge to San Marcial	Flow peaked at 15,600 cfs at first station and 11,780 cfs at second; channel change at Buckman; channel change in river and property damage at San Marcial	Calkins 1937: 7 Follansbee and Dean 1915: 120
1912 May–June	Otowi Bridge to San Marcial	Flow peaked at 29,000 cfs at the first site, 23,800 cfs at Buckman, and 15,145 at San Marcial	Bureau of Agricultural Economics 1941: 22 Cooperrider and Hendricks 1937: 31 Sullivan 1924: 11
1916 May	Buckman to San Marcial	Flow peaked at 15,900 cfs at the first site and 25,145 cfs at the latter	Cooperrider and Hendricks 1937: 31
1920 May–June	Espanola to San Marcial	Peak flow of 28,800 cfs at Buckman; community bridge at first location destroyed; partial collapse of Tome church; parts of Albuquerque and San Marcial damaged; flow at latter 22,500 cfs	Anonymous 1978: 7–1 Calkins 1937: 8 Cooperrider and Hendricks 1937: 31 Kelley 1982: 17 Kessell 1980: 152 Rodey and Burkholder 1927: 17 Sullivan 1924: 11
1921 June	Entire region	Flow of 17,400 cfs at Buckman and 19,360 cfs at San Marcial; flood peaked at 100,000 cfs downstream?	Rodey and Burkholder 1927: 16 Sullivan 1924: 12

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Table 17—Historic Rio Grande floods, 1591–1942 (continued).

Date	Location	Impact	Source
1924 May	Buckman to San Marcial	Flow peaked at 16,910 cfs at Buckman and 12,400 cfs at San Marcial	Cooperrider and Hendricks 1937: 31
1929 August–September	Buckman to San Marcial	Widespread property damage; Bernalillo town plaza was destroyed; torrential rains on Rio Puerco and Rio Salado watersheds and Rio Grande tributaries around Socorro virtually destroyed San Acacia and also impacted San Antonio, Valverde, and La Mesa; at San Marcial, peak flow reached 47,000 cfs; region's crops virtually destroyed, as was San Marcial, San Acacia, and San Antonio	Bowen and Saca 1971: 53 Cooperrider and Hendricks 1937: 31 Harper et al. 1943: 33–34 Scurlock 1982a: 13
1933 or 1934	North Valley of Albuquerque	North Valley flooded east to Rio Grande Boulevard	Sargeant and Davis 1986: 105
1937 late August–early September	Albuquerque to San Marcial	Levees washed out at number of locations; agricultural fields and crops damaged	Calkins 1937: 18 Happ 1943: 1 Happ 1944: 4 Kelley 1969: 17
1939	Alameda to downtown Albuquerque	Flood washed pine trees down west side of Sandias onto Edith and North 2nd area; residents collected them for fuelwood	Sargeant and Davis 1986: 106–107
1940 August	Cochiti Pueblo to Albuquerque	Valley flooded; worst flood since late 1880s struck Bernalillo; Sisters of Loretto convent destroyed	Olson 1976: 73
1941 January–May	Espanola to Socorro	Twenty-nine inches of precipitation fell during this period; widespread property damage; more than 50,000 acres inundated in valley	Kelley 1969: 71 Olson 1976: 90 Tuan et al. 1973: 143–145 Vlasich 1980: 34
1941 September 20	Mouth of	Some 250 acre-feet of sediments, up to 9 feet deep, Calabasillos Arroyo	Tuan 1966: 594 deposited in river
1942 April–June 6	Otowi Bridge to San Marcial	The flow at Albuquerque peaked at 19,600 cfs and at Bernardo 21, 000 cfs	Happ 1942 ca.: 2–5 USGS 1994
1942	Otowi Bridge	Heavy snows and rain produced third greatest annual flow in this century	Crawford et al. 1993: 18

Among the greatest floods of the period were the 1872 and 1884 spring floods, which crested at an estimated 100,000 cfs. The 1874 flood peaked at about 40,000 cfs, the May 1897 at 21,750 cfs, the June 1903 at 19,300 cfs, the 1904 at 33,000 cfs, the 1905 at 29,000 cfs, the 1912 at 29,000 cfs, the 1920 at 28,800 cfs, and the 1942 at 21,000 cfs.

Following the devastation caused by the floods from 1849 to 1921, the Middle Rio Grande Conservancy District was created by the legislature in 1923 and formed in 1925, in part to control flooding, as was the Corps of Engineers' Albuquerque District, organized in 1935. During this same period, the U.S. Department of Agriculture was made responsible for controlling floods on watershed tributaries. The Bureau of Reclamation, established early in the century, also was involved in flood control. Dams, levees, drainage canals, and other water control works were constructed by these entities. Major flood control dams constructed by the Corps included El Vado (1936), Jemez Canyon (1953) (Fig. 13), Abiquiu (1963), Galisteo (1970), and Cochiti (1975). With the completion of the Cochiti Dam, the threat of flooding in the Albuquerque area virtually ended. However, runoff waters from intense local summer rainstorms still result in water damage to neighborhoods built on the old channel along North 2nd and 4th streets and other low-lying areas. Flash flooding along arroyos and streets at the base of the Sandias has resulted in loss of life and property damage in recent years.

Figure 12—Flood at Escondido, 1941. Courtesy of the Albuquerque Museum (negative no. 1980.061.490).

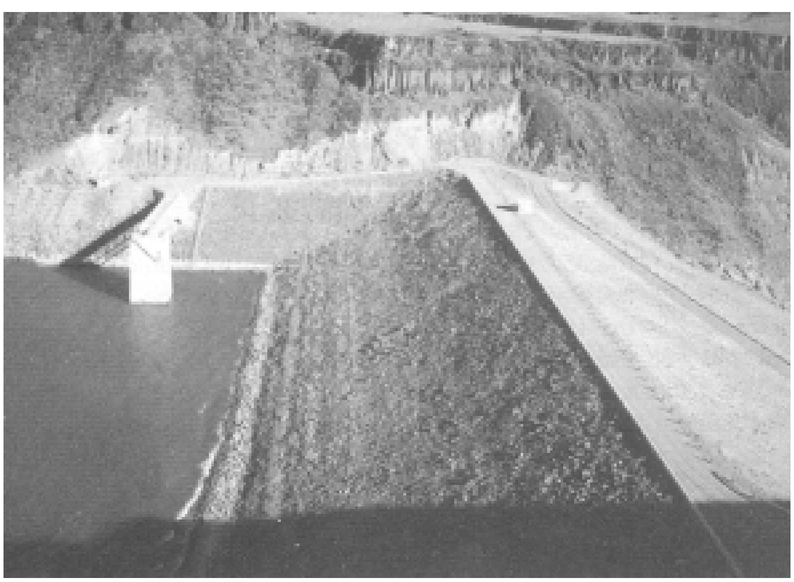

Figure 13—Jemez Canyon Dam. Photo by author.

HISTORIC DROUGHTS

Droughts have perhaps been the single most significant "natural" climatic event adversely affecting historic human populations in the Southwest. Historic documentary data, as well as archeological evidence, including tree-ring data, show that periodic droughts of varying magnitude have impacted past human activity and other environmental components. At least 52 droughts lasting 1 year or more, totalling about 238 years, occurred in the Middle Rio Grande Basin in the historic period (448 years). Droughts, therefore, have had a mean occurrence of 8.6 years, and a mean length of 4.6 years (Table 18). Some of the more important effects of extended dry periods have been decrease or loss of water sources, diminishment of indigenous and cultivated food plants, decrease in native fauna, and

Table 18—Historic New Mexico droughts, 1542–1989.

17th century	18th century	19th century	20th century
1542	1700–1709	1801–1803	1900–1904 mid
1570–1573	1707	1805–1813	1907 late–1910
1578–1580s	1714–1717	1817–1822	1917–1918
1598–1606	1719 summer	1824–1825	1920–1925 early
1608–1609	1727	1829–1830	1927–1928
1620–1623	1729–1730	1841–1843	1932 late–1937
1625–1633	1734–1739	1845–1847	1939–early 1940
1635–1640	1748–1759	1849	1942 late–1948
1651–1672	1768	1851–1853	1950–1956
1675–1680	1772–1774	1859–1863	1959 late–1963
1681–1686	1775–1785 early	1873–1877 summer	1971
1689–1699	1787–1790	1877–1883	1980
		1886–1890	1989
		1892 summer–1896	
		1898–1900	
Total period years: 448 Total droughts: 52 Total drought years: 238	Mean length: 4.6 Mean occurrence/years: 8.6		

Sources: Bancroft 1889: 184–185, 195, 214–215, 245, 739–740; Clark 1987: 89, 147, 171, 218, 227, 234, 396, 407; Fritts 1991: 134; Gatewood et al. 1996: B11–B12, B23; Thomas et al. 1963: D3–D5; Tuan et al. 1973: 50–59

loss of domesticated animals. Combined with intensive resource use, such as grazing and irrigation farming, these impacts were generally exacerbated and led to other changes in environmental components. The extent and significance of droughts generally varied over the region. A given location might be less impacted than another due to more reliable sources of surface or ground waters. For example, sufficient irrigation water was sometimes available along the drought-stricken Middle Rio Grande Basin when the mountains in the Upper Rio Grande watershed had a normal or above-normal snowpack.

One or more of these drought-caused impacts have led to human suffering or loss of life and temporary abandonment of villages, hunting-gathering areas, or even a region. Expanding one food procurement adaptation (e.g., hunting-gathering) or de-emphasizing or abandoning another (e.g., farming) was sometimes employed by various indigenous groups as a survival strategy during these times of hardship. Also, disputes over water and water rights, and raiding or even general warfare, sometimes erupted. While at first review there appears to be a direct link between drought and raiding, or all-out warfare, and sometimes subsequent abandonment of villages or areas, it was, in general, only one of several relevant causal factors. Kelley (1952) was perhaps the first investigator in the Southwest to suggest a correlation between drought conditions, as indicated by tree-ring data, and raiding/abandonment in the protohistoric period. Two other archeologists, Stuart and Gauthier (1981: 316–318), compared Apache raids and Pueblo uprisings with drought periods in northern New Mexico, and they came to the conclusion that these environmental stress times were but one of several factors that contributed to warfare. Brugge (1986: 157–160) tested correlations between drought years and raiding in northwest New Mexico, and he came to the same basic conclusion.

A 1660s drought was also one of several factors leading to abandonment of the Salinas and Piro provinces, including the mission pueblos of Abo, Quarai, Gran Quivira, and Senecu in the early to mid 1670s. The authors (Tainter and Levine 1987: 74, 84–87) of this study suggested a number of other interrelated factors: Spanish economic demands, religious persecution, subsistence change, and several others. Epidemic diseases, such as smallpox, also appear to have been a causal factor in unrest, conflict, and abandonment.

Comparisons of droughts and raids for the Middle and Upper Rio Grande basins from 1580 to 1867 are presented in Table 19 and reveal a correlation with raiding for 23 of the 35 droughts identified from published sources. The strongest cases for cause-effect, in addition to 1663–70, are the dry periods of 1748–54, 1770s, and 1845–55. During these extended droughts, intense raiding by Apaches, Navajos, and Comanches (after 1706) was widespread. Because of Spanish or Anglo pressures after 1700, abandonment of Pueblo villages and movement to a more favorable environmental location was no longer an option, as it was in the protohistoric and late prehistoric periods. Additional archival research and better tree-ring evidence are needed to clarify the causal effects and interrelationships of these factors.

Historical evidence indicates an association between epidemics and droughts in the region. This correlation

Table 19—Nomadic Indian raids and drought years, north and central New Mexico, 1580–1867.

Years of raids	Drought years	Source
1580	Yes	Stuart and Gauthier 1981: 317
1590–91	Yes	Stuart and Gauthier 1981: 317
1598–1606	Yes	Forbes 1960: 109, 158; McNitt 1972: 10; Worcester 1951: 104–105
1608–09	Yes	Forbes 1960: 109
1630–40	Yes (except for 1634)	Anderson 1985: 371; Dean and Robinson 1977; Ford 1975: 5; Hackett 1937: 109, 119–120; John 1975: 83–86; Vivian 1964: 153; Worcester 1951: 104
1650s	Yes	Bailey 1980: 56, 58; Forbes 1960: 143–144, 160–161; Reeve 1957: 42, 44; Schroeder 1974: 10a; Tainter and Levine 1987: 85–86; Worcester 1951: 104
1663–69	Yes	Correll 1976: 16; deBuys 1985: 51–52; Forbes 1960: 158–159, 163–164; Kessell 1979: 212; Loomis and Nasatir 1967: 17; Reeve 1957: 48–50; Schroeder 1963: 7; Wilson 1985: 117–118
1670–72	Yes	Correll 1976: 16; Cully 1977: 101; Gutierrez 1991: 130; Hackett 1937: 17; John 1975: 92–93; Tainter and Levine 1987: 86
1675–80	Yes	Bailey 1980: 58–59; Forbes 1960: 95–97, 167–168, 172–175; Gunnerson 1974: 99; John 1975: 95–97; Tainter and Levine 1987: 87
1681–84	Yes	Bancroft 1889: 184–185; Ellis 1974: 233; Gutierrez 1991: 139; John 1975: 110–111
1695–96	Yes	Bancroft 1889: 214–215; Beck 1962: 88; John 1975: 127; Kessell 1989: 62; Minge 1976: 28; Reeve 1961: 300–302
1700–03	Yes	Kelley 1952: 384; Minge 1976: 32; Schroeder 1974: 226–227; Simmons 1980: 194
1707	Yes	Brugge 1979: 113–114
1710s (early)	No	John 1975: 236, 243
1715–17	Yes	John 1975: 238; Meyer 1984: 98–99; Schroeder 1974: 238, 243
1719	No	Kenner 1969: 29
1744–54	Yes	Bancroft 1889: 245; Brugge 1983: 494; Ellis 1974: 234; Haskell 1975: 180; Jones 1988: 149, 152; Kenner 1969: 41; Pattie 1966: 268; Schroeder 1974: 154, 181; Swadesh 1974: 35, 38; Tainter and Levine 1987: 95; Tyler 1954: 353; Wallace and Hoebel 1952: 45
1760–63	No	Ellis 1974: 243; Kenner 1969: 43
1768	Yes	Gunnerson 1974: 247–248; Kenner 1969: 45–46
1770–81	Yes	Bailey 1966: 27, 1980: 100–104; John 1975: 474–475, 605–610; Jones 1966: 133–134, 140, 150–156; Kenner 1969: 46–51; Tyler 1954: 350
1785–87	No	Kessell 1979: 408; Thomas 1932: 279–290
1792–93	No	Gunnerson 1974: 275; Jones 1966: 166
1790s (late)	No	Minge 1976: 38
1801–03	Yes	Gunnerson 1974: 284, 287–288; Simmons 1973: 77; Tainter and Levine 1987: 98
1804	No	Schroeder 1974: 11–12
1822–25	No	Betancourt 1980: 37–39; Ellis 1974: 235; Worcester 1979: 35–36
1831–39	No	Betancourt 1980: 37–39; Minge 1965: 65; Swadesh 1974: 58; Twitchell 1963, II: 47–48
1840	No	Minge 1965: 65
1841–43	Yes	Minge 1965: 65–69, 89
1845–55	Yes (except for 1848, 1850, 1854–55)	Betancourt 1980: 40; Couchman 1990: 43–44; Denevan 1967: 701; Dockstader 1979: 525; Kenner 1969: 117; Minge 1965: 89; Schroeder 1965: 67–68, 1974: 185, 215; Swadesh 1974: 263–275; Wallace and Hoebel 1952: 45
1859–60	Yes	Beadle 1973: 514–515; Frazer 1983: 186; Sunseri 1973: 33
1864–65	No	Ogle 1970: 47–49; Schroeder 1974: 232
1867	No	Schroeder 1974: 219

involves crop failures due to the drought and subsequent famine. Human populations were then more susceptible to contracting diseases, as their immunity was lowered due to nutritional deficiencies caused by inadequate diet. The 1781 smallpox epidemic followed a severe drought of 10 years. Drought also fosters a concentration of microbial contaminants in declining surface water sources (Earls 1985: 157–158, 162).

Archeological evidence and historical records reveal a relatively long succession of alternating periods of below-normal precipitation and above-normal precipitation. Usually accompanying these dry and wet periods are warmer and cooler temperatures, respectively. For droughts, these above-normal temperatures contribute to the adverse impacts noted above. Extended, severe regional droughts have an average duration of 10 to 13 years and occur every 22–25 years (Thomas 1963: H3). Less severe and more localized droughts appear to occur more randomly and for shorter periods. Wet, or strong El Nino, years may have occurred every 9.9 years (Quinn et al. 1987: 14455).

Tree-ring evidence and historical records indicate that the most severe droughts occurred in 1578–89, 1598–1606, 1630s, 1663–70, 1682–90, 1734–39, 1748–59, 1772–82, 1841–55, 1895–1904, 1931–40, and 1952–1964 (Bark 1978: 12–13; D'Arrigo and Jacoby 1992: 243; Fritts 1991: 127, 133, 134, 141, 190). These major droughts and less severe, or smaller-scale, ones that occurred in the last 100 years are shown in Table 18 and Fig. 14.

With rapid growth of the human population in the Middle Rio Grande Basin, drought still poses a serious threat to human economic activities such as farming, ranching, recreation, and tourism, modern technological advances notwithstanding.

SUMMARY

Climatic variability over the past 457 years has been a major environmental factor in shaping the study region's landscape and history. Periodic droughts, El Nino years, frosts, and lightning have combined to produce dynamic spatial and temporal weather patterns. Among the environmental elements and events affected, determined, and maintained are streamflow, vegetative communities, wildlife populations, and wild fires.

The most notable climatological shifts or trends in the study region have been the Little Ice Age, which occurred during the first 250 years of the historic period, and the more recent warming trend from the late 1800s to the present.

Droughts have had the most eco-cultural impact, not only on the "natural" constituents named above but also on various human activities. Crop loss, decimation of flora and fauna, and associated high temperatures have adversely affected such pursuits as farming, gathering, hunt-

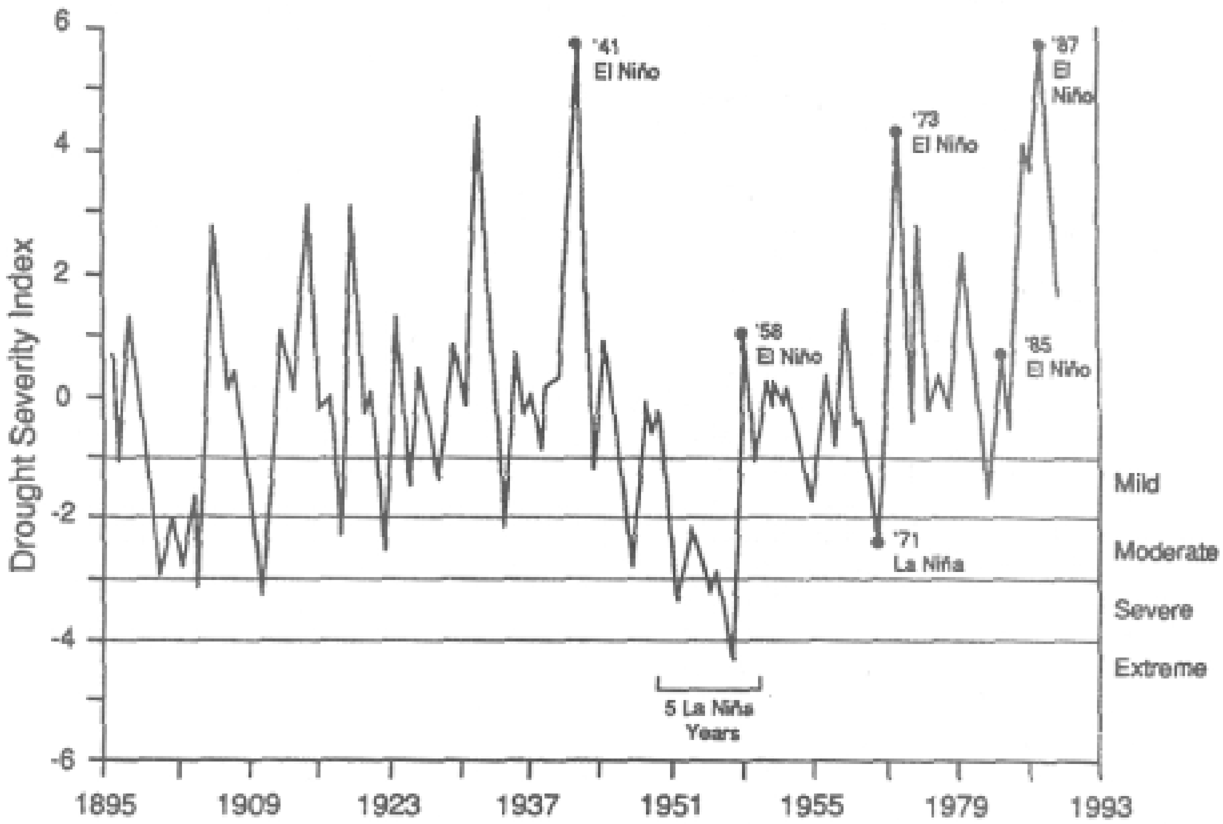

Figure 14—Drought Severity Index, 1895–1988.

ing, livestock raising, and mining. Extreme, extended dry periods have resulted in groups changing resource exploitation strategies, raiding to procure needed food, or even abandoning an area, including settlements.

Floods caused by periods of above-normal precipitation, especially El Nino years, have had widespread impacts on human populations. On the negative side, flooding has resulted in loss of human life and livestock or destruction of homes or entire communities and fields and crops. Deposition of rich alluvium on agricultural fields and pastures, leaching of salts from irrigated lands, and maintenance of aquatic ecosystems on which groups have in part been dependent were positive consequences of flooding.

CHRONOLOGY

1429–40 Tree-ring data indicate that this was one of the wettest periods in the last 6 centuries (D'Arrigo and Jacoby 1991: 95, 98).

1430–50 (ca.) The Little Ice Age, with average temperatures 1.8° to 3.6° F lower than those of recent decades, began in Europe and North America (Lamb 1977: 454–473; Swann 1977: 29–36).

1455–90 This was a period of increased moisture in the region (Schoenwetter and Dittert 1968: 46).

1487–98 Based on tree-ring data, this was one of the wettest periods in the last 6 centuries (D'Arrigo and Jacoby 1991: 95, 98).

1400s (late) An increase in precipitation occurred over the region (Kelley 1952: 384; Gunnerson 1974: 132).

1400s (late) Prehistoric villages and fields were temporarily, or sometimes permanently, abandoned due to alternating floods and droughts. In the latter case, new villages and field sites with more available moisture were found (Stuart 1985: 96).

1400s (late to early 1500s) Following their arrival on the northeastern plains of New Mexico, the Plains Apaches found life hard during the severe winters, which brought extremely low temperatures, drifting and blowing snow, and a scarcity of game. Some Apache groups began to winter at the eastern pueblos such as Pecos, trading for corn and blankets (Kenner 1969: 8)

1525 Tree-ring data indicate that a drought struck the Upper Rio Grande Basin and southwestern Colorado (Cully 1977: 101).

1531–32 This was a wet or "El Nino" year (Quinn et al. 1987: 14450).

1533–35 A drought gripped the Southwest and caused hardship among various Indian groups in southwest Texas, New Mexico, and northern Chihuahua (Ellis 1974: 231; Leighly 1963: 67–68).

1539–40 (winter) Exceptionally cold temperatures and deep snow halted the Melchior Diaz expedition en route to Cibola (Hammond and Rey 1940: 157).

1540 (late September or early October) Extreme cold at Taos Pueblo marked the beginning of long winters (Schroeder 1972: 44).

1540 (late October) Only a day or so south southwest of Zuni Pueblo, the main body of the Coronado expedition, especially Mexican Indian allies, suffered from a "great fall of snow. . . ." Some of the soldiers found some caves, which sheltered the party from the cold (Hodge 1946: 306).

1540 (late November-early December) Part of Coronado's army was stopped by heavy snowfall as they left the Zuni villages. Snow fell almost every night, delaying their march for 10 days. Horses were half buried by each night's snows (Hodge 1946: 316).

1540 (early December) The last of Coronado's contingents of soldiers from Mexico camped at Matsaki, a Zuni village. Over a 10-day period snow fell every afternoon and nearly every night in the Zuni-Acoma area. Snow accumulation at the end of this period was one-half of an estado, equal to the height of an average Spaniard. This condition hampered movement toward the Rio Grande and other activities (Bolton 1964: 213–214; Hammond and Rey 1940: 222; Hodge 1946: 316).

1540–41 (December-April) Deep snow, intense cold, and a frozen Rio Grande gripped central and northern New Mexico. Suffering from the extreme cold and deep snow at Tiguex, Coronado demanded and received blankets, animal skins, turkeys, and maize from the Pueblos. This was a major factor in the breakout of hostilities between the Spanish and the Pueblos (Bancroft 1889: 56, 59; Dutton 1963: 4–7; Hodge 1946: 204–211, 316, 320, 328).

1540–41 Snow occurred over 6 months of each year in the Zuni Pueblo area (Schroeder 1972: 44).

1540–99 (winters) Long, harsh winters and dry summers prevailed, and crop yields were poor (Manley 1992: 14).

1541 (January-February) Snow fell almost every day during this period. Coronado's troops were limited in their movement and suffered from the cold. The Pueblos, who had given up blankets and food to the Spaniards, experienced a hard time as well (Bolton 1964: 204–205, 216).

1541 (February 20-March 31) Coronado laid siege to Moho Pueblo in the Tiguex Province. After the snow stopped falling, the pueblo inhabitants suffered from little or no water. They eventually abandoned their village and some fought their way through the Spanish lines (Bolton 1964: 219–230).

1541 (winter-spring) The Rio Grande was frozen until May; rain in late summer hindered transport in September and October (Bancroft 1889: 59).

1542 Tree-ring data indicate that a drought struck the area (Ellis 1974: 231).

1550 By this date, the Little Ice Age had severely impacted northern New Mexico. The growing season decreased, summer rainfall diminished, and average seasonal temperatures dropped (Bradley 1976: 3; Reher 1977: 216–217).

1552 This was an El Nino year (Quinn et al. 1987: 14450).

1550s Tree-ring data indicate that this decade experienced above-average precipitation (Ellis 1974: 231).

1560–85 Drought may have been a factor in the abandonment of some Pueblo IV villages (Wendorf and Reed 1955: 153).

1561–93 Based on tree-ring data, precipitation in central and northern New Mexico was below normal. Tewa and Keres pueblos, east of the Rio Grande, were abandoned due to the drought and interrelated Plains Apache raids (Ellis 1974: 232; Fritts 1965: 432; Schroeder 1972: 48).

1567 (late to October 1568) This was an El Nino year (Quinn et al. 1987: 14450).

1570–90 Generally, this was an abnormally dry period, perhaps the most severe in the historic period (Baisan 1994: 3; Ladurie 1971: 30–31, 285).

1570–1600 Tree-ring analysis shows drought conditions of exceptional magnitude prevailing across the Southwest (Thomas 1963: H3). Tewa and Keres pueblos, east of the Rio Grande, were abandoned, in part due to this more xeric period (Schroeder 1968: 296).

1573–93 A severe drought during this period may have forced Navajos and Apaches to seek water sources in higher elevations in the mountains of southwestern Colorado and northwestern New Mexico (Bailey 1980: 32).

1574 This was an El Nino year (Quinn et al. 1987: 14450).

1578 This was an El Nino year (Quinn et al. 1987: 14450).

1579–98 Tree-ring data indicate that this was the most severe drought in the historic period (D'Arrigo and Jacoby 1991: 97–98).

1570s–80s Tree-ring data indicate that this was a period of severe drought (Fairchild-Parks et al. 1995: 8–9).

1580 Tree-ring data indicate that this was a dry year in the Upper Rio Grande and southwestern Colorado (Cully 1977: 101).

1581 (fall) The Chamuscado-Rodriguez expedition cut short its exploration of the Salinas Province due to snow and cold temperatures. Proceeding up the Jemez River valley, the expedition had to turn back again due to "heavy snowfalls" (Hammond and Rey 1966: 62, 106–107).

1581 (December) The Chamuscado-Rodriguez expedition traveled westward to Zuni Pueblo, but a heavy snowfall turned them back to the Rio Grande (Hammond and Rey 1966: 137).

1583 (January 22) Close to present El Paso, members of the Espejo expedition had to break the ice in a marsh with picks and bars to procure drinking water (Hammond and Rey 1966: 170).

1583 (March 15-April 7) Espejo noted that the Zunis from Hawikuh were planting their fields. Showers, mainly in the form of snow, fell frequently. The expedition was provided with "plenty of hares and rabbits" (Hammond and Rey 1966: 184–185).

1583 (March) Espejo's expedition suffered from heavy snowfall and extreme cold from Acoma to El Morro (Sanchez 1987: 38).

1583 (July 2–3) At the Tanos pueblos in the Galisteo Basin corn fields were suffering from lack of rain (Hammond and Rey 1966: 206).

1583 Espejo noted that Pueblo fields in northern New Mexico were either ditch irrigated or "dependent on the weather [dry-farmed]" (Bolton 1946: 178).

1590 (December 24-February 14, 1591) Castano de Sosa's expedition encountered heavy snow and intense cold on the Gallinas River southeast of Pecos Pueblo. As he moved from pueblo to pueblo, as far north as Taos and south to Santo Domingo and the Galisteo pueblos, frequent snows, which accumulated up to 3 feet, hampered the expedition. Rivers were frozen, some to the bottom of the stream (Schroeder and Matson 1965: 73, 103, 110, 123, 124, 145, 148, 152, 154).

1591 (early January) A contingent of men from the Sosa expedition travelled from southeast of Santa Fe into the Tewa country near San Juan. They were hampered by snow up to 3 feet deep (Sanchez 1987: 46–47).

1591 (January 13–14) Near Santa Clara Pueblo, Sosa continued to note the snow depth, ". . . the snow was a yard (vara) deep, the like of which none of us had seen. It was so deep the horses could hardly walk" (Hammond and Rey 1966: 283; Schroeder and Matson 1965: 123).

1591 (late January) Sosa found the Tesuque River frozen solid, some "two spans thick," and had to use pickaxes to break through it. Additionally, "the entire land was covered with snow," and the weather was "bitterly cold" (Hammond and Rey 1966: 284).

1591 (March 11) The Sosa expedition crossed the Rio Grande near Puaray; the river was in "full flood." As Sosa approached, the Tiwa Pueblos abandoned their villages on the west side of the Rio Grande, but some could not cross the flooding river (Hammond and Rey 1966: 292).

1591 (spring) Santo Domingo Pueblo, then located on the Galisteo River, was flooded, probably due to high runoff from the heavy winter snowpack (White 1935: 12).

1597–98 (winter) Tree-ring evidence indicates this was a very dry period (Baisan 1994: 2).

1598 (pre) A Tewa Pueblo village above San Juan was destroyed by the flooding Rio Grande. The villagers moved a few miles south, but their village was once again devastated by flood. Once again they moved south, this time to high ground across the Rio Grande from the pueblo of Yunque, which allowed them to settle the new pueblo named Okeh. A few years later Onate and his Spanish colonists established the first Spanish town in New Mexico at Yunque, and a few months later the Spaniards moved across the river to Yunque to construct the new capital of San Gabriel (Ellis 1987: 15–16).

1598 (late May) Crossing the Jornada del Muerto in one of the hottest and driest times of the year, Onate's expedition suffered from lack of water. Men were sent in various directions to find water, but it was a canine "member" of the party that found two water holes, at an area that was named Laguna de Perrillo (Simmons 1991: 103–104).

1598 (late October) When Juan de Onate's men reached El Morro, a sudden snowstorm struck, and their remuda stampeded. Some animals were not recovered (Simmons 1991: 127).

1598–99 (winter) This was a wet season; the snowpack in the mountains was probably deep (Baisan 1994: 2).

1598–1601 (winters) Severe cold and snows caused suffering among the Spanish settlers at San Gabriel (Simmons 1991: 158).

1500s (late) The drought forced some Tewa and Keres pueblos to be abandoned (Schroeder 1972: 48). Drought conditions probably forced Jemez Pueblos to move to higher elevations also (Schroeder 1968: 298).

1500s (late) A severe drought caused the Rio Grande Pueblos to depend more heavily on ditch irrigation of their crops versus floodwater or dry farming (Simmons 1972: 137).

1600 By this year, the Pueblos, who had been living on the Pajarito Plateau, had abandoned their villages and fields and moved to lower elevations along the Rio Grande. This movement may have been due in part to the drought and the cold snowy winters in the mid to late 15th century (Rothman 1989: 191–192).

1600–01 (winter) Onate's colonists suffered in the severe cold, which resulted in the Rio Grande and Rio Chama freezing over. Snow was common over the 8 months of winter (Simmons 1991: 158).

1600–01 Tree-ring data indicate these were exceedingly dry years (Ellis 1974: 232).

1600–01 Drought, in part, over these 2 years caused some of Onate's colonists to desert San Gabriel and return to Mexico (Hammond and Rey 1953: 60–61).

1600–80 The Apaches and Navajos raided Pueblo and Spanish villages during drought years when their local animal and plant foods were scarce. This environmental stress was one cause of the Pueblo Revolt (Sando 1979a: 195).

1601 The drought, followed by an early frost, caused a failure in most of the northern Pueblo corn crops (Hammond and Rey 1953: 696). Fray Francisco de San Miguel reported that the Spanish military and settlers had confiscated virtually all of the food from the northern Pueblos, and many of them were dying (Kenner 1969: 12).

1601 Food shortages continued at San Gabriel; Spaniards also suffered from the intensely cold winters. One soldier wrote "The cold is so intense that the rivers freeze over, and it snows most of the time during the winter, which lasts eight long months" (Simmons 1991: 158).

1602–10 Based on tree-ring evidence, drought appears to have spread during these years across the Southwest (Fritts 1991: 141).

1607 This was an El Nino year (Quinn et al. 1987: 14450).

1608 (pre) Mountain Querechos living west of the Rio Grande competed with Pueblos for the same game populations, and during drought periods, these nomads would raid the Pueblo villages for food, as they had no surplus corn or other produce to trade the Querechos (Forbes 1960: 109).

1609–10 (post) New settlers at Santa Fe received two suertes for a house and garden, another two for a vegetable garden, and still another two for a vineyard. They also received rights to sufficient water to irrigate these plots. As the population increased, the water supply from the Santa Fe River fluctuated with seasonal and annual precipitation, and in some years there was not adequate irrigation water (Clark 1987: 13).

1609–23 Tree-ring data indicate that this was, generally, the wettest period in the 17th century (D'Arrigo and Jacoby 1991: 95, 98; Rehr 1977: 136).

1611–20 Based on tree-ring evidence, precipitation was above average (Fritts 1991: 141).

1614 This was an El Nino year (Quinn et al. 1987: 14450).

1619 This was an El Nino year (Quinn et al. 1987: 14450).

1600s (early) During dry years, buffalo ranged west to the saline lakes in the Estancia Valley near the Tompiro villages (Schroeder 1979: 241).

1600s (early) Based on tree-ring evidence, temperatures gradually rose during the early part of this century, reaching "high-ranking values" in the latter half of the 1640s and 1650s (Fritts 1991: 125).

1621–26 Fray Salmeron described the climate of northern New Mexico as "cold and healthful, with the climate of Spain." The Pueblos all wore "shoes because of the cold" (Milich 1966: 55, 57).

1624 This was an El Nino year (Quinn et al. 1987: 14450).

1620s Based on tree-ring evidence, a drought occurred in this decade (Fritts 1991: 133).

1620s The population of the Jemez Pueblo had declined, perhaps due, at least in part, to the severe drought of the late 1500s, which led to famine and war with Navajos and Apaches (Schroeder 1968: 298).

1630 Fray Benavides wrote this about the effect of the cold winters: "Every winter a great number of Indians out in the country are frozen, and many Spaniards have their ears, feet and hands frozen" (Chavez 1992: 54). He also wrote "in summer the heat is more intolerable than the cold" (Ayer 1965: 39).

1631–40 Based on tree-ring evidence, precipitation was below normal (Fritts 1991: 190).

1630s (early) Famine hit the Tewa Pueblos due to a shortage of irrigation water (Ford 1975: 5).

1634 This was an El Nino year (Quinn et al. 1987: 14450). The Tewa Pueblos, however, experienced a lack of irrigation water (Schroeder and Matson 1965: 120).

1637–66 Based on tree-ring evidence, precipitation generally increased (Fritts 1991: 144).

1638–39 Two priests described the mission areas as having rigorous winters with deep snows and extreme cold temperatures. One noted that the rivers froze over in winter, but the summers were hot (Hackett 1937: 109, 119–120).

1630s A drought was partly responsible for intense Indian raids across New Mexico; the nomadic raiders burned an estimated 50,000 bushels of corn. This virtually wiped out the provincial stores. At the same time, a new epidemic killed 3,000 Indians, 10 percent of the Pueblo population (John 1975: 83–86; Vivian 1964: 153).

1630s–40s (early) Drought-caused famine and European-introduced disease were major factors in the decline of the Pueblo population. By 1644 only 43 pueblos in New Mexico were occupied, a 71 percent decline in villages (Anderson 1985: 371).

1630–40s Based on tree-ring evidence, moderate peaks in volcanic activity occurred, with associated warming in the West (Fritts 1991: 125).

1640 Severe drought and resultant decrease in food supply caused hardship and high fatalities (Hackett 1937: 109, 119–120).

1640 Pueblos produced little food in their fields because they were meeting Spanish demands for labor; the scant rainfall was also a factor (Simmons 1979a: 184).

1641–50 This was a period of above-normal precipitation (Ladurie 1971: 30, 32).

1645–1715 Sunspot activity may have reached an all-time low for the historic period. Temperatures during this period were the lowest of the Little Ice Age (Eddy 1976: 1189, 1199).

1650–80 Droughts were a major factor in the Piro's abandonment of the Rio Abajo villages (Earls 1992: 18).

1652 This was an El Nino year (Quinn et al. 1987: 14450).

1657–66 Based on tree-ring data, temperatures were above normal (Fritts 1991: 190).

1658–59 Rainfall was below normal, and a famine occurred among the Apaches during the first year. They brought their slaves and own children to the pueblos to exchange for food the following year (Forbes 1960: 151).

1659 (summer) The famine forced the Indians to eat "grass seeds... and very injurious herbs, and the Spaniard on bran, spinach, green barley and other herbs" (Gutierrez 1991: 119).

1650s Due in part to stress caused by drought, disease, encomenderos, and Apache raids, sorcery increased among the Piro (Tainter and Levine 1987: 86).

1660–69 Tree-rings indicate a below-normal precipitation and above-normal temperatures for Chupadera Mesa in the Salinas Province (Wilson 1985: 117–118).

1663 A provincewide drought severely impacted crops, livestock, irrigation water, and other environmental components (John 1975: 92). The main water source at Gran Quivira was a few wells located a quarter league to the west of the pueblo. At this time of drought, the wells yielded a relatively limited amount of water. Residents of Las Humanas Pueblo, experiencing a water shortage, saved their urine and used it for making adobe bricks and plaster (Hackett 1937: 142, 162).

1663–65 A food shortage resulted in the Apaches increasing their raids (Forbes 1960: 159).

1663–71 A severe drought struck Pueblos and Spaniards, resulting in little or no crop production, livestock losses, and human fatalities. Under environmental stress, Navajos and Apaches, sometimes joined by Piro Pueblos, raided their villages. Compounding the unrest and suffering, an epidemic disease hit all of the groups (Forbes 1960: 161; Hackett 1937: 17; John 1975: 92; Reeve 1957: 48–50; Schroeder 1968: 297; Simmons 1979: 184; Vivian 1964: 3, 153). The extended drought and associated general unrest was one reason the Pueblos revolted in 1680 (Loomis and Nasatir 1967: 17; Schroeder 1968: 297).

1665 (spring) The mission supply caravan coming north on the Camino Real was delayed 3 months at El Paso by Rio Grande floodwaters (Moorhead 1958: 35).

1666–67 Compounding the problems of drought-famine, an epidemic struck from northern New Mexico to Nueva Vizcaya (Forbes 1960: 161).

1666–70 This severe drought was interpreted by the Pueblo Indians as evidence that the Catholic religion "did not ensure an orderly and fruitful progression of the seasons as they believed theirs did" (deBuys 1985: 51).

1666–71 A severe drought caused a very poor corn crop; famine and pestilence followed. The Indian population dropped to 17,000 from a high of about 40,000 in 1638 (Correll 1976: 16; Forbes 1960: 160; Gutierrez 1991: 130).

1667 Not until this year did the Apaches aggressively raid Pueblo and Spanish villages. The raids seem to have been related, at least in part, to the famine caused by the extended drought. The Piros, who up until this year maintained peaceful relations with the Spanish, allied with Apaches, began a revolt. These hostilities continued into the 1670s, fueled by the drought-caused famine and a severe disease epidemic (Forbes 1960: 160–164).

1667–1716 Based on tree-ring evidence, these years were "cooler than it had been earlier" (Fritts 1991: 147).

1668 This was the third year in which there was a crop failure due to the drought. At the pueblo of Las Humanas (Gran Quivira), in the previous year, more than 450 Indians died due to the famine, and water was so scarce that the residents had to depend on 32 wells. The Apaches frequently raided the region during this time of environmental stress (Kessell 1979: 212; Schroeder 1979: 241; Wilson 1985: 114).

1660s Crop failures of corn and cotton caused by drought brought more difficulties for the Pueblo, who had to pay tributes to the Spanish under the encomienda system (Anderson 1985: 369). The drought in the Santa Fe-Pecos area was less severe than in the Salinas area (Fairchild-Parks et al. 1995: 10).

1660s Based on tree-ring evidence, a drought occurred in this decade (Fritts 1991: 133).

1670 By this year, the Piro and Salinas pueblos were experiencing the worst drought since the 1580s and the most severe in the Spanish Colonial period (Fairchild-Parks et al. 1995: 10). Tree-ring data indicate that this was also a dry year in the Upper Rio Grande drainage and southwestern Colorado (Cully 1977: 101). With the failure of crops, loss of livestock, and decrease in wild food plants and animals, Spaniards and Pueblos were forced by the drought-caused famine to eat hides and leather straps of their carts. These were soaked in water and then boiled with roots and herbs (Gunnerson 1974: 98; Hackett 1937: 17).

1670–76 The mission caravans were unable to deliver adequate provisions to the mission Indians, who were suffering from the near-famine conditions caused by the ongoing drought (Moorhead 1958: 36).

1671–72 Following the drought of the previous years, a "pestilence" struck the province, and more people, as well as livestock, died. Apaches and Navajos raided across the region (Correll 1976: 16; Gutierrez 1991: 130; Reeve 1957: 48).

1672–78 Drought, famine, and interrelated Apache raids led to the abandonment of a number of pueblos east of the Manzano Mountains in the 1670s (Schroeder 1968: 297). Six pueblos were abandoned in the Piro-Tompiro-eastern Tewa region due to incessant Apache raiding (Forbes 1960: 167–168). Navajos, as well as Apaches, raided northern and western Pueblos, which were Spanish dominated, and several pueblos, including Hawikuh, were abandoned. Punitive Spanish military expeditions were mounted against the Navajo, and the Navajo conducted reprisal raids (Bailey 1980: 58–59).

1679 (August) The supply caravan from Mexico City was held up at El Paso by unseasonably high waters of the Rio Grande (John 1975: 96).

1670s Based on tree-ring evidence, moderate peaks in volcanic activity occurred, with associated warming in the Southwest (Fritts 1991: 125).

1680 (pre) Mining at the Ortiz deposits and the New Placers was dependent on water packed in on burros for many miles during the dry season. Snow was reportedly melted in winter with heated rocks to provide water for the mining operations (Northrop 1975: 12).

1680 (spring-summer) Father Francisco Ayeta, of El Paso, organized a caravan loaded with supplies for the missionary priests in northern New Mexico and moved north toward the pass. The Rio Grande was in flood, creating cienegas and swamps on the floodplain and forcing Ayeta to wait at the ford. With news of the August Pueblo revolt, the wagons were unloaded, then reloaded with supplies for the refugees coming down the river. A company of 134 fighting men was also organized. They got underway and crossed the river and moved north to the Fray Cristobal paraje, where they met the first of the refugees. Needing more food, Ayeta took 25 wagons by the ford above El Paso, but the river had again risen due to rains in the area. In attempting to cross the Rio Grande below at Canutillo, across from the paraje of La Saliveta, he almost drowned attempting to get a wagon across the river (Sonnichsen 1968: 32).

1680 (August) A deep snowpack, a late spring, and intense summer rains caused flooding of the Rio Grande, which Pope and other Pueblo revolt leaders had counted on (Folsom 1989: 83–85, 121; Kessell 1979: 224).

1680 (December) Marching upriver from El Paso, Otermin's small reconquest army was hindered along the Rio Abajo by snow and extreme cold temperatures. A planned raid on Isleta's granaries by Pueblo "rebels" did not occur, due in part to snow cover and very cold temperatures. Moving northward toward Santa Fe, Governor Otermin was finally turned back by the cold winter weather and a shortage of forage for the horses. He decided to withdraw to El Paso (Sanchez 1987: 129, 138; Simmons 1977b: 73).

1681 (fall) Drought reduced the crop harvests of the northern Pueblos, who were starving. Many villages were abandoned (Hackett and Shelby 1942, I: cxxxvii-cxxxviii).

1681 (December 23-January 31, 1682) A Spanish army of attempted reconquest under Governor Antonio de Otermin camped at Isleta Pueblo and experienced severe hardship due to the snow and extremely cold temperatures. A number of their horses died due to "severe freezes, closing of the rivers [frozen over], and many snows." Retreating southward, in part due to the weather, the army reached Las Tusas, near the Fray Cristobal range, where the snow was deep (Hackett and Shelby 1942, II: 321, 337, 351, 354, 362–365).

1681–83 Crop failures due to drought and continuing Indian raids caused hardship among the Spanish survivors and their Indian allies at San Lorenzo, below El Paso del Norte, following the Pueblo Revolt (Beck 1962: 82).

1681–87 A regional drought resulted in meager agricultural harvests, and the Pueblo alliance began to crumble. Hunger and pestilence was once again widespread, and the Utes and Navajos waged war against Jemez, Taos, Picuris, and Tewa. Civil unrest was also caused by several Spanish invasions (Baisin 1994: 2; Bancroft 1889: 184–185; Ellis 1956: 29, 1974: 233; Fritts 1991: 190; Gutierrez 1991: 139).

1687–88 This was an El Nino year (Quinn et al. 1987: 14450).

1680s Based on tree-ring evidence, warming temperatures occurred (Fritts 1991: 125).

1691 (February) General Diego de Vargas, when he became governor, found the El Paso colonists in deplorable condition due to inclement weather and continuing nomadic Indian raids (Beck 1962: 85).

1692 (October 17–28) The soldiers and colonists of the Vargas expedition of reconquest suffered from lack of food and climatic elements as they marched up the river from El Paso. The Pueblos had little food due to loss of crops to grasshoppers in the summer. At the abandoned hacienda of Mejia, near Albuquerque, Vargas wrote "The winter weather here is severe and there has already been some snow and heavy frost this month ..." (Kessell and Hendricks 1992: 524). The Vargas expedition was hampered by snow, rain, and bad roads on its march from Pecos to the Galisteo pueblos (Espinosa 1940: 170; Twitchell 1963, I: 385–386).

1692 (December 9) Having carried out what he considered a successful reconquest, including the western Pueblos, Vargas and his army moved down the Rio Grande. The expedition experienced "a great windstorm and snows . . ." at a site with "no pasturage for the horses . . . and no firewood . . ." (Kessell and Hendricks 1992: 592). Vargas elected to take his army down the rougher Rio Grande branch trail of the Camino Real rather than take the Jornada del Muerto route. He cited the lack of adequate water in the Jornada as the reason for his decision (Crouch 1989: 56).

1692 Vargas described New Mexico's climate as "so very cold with abundant snow and rain and such heavy frost and freezes ..." (Kessell et al. 1995: 110).

1693 (early November) Returning to northern New Mexico with his army and colonists, Vargas reported that his troops "have suffered harsh weather with continual snow, freezes, and high winds . . ." (Bailey 1940: 95; Kessell et al. 1995: 400).

1693 (December) The soldiers and settlers led by Vargas endured severe hardship at Santa Fe due to the severe cold, deep snow, and a meager food supply. Also, adequate fuelwood could not be procured because of the impassable snowpack on roads and trails. Twenty-two Spaniards died as a result of these conditions. Vargas sent a group of Pueblo Indians into the mountains above Santa Fe to cut timber for the repair of San Miguel chapel. Cold weather turned them back without the wood materials (Espinosa 1942: 151–154; Twitchell 1963, I: 391).

1695–96 There was a general failure of Pueblo and Spanish crops due to a drought and crop worms. Residents were forced to eat "dogs, cats, horses, mules, bull-hides, foul herbs, and old bones." More than 200 individuals died due to starvation and "noxious food." Spanish and Pueblos suffered from the harsh weather. An epidemic also struck, resulting in further hardship and loss of life. Some Pueblos staged minor revolts (Bancroft 1889: 214–215; Kessell 1989: 62; Reeve 1961, 1: 300–302).

1696 June Vargas ordered the residents of Bernalillo, a new settlement that was at this time on the west side of the Rio Grande, to leave their village and take refuge in Santa Fe due to Pueblo unrest. Because the river was "running high," Bernalillo residents could not cross to the east side with their sheep (Espinosa 1942: 255).

1696 (summer) The famine among some of the northern Pueblos was a major cause of another revolt (Beck 1962: 88).

1696 (October 22) East of Picuris Pueblo, Vargas "lost the trail" of Pueblo rebels from Picuris and Taos "because of rain" (Gunnerson 1974: 123).

1696 (October 28-November 7) The Vargas expedition followed the fleeing Picuris eastward onto the eastern plains of New Mexico, but it was turned back by snowstorms and very cold temperatures. The Spaniards lost more than 200 horses and 5 mules; their Pueblo allies from Pecos and Tesuque lost even more. The expedition lived off the meat of the dead horses and roasted corn (Kenner 1969: 21–22; Thomas 1935: 58).

1698–1704 A severe, extended drought struck northern New Mexico and resulted in a catastrophic loss of livestock. The inclement weather forced some Rio Grande Pueblos to take refuge in the Acoma and Laguna areas (Ellis 1974: 397; Simmons 1982: 85). The ongoing drought and disease caused a decline in the population of Acoma (Minge 1976: 32). Governor Cuervo, succeeding Vargas as governor, reported that the drought had caused crop failure and loss of livestock. Raiding by nomadic groups intensified during these years, in part due to the stress of the severe drought (Simmons 1980: 194). Pueblo and other farming Indians were forced to abandon some villages or agricultural sites (Kelley 1952: 384).

1690s Based on tree-ring evidence, lower temperatures occurred (Fritts 1991: 125).

1700–10 Based on tree-ring evidence, dry conditions generally existed, although they were not as dry as in the previous century (Fritts 1991: 127).

1701 This was an El Nino year (Quinn et al. 1987: 14450).

1704 Spanish settlers and soldiers suffered from hunger and inadequate clothing, a condition blamed on a harsh winter and nomadic Indian raids (Baxter 1987: 21).

1704–09 A drought struck the region (Ellis 1974: 397; Hackett 1937: 375).

1706 (January 12) Fray Juan Alvarez at Nambe Pueblo reported the road from Santa Fe to Pecos was periodically closed by heavy snow. He also noted ice in the Rio Grande near San Ildefonso and Santo Domingo (Adams 1954: 47, 65, 105; Hackett 1937: 375).

1707 The region experienced a severe drought, and most crops were lost. This caused unrest among the Navajos and Pueblos, and the former began to raid Spanish villages after 3 years of peace (Brugge 1979: 113–114).

1712 (mid September) Heavy rains fell for 3 days on Santa Fe, causing the roof of the Palace of the Governors to leak (Horgan 1965: 87).

1714–15 This was an El Nino year (Quinn et al. 1987: 14450).

1714–17 Tree-ring data indicate that precipitation was below normal (Ellis 1974: 234).

1714–34 At least three droughts caused crop failure during this period (Simmons 1982: 111).

1715–16 Wildfires were common during these drought years (Baisan 1994: 3; Swetnam and Betancourt 1990: 1019).

1717 By this year, based on tree-ring evidence, there was declining precipitation, but the percentage changes were small and the differences insignificant (Fritts 1991: 148).

1717 (to 1718) Based on tree-ring evidence, precipitation began to increase (Fritts 1991: 127, 190).

1719 (summer) Rainfall was below normal (Baisan 1994: 3).

1720 This was an El Nino year (Quinn et al. 1987: 14450).

1727–39 This period was one of episodic drought and wet years across the province (Ellis 1981: 411; Hill 1940: 415; Simmons 1982: 111).

1728 This was an El Nino year (Quinn et al. 1987: 14450).

1720s Tree-ring data from Sevilleta National Wildlife Refuge indicate that these years were exceptionally wet (Fairchild-Parks et al. 1995: 8).

1730 The northern Pueblos harvested abundant crops owing to favorable weather (Adams 1954: 97).

1734–36 Based on tree-ring evidence, these years were the fourth, in order of importance, driest 3-year period over the last 5 centuries (Fritts 1991: 134).

1735 A Rio Grande flood destroyed the church at upper Bernalillo, on the west bank of the river. This marked the beginning of a 2-mile westward shift of the river channel in this area, forcing the residents to move to the east side of the river (Bowen and Sacca 1971: 56–59; Snow 1976: 172–175).

1735–39 Tree-ring data indicate precipitation was below normal (Ellis 1974: 234).

1739 By this year a number of Albuquerque area residents had moved down the Rio Grande, in part due to a shortage of water for their fields (Gatewood et al. 1964: B13; Thomas et al. 1963: D3).

1730s–40s Tree ring data from Sevilleta National Wildlife Refuge indicate that this was the worst drought period in the last 400 years (Fairchild-Parks et al. 1995: 8).

1741 A major flood occurred along the Rio Grande (Beal and Gold 1988: 125).

1742 Due at least in part to the drought of the previous decade, all of the revolt period Pueblo refugees from the Rio Grande, except residents of Hano, left the Hopi area and returned to their former villages (Adams 1981: 326).

1745–47 Tree-ring data indicate that precipitation was above normal in northern New Mexico (Baisan 1994: 2; Ellis 1974: 234).

1746 Chama Valley settlers avoided locating on the north bank of the river because of periodic flooding; they settled on the south bank (Swadesh 1974: 37).

1747 This was an El Nino year (Baisan 1994: 3; Quinn et al. 1987: 14450).

1748 Tree-ring data indicate that this may have been the driest year in the century (Baisan 1994: 3; Ellis 1974: 234).

1748 The frequency of wildfires was substantially above normal (Swetnam and Betancourt 1990: 1019).

1748–50s Based on tree-ring evidence, an extreme drought occurred (Fritts 1991: 127).

1750 (pre) Santa Ana Pueblo began acquiring better farmlands along the Rio Grande because its fields on the Jemez River were periodically destroyed by floods (Kessell 1980: 168).

1752 The Rio Grande was dry for almost 400 miles (border to border), primarily due to drought (Pattie 1966: 268; Tuan et al. 1973: 56).

1753–1885 Livestock grazing (Navajo and Hispano) in the Rio Puerco valley and climatic change (droughts and locally intensive rains) were the probable causes of the beginning of severe erosion (Bryan 1928: 280–281).

1754 (ca.) The Santa Rosa de Lima church was moved from the confluence of the Abiquiu Creek and Chama River to higher ground due to continual flooding (McDonald 1985: 121).

1755–57 Based on tree-ring evidence, these years were the third, in order of importance, driest 3-year period in the last 5 centuries (Fritts 1991: 134).

1760 (winter-spring) Low temperatures created ice on the Rio Grande. Later in the period, the cold killed fruit tree blossoms in the Isleta area, and as a result there was no fruit. The valley below Albuquerque also flooded (Adams 1954: 47, 65, 105).

1760 (July) Bishop Tamaron went from Isleta to Tome and there prepared for his journey to El Paso. He left on July 8 but could not cross the river due to floods (Adams 1954: 43, 71).

1760 Bishop Tamaron noted that Isleta Pueblo was located on an elevation in the Rio Grande floodplain and was indeed an island when the river flooded (Adams 1954: 202–208).

1760 Bishop Tamaron crossed a frozen Rio Grande at the Barelas ford to reach Atrisco on the west bank (Simmons 1978: 46).

1760 The Rio Grande ran "full" throughout the year (Tuan et al. 1973: 56).

1760 Residents of the El Paso area were diverting about one-half of the waters of the Rio Grande for agricultural and domestic use. The diversion dam washed out and was rebuilt virtually every year (Clark 1987: 14).

1760–70 Based on tree-ring evidence, temperatures in this decade were cool, but temperatures were near 20th century means (Fritts 1991: 126, 150).

1761 This was an El Nino year (Quinn et al. 1987: 14450).

1763 By this time, an "upper" and a "lower" Bernalillo were recognized. Soon, however, the upper settlement was forced upriver to Algodones by floods, a location of higher elevation (Snow 1976: 172–175).

1767 A severe flood on the Santa Fe River impacted Santa Fe. The river channel shifted into the Rio Chiquito, which is now covered by Water Street (Twitchell 1963, I: 447; Workers of the Writers' Program 1940: 426).

1769 Father Dominguez reported that the flooding Rio Grande had moved east and destroyed most of the homes and farmlands at Tome. The river continued to flow in this new channel until at least 1777, leaving its old bed to be farmed by citizens of Belen, opposite (to the west of) Tome (Adams and Chavez 1956: 8; Kessell 1980: 150).

1770 Over half the church bells in New Mexico were found to be cracked due to their being rung in cold weather (McDonald 1992: 33).

1772–79 A severe drought persisted over the province, and Pueblo and Spanish crops failed except where there was adequate irrigation water. As a result there was little produce to trade to the Navajo, Apache, or Comanche, who were suffering shortages of wild animal and plant foods themselves. Raids on the Rio Abajo by these Indians consequently increased (John 1975: 474; Jones 1966: 133–134, 150–156).

1773–74 A visitor from Virginia claimed "no diseases have appeared since the settlement of the province by Spaniards, which can be said to be peculiar to the climate and country" (Hodge 1929: 249).

1773–76 Fray Dominguez reported that the people of Acoma were experiencing hardships from the ongoing drought (Adams and Chavez 1956: 194).

1773–82 Based on tree-ring evidence, an extreme drought occurred (Fritts 1991: 127).

1774 (February 9–11) A traveler found little snow in the Sangre de Cristo Mountains, apparently crossing from west to east via Glorieta Pass. The weather was mild, with a light west wind (Hodge 1929: 261).

1774 (February 12–13) "It rained incessantly" in the Las Vegas area (Hodge 1929: 262).

1774–76 Crop harvests at Taos Pueblo during these drought years were above normal owing to a reliable water supply for irrigation (Adams and Chavez 1956: 112; Bodine 1979: 256).

1775 (summer) Devastating Comanche raids were, at least in part, related to the continuing drought. Spanish and Pueblos losses were six times greater than those of the Comanche. Pecos and Galisteo were the hardest hit, and residents resorted to eating animal hides and old shoes. Populations of the two settlements decreased almost 50 percent during the decade (Kenner 1969: 48–49).

1775 This was an El Nino year (Quinn et al. 1987: 14450).

1775–1800 Hispanos in northern New Mexico reported that springs and creeks had ceased flowing (Hewett et al. 1913: 48).

1776 (pre) (winters) According to Fray Francisco Atanasio Dominguez, frozen acequias and streams in Santa Fe shut down mill operations (Adams and Chavez 1956: 31). A stone embankment had been built on the Santa Fe River to prevent flood damage to property in the villa (Adams and Chavez 1956: 40).

1776 (pre) Two farm plots and a large kitchen garden at Zia were washed away by the flooding Jemez River (Adams and Chavez 1956: 170).

1776 The residents of Pecos Pueblo were suffering due to the drought, which resulted in little or no crop harvest and a shortage of water for domestic use. Wells had been dug near the pueblo to provide domestic water (Adams and Chavez 1976: 213; Kessell 1979: 347).

1776 Fray Dominguez described the Santa Fe River as "Its current is so swift that in times of freshet it has done some damage, and although this was not extreme, measures have been taken to avoid further harm by installing a stone embankment... although it carries enough water to be called a river, it is not overabundant. Indeed, it is usually insufficient, and at the best season for irrigating the farms, because there are many of them it does not reach the lowest ones, for the first, being higher up, keep bleeding it off with irrigation ditches, and only in a very rainy year is there enough for all. In such seasons ranchos five leagues downstream benefit as much as the rest" (Adams and Chavez 1956: 40).

1776 Fray Dominguez reported that residents of the Galisteo Pueblo were suffering from famine due to the drought and Comanche raids. Those who had not abandoned the settlement were eating hides of cows, oxen, and horses and the leather of saddles and shoes (Adams and Chavez 1956: 217).

1776 According to Dominguez (Adams and Chavez 1956: 7–8), "The river [Rio del Norte] is in flood from mid-April to the end of June. The force of the freshets depends upon whether the winter snows have been heavy or light, but they never fail, for it always snows more or less. In a very rainy year the flood season lasts a long time, and the longer it lasts, the greater damage it does, whether to people or cattle who are drowned, or to farmlands that are swept away, or even to nearby houses that are carried off."

1776 Fray Dominguez reported that farmlands around Quemado and Cieneguilla were "fertilized" by overbank floodwaters of the Santa Fe River (Adams and Chavez 1956: 41).

1776 Zia Pueblo had a league (2.64 miles) of irrigated farmland along the Jemez River and some arable land in tributary canyons above and below the village. Below-average precipitation and poor soils prevented good crop harvests in some years (Adams and Chavez 1956: 175).

1777 The continuing drought caused most Zuni villagers to abandon their pueblo and to move east to join other Pueblos (Simmons 1979: 190).

1777–80 Drought continued in New Mexico, which, combined with the 1780 smallpox epidemic, killed some 5,025 Pueblo Indians (Workers of the Writer's Program 1940: 69).

1778 Governor Anza recommended that two annual expeditions composed of militia and Pueblo auxiliaries be made against the Apaches. One would come at the beginning of the rains in July, while the second would be at the onset of winter. This plan left the spring for planting, irrigating, and weeding and September and October for crop harvest (Thomas 1932: 185).

1778–87 Tree-ring data indicate that these were perhaps the most severe drought years in the 18th century (D'Arrigo and Jacoby 1991: 95, 97–98).

1779 (summer) Rainfall was below normal (Baisan 1994: 3).

1779–80 The extended drought forced some Pueblo and nomadic Indians into Spanish villages (Gutierrez 1991: 372).

1780 Above-normal spring runoff brought severe flooding at San Felipe and other pueblos along the Rio Grande. Sparse summer pasture resulted from below-normal precipitation in the summer (Kessell 1980: 132; White 1935: 18–19).

1780 The Tome courthouse, located on the plaza west of the church, was damaged by a Rio Grande flood (Ellis 1955: 95).

1782 Fray Morfi reported that Santa Ana Pueblo was subjected to "great winds" and floods of the Jemez River, which deposited sand on the agricultural fields. Additionally, the river water was "salty" due to its tributary, the Rio Salado. Because of this and the lack of irrigation water, the fields were virtually nonproductive. The latter situation was perhaps caused by downcutting of the river to a point below which gravity-flow acequias could deliver water (Thomas 1932: 98; White 1942: 27–28).

1782 Fray Morfi reported that the lake for which Laguna Pueblo was named was dry most of the year. In March, April, and May the lake filled with run-off water from the San Mateo Mountains. The lake was located a little more than one-half mile west of the pueblo and was estimated to have had a circumference of just over 5 miles (Thomas 1932: 103).

1785 Forest fire frequency was above normal (Swetnam and Betancourt 1990: 1019).

1786 This was an El Nino year (Quinn et al. 1987: 14450).

1780s–90s Based on tree-ring evidence, temperatures began to warm throughout the region, reaching maximum values at the start of the next century (Fritts 1991: 126).

1791 This was an El Nino year (Quinn et al. 1987: 14450).

1791 ca. Based on tree-ring evidence, the reconstructed temperature rise occurring around this time was surpassed only by warming of the 20th century (Fritts 1991: 151).

1792–93 (winter) This was a wet period. San Felipe de Neri, an adobe church in Albuquerque, collapsed, probably due to the above-average precipitation during this period (Baisan 1994: 2; Simmons 1982: 120).

1800 (ca.) The annual trade caravan to Chihuahua, which included large flocks of sheep, began leaving La Joya de Sevilleta in August instead of the traditional month of November. This change was made to take advantage of summer rains, which filled the waterholes and ensured good grazing grass (Baxter 1987: 63).

1800 (ca.) The adobe parish church in Santa Fe had been damaged by heavy rains and had to be rebuilt (Chavez 1972: 8).

1800–10 Based on tree-ring evidence, below-normal precipitation prevailed (Fritts 1991: 128, 151).

1801 (summer) The horses of the Spanish military suffered, and some died, from high temperatures (Gunnerson 1974: 284).

1803 Irrigation prevented a crop loss due to drought in the Rio Grande Valley (Bancroft 1889: 302).

1803–04 This was an El Nino year (Quinn et al. 1987: 14450).

1805 (summer) Rainfall was below normal (Baisan 1994: 3).

1805 A Santa Fe presidial soldier was killed by a bolt of lightning while riding a mule (Simmons 1977b: 102).

1807 (March 5–6) As they departed Santa Fe, a snowstorm hampered travel by Zebulon Pike and his Spanish captors. He noted that 1 foot of snow covered the ground north of San Felipe Pueblo (Coues 1987, II: 614–616).

1810–21 Based on tree-ring evidence, there was a general downward trend in temperature. Temperature decline was most rapid around 1821 (Fritts 1991: 128).

1814 This was an El Nino year (Quinn et al. 1987: 14, 1450).

1814 Residents of Santa Fe suffered due to deep snow and shortages of food (Baxter 1987: 77).

1815 (ca.) The governor of New Mexico, Alberto Mayvez, reported that the province was economically poor due to extremely cold weather, which had virtually ruined farming and ranching efforts (Simmons 1991: 70–71). Severe, long winters devastated the agricultural and livestock industries in northern New Mexico (Simmons 1983: 6–8).

1815–16 These were very wet years (Baisan 1994: 3).

1817–22 (summers) Precipitation was below normal (Baisan 1994: 3).

1818–19 Wildfires were common (Baisan 1994: 3).

1818–23 Precipitation was below normal, causing problems for ranchers and farmers in northern New Mexico. In spite of the drought conditions, sheep herds increased in number (Bancroft 1889: 302; Denevan 1967: 701; Ellis 1974: 235).

1819–29 Dendroclimatic studies in the Tijeras Canyon area indicate that precipitation was below normal, and temperatures were above normal. The precipitation the first year was estimated to have been only about 6 inches, more than 50 percent below today's normal. No crops were harvested by Hispanic land-grant settlers in the canyon that year (Cordell 1980: 52, 64–65; Quintana and Kayser 1980: 52).

1820–21 (winter) This was a wet period (Baisan 1994: 3).

1820–22 A drought caused hardship, but irrigation saved crops along the Rio Grande (Bancroft 1889: 302).

1820s (early) The irrigation system at San Antonio Plaza on the east side of the Sandias was abandoned due to poor quality and insufficient quantity of water (Quintana and Kayser 1980: 57).

1820 (post) A Rio Grande flood destroyed the Bernalillo church (Chavez 1957: 3).

1821 (August) Comanches raided the El Vado district of the upper Pecos River. The extended drought, and the governor's failure to give these Indians gifts, probably caused the raiding (Kessell 1979: 436).

1821–30 Based on tree-ring evidence, "average temperature and precipitation patterns were not greatly different from the embedded anomalies of 1602–1900" (Fritts 1991: 154).

1821–46 Navajos raided the Santa Ana Pueblo area during drought years (Bayer et al. 1994: 115–116).

1822 Tree-rings indicate precipitation was substantially below normal (Ellis 1974: 235).

1822 Wildfires were common (Baisan 1994: 3).

1822–23 Major flooding occurred on the Rio Grande from Bernalillo to El Paso (Carter 1953: 4).

1822 (post) Those seeking a cure for their bad health, mostly tuberculars, began travelling the Santa Fe Trail to New Mexico. Others made the trip to prevent illness through exercise and breathing the clean air (Barbour 1990: 47).

1823 (early June) Surveyors of the El Canutillo grant near El Paso were forced to halt their work due to the flooding Rio Grande (Bowden 1971: 94).

1823 A major flood occurred along the Rio Grande (Lange et al. 1975: 73).

1824–25 (winter) Ten trappers left Santa Fe to work the Green River, but deep snow and intense cold forced them into winter quarters in southwest Colorado (Weber 1971: 79).

1827 In Santa Fe a "great rain almost ruined all the houses in town" (Cleland 1950: 224).

1827 Don Jose Agustin de Escudero reported that New Mexicans had to spend 6 months of every year in their homes due to the severity of the climate (Carroll and Haggard 1942: 40).

1827–37 Based on tree-ring evidence, the annual average precipitation exceeded 20th century levels (Fritts 1991: 154).

1828 The Rio Grande flooded, destroying property in the Rio Abajo and cutting a new channel in the Los Pinos-Peralta area (U.S. Court of Private Land Claims 1899: 24–26). The flood also caused extensive damage. Peak discharge was estimated at 100,000 cfs, and water extended across the entire Rio Grande floodplain (Carter 1953: 19).

1828 A Rio Grande flood at Ranchito de Santa Ana caused the river to shift eastward, destroying some old houses (Bayer et al. 1994: 114).

1828 The Rio Grande, in flood, was diverted away from Tome Plaza by a burro, or levee (Ellis and Baca 1957: 22). A priest of the Tome parish later said ". . . that Tome should be called `the charcos city'—referring to the standing pools of water . . . a heritage of the great flood of 1828" (Ellis 1955: 201). Later, Tome and Valencia citizens were in disagreement about moving the Tome church and plaza to higher ground. According to Tome residents, the church was in a precarious state, but Valencians disagreed. The church remained at its original site (Chavez 1957: 98).

1828 Gold was discovered at El Real de Dolores in the Ortiz Mountains southeast of Santa Fe. Mining was hampered due to a lack of adequate water supply. Most of the mining was done in the winter, when snowmelt could be used (Christiansen 1974: 24–25).

1828 This was an El Nino year (Quinn et al. 1987: 14450).

1829 The San Miguel church at Socorro was destroyed by a Rio Grande flood (Burrus 1984: 148).

1829 Tree-ring data indicate that precipitation was below normal (Ellis 1974: 235).

1829–30 The drought caused priests to lead prayers for rain (Bayer et al. 1994: 115).

1829–42 Trade caravans usually left Santa Fe in October to travel the Old Spanish Trail to California before snows began. Returning caravans left in April so they could cross rivers before runoff from snowmelt raised them to flood levels (Hafen and Hafen 1993: 187).

1820s–30s (winters) When the snow was too deep for their livestock, trappers would cut cottonwood branches, and the animals would eat the bark. Some believed too much bark would cause the hair of an animal to fall out. Adequate water for stock was usually a more critical factor; waterholes had to be chopped through the ice of frozen streams or springs (Lavender 1954: 78).

1830 (spring) Ponce de Leon, whose grant is the present site of El Paso's business district, lost his home on the bank of the Rio Grande in a flood. His fields and crops suffered considerable damage also (Bowden 1971: 105).

1830 A major flood occurred along the Rio Grande. Two churches and convents were destroyed at two unspecified locations along the river (Kessell 1980: 132; Lange et al. 1975: 73).

1830 (November-December) Work at the Tiro mine in the Los Cerrillos area was suspended due to a "great cold spell" (Potash 1949: 338–339).

1831 Antonio Barreiro wrote that the larger, regional streams froze so solidly in winter that loaded wagons could cross the ice. He also reported that milk froze in pails (Barreiro 1928: 11–12).

1831 (or 1832) The Rio Grande shifted course, and Pueblo de Senecu, located east of El Paso, was "moved" from the south to the north side of the river (Bowden 1971: 129).

1831–32 (winter) The weather in the southern Rocky Mountains was extremely severe. Two Mexican servants of an Anglo trapper froze to death while attempting to take supplies from Taos into the northern mountains (Weber 1971: 202).

1831–32 (winters) These two seasons were described as being colder than those in Europe. Winter weather began in September, with the severest weather occurring in December or January. Snow cover in the higher elevations remained on the ground year round, and rivers sometimes froze to the extent that the ice would support heavily loaded carts and pack trains. Severe winters caused major losses of livestock and some loss of human life (Bailey and Carroll 1942: 24–25).

1831–40 Based on tree-ring evidence, this appears to have been an extremely wet decade. In fact,

	it may have been the wettest since 1600 (Fritts 1991: 129, 154).
1832	(July) A flood on the Rio Chama washed away a diversion dam and ditch above Abiquiu (Ebright 1979: 21).
1832	(summer) In northeast New Mexico, Josiah Gregg's (1966, I: 108) caravan experienced a thunderstorm. A bolt of lightning killed an ox.
1833–42	Based on tree-ring evidence, this was the coldest period in the last 5 centuries (Fritts 1991: 128).
1835–49	Tree-ring data indicate that this was the wettest period of any other comparable time range in the historic period (D'Arrigo and Jacoby 1992: 243, 251).
1837	Forest fire frequency was below normal (Swetnam and Betancourt 1990: 1019).
1837	Priests were again asked to lead prayers for rain because of the drought (Bayer et al. 1994: 115).
1830s	Gregg (1966, I: 146–147) wrote this on the climate: "Salubrity of climate is decidedly the most interesting feature in the character of New Mexico. Nowhere, not even under the much boasted Sicilian skies, can a purer or a more wholesome atmosphere be found." Some Hispanic residents told him that rainfall increased during this decade (Gregg 1966, II: 203). He (1966, I: 148) observed that the Santa Fe wagon trains were especially welcomed in the capital during droughts, when they brought relief to the area residents. Some Hispanics thought the Americans brought rain, but Gregg remarked that this was a "superstition," as the traders arrived during the usual rainy season of July and August. Gregg (1966, II: 94) also wrote "Owing a little to the dryness of the climate, Mexican animals have unusually hard hoofs. Many will travel for weeks, and even months over firm [packed] and often rocky roads of the interior ... without any protection whatever to the feet ...."
1830s	(winters) These seasons were described as "long" but not as cold as those of the previous century (Gregg 1966, I: 147–148).
1830s–40s	Precipitation was above normal during most of this period. Perhaps as a result, fires in grasslands and forests were few in New Mexico and Arizona. Another possible cause for so few fires was the intense grazing of the grass understory by sheep, removing grassy fuels important to spreading fires (Swetnam 1990: 10).
1841	A decline in annual precipitation began (Fritts 1991: 129).
1840s	(mid) (to early 1850s) Severe drought due to below average precipitation occurred (Denevan 1967: 701; Ellis 1974: 235). Perhaps in response to these conditions and an accelerating decrease in bison on the eastern plains, various nomadic Indian groups stepped up their raiding along the Rio Grande (Bloom 1914: 37–38).
1844–45	This was an El Nino year (Quinn et al. 1987: 14451).
1845–47	Based on tree-ring evidence, these years were among the driest 3-year periods in the last 5 centuries (Fritts 1991: 134).
1846	(pre) Spanish livestock raisers sometimes requested Pueblo governors to allow them to graze their animals on Indian lands "for a year or two, generally during years of drought." Often the Spaniards would continue to use the land and would eventually gain legal title to it (Sando 1992: 113).
1846	(November 24) Lt. James Abert (1962: 127), at Valverde, wrote ". . . the river was frozen across, but by breakfast time the ice was floating down the rapid current in great quantities. . . ."
1846	(December 10–15) Near Valverde, Abert's (1962: 132–135) men suffered from cold temperatures and snow. On the last day they packed, crossed the river at the Valverde ford, and began their march upstream to Santa Fe on the west bank road.
1846	(December 28) Abert's (1962: 141) command suffered from the effects of a severe snowstorm as they left Santa Fe. They were forced to camp at Apache Canyon. A number of oxen died, and wolves and ravens were seen scavenging the carcasses.
1846	(December 31-January, 1, 1847) Another severe snowstorm struck Abert (1962: 142–143) and his men, and they sought shelter in a pine forest west of Ojo de Bernal. They camped at the spring and awoke to 5 inches of snow on the ground, a strong wind, and very cold temperatures.
1846	Adolph Wislizenus (1969: 25) wrote "... the Rio del Norte is never frozen with ice thick enough to admit the passage of horses and carriages, as was formerly believed."
1847	(January 3) Abert (1962: 144) reported thick ice on the Rio Sapello, making crossing difficult. The same was true at the Rio Mora.
1847	(January 7–8) The snow and cold in the Rio Rayado area continued to hamper Abert's (1962: 147–148) travel. Wolves were eating downed oxen, and some attacked the mules.

	Ice on the Rio Vermejo was crossed by the men, their animals, and the wagon.
1847	The "mountains all around" Santa Fe were "covered with snow..." (Frazer 1981: 39).
1847	Forest fire frequency was above normal (Swetnam and Betancourt 1990: 1019).
1849	(June 15–20) William H. Chamberlain, traveling from Santa Fe through the Tijeras Canyon to the Rio Grande, wrote "Everything here appears to be suffering from drought." However, the river at Albuquerque was "nearly a mile wide," and "its flow was higher this season than ever known before" (Bloom 1945: 144–146).
1849	(August 14-September 23) This was a dry period for the region between the Rio Puerco-of-the-East and the Chuska Mountains (McNitt 1964: 163).
1849	This was a drought year, and the Rio Puerco-of-the-East was dry (McNitt 1964: 163).
1849–50s	(falls) New Mexico's normally dry autumns resulted in "the grass not lose[ing] its nutritious properties by being washed with rains. It gradually dries and cures like hay, so that animals eat it freely, and will fatten upon it even in midwinter. It is seldom that any grain is fed to stock in either of these territories" (Marcy 1988: 113).
1840s	Santa Fe Trail traders were welcomed by the Pueblos, who believed their arrival was "a sign that the rains would soon come (Bayer et al. 1994: 115).
1840s–60s	Based on tree-ring evidence, this was a warming period, followed by a cooling period (Fritts 1991: 128).
1840s–70s	Every "new moon" and in August, individuals from Placitas forecast the weather as related to farming activities (Batchen 1972: 22–23).
1850–1994	(winters) The average precipitation for Albuquerque was 1.6 inches (Liles 1994: 35).
1800s	(mid) The old Corrales church was destroyed by Rio Grande floods (Marshall 1989: 47).
1851	A drought, hail, and grasshoppers notwithstanding, the crop harvest was good in the territory (Sunseri 1979: 22). Some ranchers were forced by the dry conditions to drive their cattle and sheep herds to market in California (Loomis 1962: 21).
1851	Forest fire frequency was above normal (Swetnam and Betancourt 1990: 1019).
1851–60	Based on tree-ring evidence, precipitation was below 20th century means (Fritts 1991: 155).
1852	(June) This was the wettest month ever recorded in Albuquerque; 8.15 inches of precipitation fell (Liles 1994: 6).
1852	Gila Apaches struck Rio Grande settlements in Valencia and Socorro counties repeatedly (Schroeder 1963: 12). These attacks may have been, in part, related to the drought of the previous 2 years.
1852	Military physician John F. Hammond noted that the Rio Grande in the Socorro area was running above normal flow from May to late July due to the snowmelt runoff. During these periods, the river ran 200 to 600 yards wide and 4 to 6 feet deeper than normal flow. Floods destroyed "hundreds of acres of cultivated land in a single season, and formed extensive deposits ... and that [water] used for irrigation makes a heavy deposit which improves the land." Changes in the channel reportedly took place almost every year (Hammond 1966: 24–25).
1852–62	The drought caused hardship among all New Mexicans, and nomadic Indian groups raided widely (Horgan 1954, I: 831).
1850s	(early) Whenever the Rio Grande rose, its waters ran in its new (present) channel and the 1831 or 1832 channel, forming a 20-mile-long island on which the pueblos of Isleta del Sur and Socorro and the Presidio de San Elizario were located (Bowden 1971: 143).
1853	(February) A reservation for the Jicarilla Apaches was established about 20 miles west of Abiquiu on a tributary valley of the Chama River. Here there was good grazing and shelter from winter weather, and in the nearby mountains there were abundant game animals and good timber (Tiller 1992: 41–42).
1853	(spring-summer) The Rio Puerco west of Abiquiu went dry, preventing the Jicarilla Apache from growing crops on lands set aside for them by the government (Tiller 1992: 43).
1853	(September) An early frost killed the peaches along the lower Rio Grande before they could be harvested (Hume 1942: 210).
1853	(September 21) Brevet Lieutenant-Colonel Thomas Charlton Henry, a U.S. Army surgeon stationed in New Mexico, was waiting at the north end of the Jornada del Muerto with a detachment of soldiers for the "advent of rain" and the oxen to recuperate. He described the Rio Grande as "a magnificent stream. Its waters are muddy, like those of the Missouri, yet on standing sediment is quickly deposited, and the water is very palatable" (Hume 1942: 210).
1850s	(early to mid) The period of the "Little Ice Age" generally ended, and a gradual warming trend began (Fritts 1965: 438–442; Swan 1977: 31).
1854	(spring) W.H.H. Davis (1982: 351, 353), visiting the Bernalillo-Albuquerque area, wrote

"... there are flies and mosquitoes, which swarm in and out of doors in untold millions." He described the water from the Rio Grande as "so muddy that you can not see the face in it until it shall have settled several hours." He described the climate of Albuquerque as "oppressively warm in the summer season" and in "some seasons of the year high winds prevail, when the sun is almost obscured by the clouds of fine dust.... No climate in the world is better adapted to the [grape]vine than the middle and southern portions of New Mexico...."

1854 (April 4) U.S. Army troops, pursuing Jicarilla Apaches, were hampered by a violent wind and snowstorm. Upland areas above 6,000 feet were blanketed by 3 feet of snow (Tiller 1992: 48).

1854–55 (summers) This was an exceptionally wet period. Rains were abnormally intensive and lasted beyond the normal summer "monsoons" in northern New Mexico. In the first year, the summer rains began early and extended into fall, ending the first week in November. Houses were damaged in Santa Fe; some adobe structures were destroyed (Davis 1982: 298–299).

1854–55 Albuquerque experienced two "wet" years, with 12.51 and 10.54 inches of precipitation (Tuan et al. 1973: 8).

1855 (early May) U.S. Attorney W.W.H. Davis described the Casa Colorado area during a dust storm: "At Casa Colorado we struck a young desert, an excellent pocket edition of the great African Zahara, over which we journeyed for about four miles. A high west wind was blowing at the time, and there was no grass upon the ground to keep the sand where it belonged: it drifted about like snow in a winter's storm; the particles were fine and dry, and the atmosphere was so filled with them as almost to obscure the sun. The sand blew into our faces like hail, and our poor animals, at times, would stop, refusing to face the storm. In many places the loose sand was piled up in conical-shaped hills, several feet in height, and the finer particles were constantly whirling around them. For the distance this region extends, it is as perfect a desert waste as can be, and we were right glad when we reached the southern border, and once more had a hard road under our horses' feet" (Davis 1982: 359–360).

1855 (July) The Rio Puerco west of Albuquerque was dry, but a little water was found in the Rio San Jose (Davis 1982: 392).

1855 (winter) The Rio Grande ceased flowing 25 miles above Las Cruces, near the San Diego ford (Horgan 1954, II: 831–832).

1855 Survey of the principal meridian south of the base line, near Socorro, during a dry period was discontinued due to the high price of water (75 cents/gallon) for the survey crew and their mules. Work did not resume "until the rains came" (Westphall 1965: 10).

1855 A flood on the Gallinas caused property damage in Las Vegas (Perrigo 1982: 87).

1855 (ca.) Flooding on the Rio Grande was damaging the Belen church, and within a few years it was totally destroyed by floodwaters (Espinosa and Chavez n.d.: 146).

1856 (November 2) A snowstorm and strong winds struck the Larkin party on the Santa Fe Trail, spoiling their hunting. They camped that night in the snow at Raton Pass (Barbour 1990: 95).

1856 (November 6) Another snowstorm struck the Larkin group near Ocate Creek (Barbour 1990: 97).

1856 (November 23) There were 6–8 inches of snow on the ground at Santa Fe (Barbour 1990: 105).

1856 (November 28) Larkin left Santa Fe and travelled 42 miles through "deep snow" to Algodones (Barbour 1990: 106–107).

1856 (November 28-December 3) The weather was "excessively cold" in the Algodones-Santa Fe area (Barbour 1990: 107).

1856 (December 9) Snow still covered the ground at Santa Fe (Barbour 1990: 109).

1856 The "old town" of Sabinal was destroyed by a Rio Grande flood, which cut a new, straight channel through the town site (Lange and Riley 1970: 14).

1856 The Rio Grande flooded in the Sabinal area and silted over the location where Chiricahua and Mescalero Apaches had lived in agricultural communities during the early 1790s. This settlement was part of an attempt to maintain peace between the Apaches and the Spanish (Simmons 1991: 57–60).

1857 (January 7–9) Snow fell all of the first day at Santa Fe, with 8 inches on the ground the next morning. There was more snow on the 8th, and then it became bitterly cold on the third day (Barbour 1990: 115).

1857 (June or July) The Rio Grande was about a half-mile wide and too high to cross from the west bank to the east at Fort Craig (Browne 1973: 59).

1858 (March-August) This was the wettest 6-month period for Albuquerque; 14.4 inches of precipitation were recorded (Liles 1994: 6).

1858 (June 23) Emigrant John Udell, at Albuquerque, wrote "The Rio Grande River is about one mile wide here, from bank to bank...." He was describing a spring flood (Dodge 1980: 90–91).

1858 (fall) No precipitation was recorded for this season in Albuquerque, the lowest of record (Liles 1994: 34).

1858 The highest annual precipitation ever recorded for Albuquerque was 16.3 inches (Liles 1994: 6, 9).

1859–60 A drought in New Mexico resulted in a decreased crop harvest and poor native grass growth (Beadle 1973: 514–515; Frazer 1983: 154, 186; Keleher 1982: 146; Sunseri 1973: 33). Northwest New Mexico was especially hard hit, with almost no grass and little water. Large numbers of sheep and horses were reported to be dying (Heyman 1951: 49–50).

1850s (late) Precipitation was above average in the southern Rocky Mountains (Bradley 1976: 16, 191).

1850s A Rio Grande flood in the Corrales area caused a shift in the river's channel (Eisenstadt 1980: 16).

1850s (early 1860s) Some Navajos claimed that war was efficacious in bringing rain (Brugge 1985: 163).

1860 (ca.) Residents of Abiquiu reported that Rito Coyote, Rito Vallecito, and Rito Colorado de Abiquiu ceased flowing. This was explained by the saying "el tiempo se pone mas seco cado ano" (Loew 1875: 133).

1860 (spring) No precipitation was recorded for Albuquerque (Liles 1994: 32).

1860 The corn crop in New Mexico was less than expected due to drought. Residents of the territory suffered from the lack of adequate provisions (Sunseri 1979: 20, 33).

1860–65 These were drought years (Baisan 1994: 3).

1860 (ca.) (to 1885) The village of Chamberino of Santa Ana County was flooded several times by high waters of the Rio Grande. A flood in the last year destroyed all but a few houses. Some families moved to higher ground and reestablished the village (Johansen 1948: 54).

1861 (January) Ice covered the Rio Grande crossing at the Barelas-Atrisco ford. Some of the ice supported a light buggy and an army ambulance (Lane 1964: 94).

1861 (February 5) Deep snow prevented many Navajo leaders from coming to the peace council at Ojo del Oso for 10 days (Bailey 1980: 216).

1861 The Rio Grande was dry from Socorro to below El Paso (Follett 1898: 90).

1861–70 Based on tree-ring evidence, the drought continued (Fritts 1991: 156).

1862 (January 27) A traveler passing through Albuquerque had difficulties in getting his wagons across the Rio Grande (Barelas Ford?) and coping with sand storms west of town (Oppenheimer 1962: 24).

1862 (March 8) A dust storm struck a Confederate column near Judge Baird's residence. Sergeant A.B. Peticolas (Alberts 1993: 66) described this event: ". . . the wind increased to almost a hurricane. Clouds of sand came driving against our backs, and the whole atmosphere was dark with the heavy clouds of sand. The pebbles dashed stingingly against our backs, and our eyes were almost put out by the sand."

1862 (March) A dust storm at Albuquerque was described by a Confederate soldier: "The sand and gravel...[flew] in a manner that I never saw before. I would compare it to a description that I have seen of the sand storms of the great desert of Sahara" (Hall 1960: 121).

1862 (April) The retreating Confederate army suffered losses in the San Mateo Mountains, Socorro Co., due to exposure, cold temperatures, disease, and Apache attacks. Apaches also poisoned wells along the retreat route of the Confederates (Roberts and Roberts 1988: 124).

1862 (April 13) A dust storm prevented Union troops from attacking the retreating Confederate army just south of Albuquerque (Simmons 1982: 186).

1862 (April 16) Peticolas's Confederate unit found "plenty of wood" at a Hispano rancho near Belen. The severe dust storm continued all day (Alberts 1993: 107).

1862 (August) A major flood inundated much of the Rio Grande Valley from Albuquerque south, destroying crops and damaging structures in the Valencia area (Carter 1953: 4). Floods along the Rio Grande in southern New Mexico damaged fields, destroyed homes, and forced many residents to abandon their villages (Couchman 1990: 155; Sonnichsen 1980: 9).

1862 (late December to early January 1863) On a mail coach, Franz Huning encountered snow from west of Albuquerque to Zuni. On the return trip, travel was more difficult due to deep, hard-frozen snow (Browne 1973: 70–71).

1862 Following the 2-year drought lack of adequate grasses, forbs, and shrubs for grazing livestock was a factor in the ultimate defeat of Confederate forces by Union forces (Simmons 1982: 179).

1862 As a result of the drought, the demand for salt by the military increased. The military at Fort Bliss and other posts in the area especially needed the salt (Sonnichsen 1968: 182).

1862 Hispanic settlers from the Mesilla Valley established the village of La Luz in the Tularosa Valley. They moved due to the frequent floods on the Rio Grande (Schneider-Hector 1993: 42).

1862–64 Floods along the southern portion of the Rio Abajo caused shifts in the river channel and damaged acequia systems (Wozniak 1987).

1863 Continuing drought conditions forced the Navajos to raid Acoma to obtain agricultural produce (Ellis 1974: 456).

1860s early Rio Grande floods caused considerable damage to homes and farms in the Los Padillas area (Espinosa and Chavez n.d.: 159–160).

1860s early The continuing drought was a factor in causing major raids by nomadic groups on Pueblo, Hispano, and Anglo settlements in northern New Mexico (Ellis 1974: 287).

1863–64 A severe winter, followed by more drought the next spring and summer, was a contributing factor in the surrender of more than 8,000 Navajos by October of 1864. These prisoners were incarcerated at Fort Sumner on the Pecos (Bailey 1970: 60–61).

1863–65 Based on tree-ring evidence, these years were the second-driest 3-year period in the last 5 centuries (Fritts 1991: 134).

1864 (February) En route from Fort Whipple, Arizona, to Fort Wingate, a U.S. military contingent was caught in a storm that deposited 3 feet of snow. Men and their animals suffered, and the party was almost out of food when they reached Zuni, where they were given pinole and beans (Meketa 1986: 256–258).

1864 (October 29–31) A U.S. military contingent was caught in a blizzard at Raton Pass. Snow was waist deep, and most of the men suffered frozen feet and snow blindness (Meketa 1986: 56–57).

1864 This was an El Nino year (Quinn et al. 1987: 14451).

1864–65 (winter) The weather was abnormally severe, including heavy snowfall (Carter 1953: 64). Melt and runoff would result in major flooding (Yeo 1943: 13).

1865 (mid May-June 17) A major Rio Grande flood, due to runoff from the abnormally deep snowpack in southern Colorado and northern New Mexico, struck northern and central New Mexico. The Rio Grande Valley was inundated by a major flood, which caused the evacuation of communities from Atrisco to Sabinal. Crops and structures were severely damaged (Carter 1953: 64).

1865 (late spring) Late frosts killed the buds and flowers of fruit trees statewide. At about the same time, floods along the Rio Grande destroyed agricultural crops in Bernalillo County and forced most residents to move to higher ground above the valley. Settlements downstream to Mesilla suffered property and crop losses as well (Keleher 1982: 382–383; Simmons 1982: 195).

1865 (late spring) A major Rio Grande flood hit the Mesilla Valley hard where the village of Santo Tome was destroyed. The river channel shifted west, moving from the east side of Mesilla to its west side. The change in the river left Picacho on the opposite bank from other nearby valley settlements, causing a gradual abandonment of the village (Bowden 1971: 51–52; Wozniak 1987).

1865 (summer) Locusts and grasshoppers devoured the fields of wheat, corn, and beans in Taos, Rio Arriba, Mora, and San Miguel counties. Next, grasshoppers and corn worms wiped out surviving crops from Paraje to Albuquerque and west to Fort Wingate. Finally, more floods along the Rio Grande, bolstered by high water from the Rio Puerco-of-the-East, caused major damage from Sabinal to Las Cruces and Mesilla. Flooding below Albuquerque nearly completely inundated villages from Atrisco to Los Lunas. No vegetables, grain, or fruit were harvested that summer and fall, and the Pueblos were asked to donate food stores to other communities (Bancroft 1889: 739; Keleher 1982: 382–383; Simmons 1982: 195).

1865 Rio Grande floodwaters destroyed the grain crop along the valley south of Rincon (Miller 1989: 95).

1865–66 Flood refugees from Refugio de los Amoles joined other settlers to form the new village of "Old" Chamberino north of El Paso (Bowden 1971: 28).

1865–67 Fort Bliss structures at El Paso were being threatened by the Rio Grande, so two wing dams were built to divert the threatening current. Floodwaters in late May and early June swept away more than half the newly constructed quarters and all of the storehouses and corrals. In March 1868 this site was abandoned (Miller 1989: 217–218).

1865–70 Precipitation was above normal in northern and central New Mexico (Bradley 1976: 17).

1866 (January 18) A territorial statute providing for the right to move an irrigation ditch destroyed by rain or runoff was passed. Construction of a new ditch was allowed if the damaged one was impossible to rebuild and if most of those who would furnish the labor so consented. The mayordomo was authorized to relocate the acequia and given the authority to cross any land by securing the consent of the owner (Clark 1987: 26).

1866 James F. Meline (1966: 151) noted that the Santa Fe River had "a wide pebbly bed, showing capacity for frequent mountain torrents," and "in ordinary seasons its waters are lost in the granite sands, some five miles below town."

1866 San Marcial was "wiped out" by a Rio Grande flood (Pearce 1965: 146).

1866–69 (winters) Military post herds were fed hay and corn fodder, but some died nevertheless from exposure to cold temperatures and snow (Miller 1989: 201).

1866–90 Partly due to flooding of the original or Spanish section of Lemitar, Anglos established businesses and homes on higher ground (Scurlock 1982a: 12).

1867 (summer) The flooding Rio Grande destroyed houses at Los Lentes, Pueblitos, Bosque de Belen, Sabinal, and the Mesilla Valley (Miller 1989: 100).

1868 (July 5–11) Some 7,000 Navajos, returning to their homeland from Bosque Redondo, were delayed 7 days by high water on the Rio Grande at the Barelas crossing (Simmons 1982: 194).

1868 (August 6) Two male individuals, one an Indian servant, were killed by the same lightning bolt at Tome (Baca and Baca 1994: 40).

1868 (summer) The rich placer gravels at Elizabethtown could not be worked over this entire mining season due to scarcity of water (Pearson 1986: 7).

1868 A flood on the Rio Grande washed away the church and cemetery at Corrales; residents subsequently built a new church on higher ground, about one-half mile west of the old church (Armstrong 1988: 60–63).

1868 Tree-ring data indicate that this was a very wet year (Ellis 1974: 235).

1868–71 (winters) Freezing temperatures and water shortages at Elizabethtown mines halted mining operations (Murphy 1969: 56).

1869 Pools of water, which reportedly originated from early 19th century flooding, were still standing in the Tome area. Father Luis Benavidez, substituting for Father Ralliere, called it the "City of Stagnant Pools" (Ellis and Baca 1957: 25).

1869–70 (winter) Wine froze in the chalice in a church at Las Vegas (Ayer 1965: 263).

1869–70? La Constancia, the southernmost settlement on the Tome land grant, consisted of a group of farms located near the old ferry crossing on the Rio Grande. A bridge was later built here, but it soon washed out due to the low river banks. Even later it was replaced by the Highway 60 bridge, just beyond the southern boundaries of the grant (Ellis 1955: 104).

1860s Flooding of rivers hindered freighting of army supplies (Miller 1989: 311).

1860s Based on tree-ring data, temperatures were generally above average (Fritts 1991: 191).

1870 (May 30-October 1) A sleet and snow storm, followed by three nights of hard frost, killed all Navajo crops except wheat and peas. Most of the fields were replanted, but drought later adversely affected the harvest. A loss of about two-thirds of the normal harvest resulted (Brugge 1980: 57–58).

1870 fall Railroad surveyor William A. Bell traveled down the Rio Grande from Albuquerque noting that most of the cottonwood bosque was periodically removed by floods. Agricultural fields, he observed, all suffered damage during these floods (Bell 1965: 241–242).

1870 (fall-winter) The Jicarilla were unsuccessful in their hunting on the Southern Plains, and were dependent on government rations. With the arrival of cold weather, some Apaches died (Tiller 1992: 71, 73).

1870–75 (falls) Poor roads prevented contractors from delivery of hay at Fort Union and Santa Fe. Rain and early snows made some roads virtually impassable or "spoiled" hay before delivery (Miller 1989: 101).

1870 (to about 1900) During this period there was a higher frequency of intense storm events and fewer light rains. This, coupled with intense grazing and lack of light rains which infiltrate the surface soil and favor perennial grass growth, may have reduced vegetation cover. This may have resulted in increased surface erosion by wind and water to produce deflation and arroyo cutting (Grover and Musick n.d.: 8).

1871 (May-June) The Middle Rio Grande was high from 4 to 6 weeks of this period, and four people drowned. Little property damage apparently occurred (Carter 1953: 44).

1871 (August-September) Heavy rains destroyed the garden crops at Fort Selden (Miller 1989: 44).

1871 Drought stunted native grass growth in southern New Mexico, and hay contractors had difficulty in delivering the full amount to forts Bayard, Stanton, Craig, Selden, and Wingate. The contractor at the latter post had to collect hay from a 50-plus miles distance (Miller 1989: 102).

1871 This was an El Nino year (Quinn et al. 1987: 14, 451).

1871–80 Based on tree-ring evidence, the region was warm and dry (Fritts 1991: 157).

1871 (to early 1900s) Drought conditions prevailed along the middle Rio Puerco. Periodic floods and overgrazing resulted in gullying and erosion. Flood damage was exacerbated by intense cutting of timber along the river. Ring muhly and "weeds" began to replace the native gramas and other good grazing grasses (Rittenhouse 1965: 79, 82–83).

1872 (late May-early June) Flooding on the Rio Grande caused by snowmelt runoff prevented some residents of the Middle Valley from voting on a statehood referendum (Larson 1968: 112). At Albuquerque the river covered most of the floodplain between its channel and the plaza (Beadle 1973: 490). The flood caused the Rio Grande to cut into the main Las Cruces acequia (Wozniak 1987).

1872 (June 26) Following a flood 3 weeks earlier, the flow in the Rio Puerco-of-the-East was noted to be falling. The river reportedly ran only 2 months of a given year, and the water "looked exactly like dirty milk and its temperature was about 70." The valley was about 2-miles wide; the channel of the river was "some twenty-five feet deep and not more than fifty wide at the top of the bank" (Beadle 1973: 493–494).

1872 (August 19) A flood on the Santa Fe River probably exceeded 1,000 cfs (U.S. Geological Survey 1994).

1873 (spring-summer) Low precipitation resulted in little native grass growth in the Santa Fe area and in serious crop losses. Contractors to the army had to haul hay to the community from 120 miles away. The drought must have ended because in late summer the military was purchasing hay by the cart and burro load in Santa Fe (Miller 1989: 100–101).

1873 Pueblo Indian agents reported crop failures due to drought (Bancroft 1889: 739–740).

1873 Based on tree-ring evidence, the dry weather that began about 30 years earlier was "somewhat ameliorated" by this year (Fritts 1991: 129).

1874 (January 7) Wine froze in a chalice on the altar of the Belen church (Ayer 1965: 263).

1874 (April 14) The Chama River was in flood and could not be crossed safely, nor could the Rio Grande at the confluence with the Chama (Carter 1953: 73).

1874 (May 21–29) The Middle Rio Grande flood was estimated to have a peak flow of 100,000 cfs. In places, the river shifted in its channel (Nanninga 1982: 99).

1874 (May-June) A major flood of the Rio Grande from Alameda to Socorro caused widespread damage and resulted in the river flowing through an old channel east of Albuquerque's Old and New towns (Carter 1953: 9–10; Kelley 1969: 17).

1874 (mid July) A flash flood along the Galisteo Arroyo washed away a buckboard, mule, and driver. A road bridge in the area also was damaged (Carter 1953: 10).

1874 (summer) A major flood of the Rio Grande resulted in overflow waters moving into an old channel to the east of Alameda and Albuquerque, making the latter community an island for several days. Damage to buildings, crops, and other property was severe (Simmons 1982: 208).

1874 Another (?) flood on the Rio Grande washed away the church and cemetery at Corrales (Armstrong 1988: 63; Eisenstadt 1980: 13).

1874 A large flood on the Rio Grande sent the river out of its channel, causing extensive damage in El Paso and smaller communities to the north (Sonnichsen 1968: 196, 382).

1874 Pueblo Indian agents reported a good crop harvest (Bancroft 1889: 739–740).

1874–1950 Sixteen floods damaged farmlands and crops, destroyed villages, and threatened Albuquerque's North and South valleys (Fergusson 1951: 356).

1876 (January 13) An act was passed establishing a five-member board of commissioners, who were responsible for taxing residents who lived within 5 miles of the Rio Grande, to raise money for flood prevention (Clark 1987: 31).

1876 The U.S. Army built a pontoon bridge at or near the site of the present Central Avenue bridge in Albuquerque. By 1878 the bridge had been washed away by floods (Simmons 1982: 204).

1877 (summer) Rainfall was below normal (Baisan 1994: 3).

1877 An army physician reported that many individuals suffering from pulmonary diseases came from the "Missouri frontier" for the "salubrious" New Mexico climate (McParlin 1878: 323).

1877–78 This was an El Nino year (Quinn et al. 1987: 14451).

1877–78 (winter) Heavy snowfalls were estimated to have caused the loss of more than 20 percent of the region's sheep (Gordon et al. 1974: 72).

1877–83 Precipitation was below normal, and the Pueblos suffered crop losses (Bancroft 1889: 740; Denevan 1967: 701; Ellis 1974: 235).

1877–1917 Based on tree-ring evidence, precipitation generally increased (Fritts 1991: 157).

1878 (winter) A severe blizzard drove pronghorns from the San Pedro Mountains area westward to near San Felipe Pueblo. Hunters from the village killed most of them and feasted on the meat for many days (Batchen 1972: 66).

1878 The village of Placitas in Dona Ana County was founded on the Rio Grande but was soon moved to a mesa above the river because of flood waters (Johansen 1948: 53–54).

1878 There were many destructive floods in the territory (Bancroft 1889: 768).

1879 (February to July 1880) A territory-wide drought caused sheep losses from 25 to 50 percent (Gordon et al. 1974: 98). The Rio Grande was dry below Isleta during this first year (Carter 1953: 262).

1879 (summer) Rainfall was below normal (Baisan 1994: 3).

1879 A drought resulted in crop failures and the loss of many sheep for the Navajo, who increased their raids on Zuni and Hispanic livestock (Ellis 1974: 494).

1879 The drought caused some hay contractors to fail in meeting their requirements to provide hay for the army (Miller 1989: 103).

1879 The Rio Grande below San Felipe was dry for 1 or 2 months (Lange and Riley 1970: 14).

1879 Forest fire frequency was above normal (Swetnam and Betancourt 1990: 1019).

1879–96 Reportedly, the "destruction of timber both by fire and sawmill men, the snows melt earlier in the spring and run off more quickly, and so the flood comes sooner and does not last as long as formerly" (Follett 1898: 92).

1880 (early) To prevent flooding, the new Santa Fe rail line north of Albuquerque was located about 2 miles east of the Rio Grande at the edge of the floodplain, removed from the old channels and other low-lying areas that were inundated by floodwaters (Oppenheimer 1962: 33).

1880 (summer) Navajo crops were threatened by drought in early summer. About a month later, heavy rains damaged their fields. Some fields were entirely washed away (Brugge 1980: 92).

1880 (summer) Rains almost washed out the rear wall of the adobe church at San Juan. To prevent that from happening again, some Pueblo residents "built it up with ox-horns" (Kessell 1980: 92).

1880 A major flood occurred along the Rio Puerco (U.S. Geological Survey 1994).

1880 There was a severe drought in the territory (Bancroft 1889: 768).

1880 Lack of adequate water rendered mining at the New Placers District unprofitable (Northrop 1959: 27).

1880–81 (winter) The weather was "severe," and there was deep snow (Nims 1980: 114). Heavy livestock losses were experienced by Navajos due to the severity of the weather (Brugge 1980: 92).

1880–85 (summers) The flow of the Rio Grande was reduced severely by irrigation (Baxter 1885: 687).

1880 (to late 1930s) Albuquerque experienced a considerable number of floods, and most buildings were set up to 5 feet above street level. A semipermanent lake bordered the town on the north and south. It was drained by the Middle Rio Grande Conservancy District (Oppenheimer 1962: 36).

1881 (March 18-July) Heavy snow, sleet, and cold temperatures that lasted for several days killed a minimum of 10,000 Navajo sheep. This was followed by summer drought, wind, and worms, and then heavy rains destroyed some fields (Brugge 1980: 94).

1881 (August 4) Levees to channel the river away from the pueblo of Santo Domingo during flood stages were in place (Kessell 1980: 130–131).

1881 (summer) Heavy rains at Jemez Pueblo caused the roof of the church to collapse (Kessell 1980: 183).

1881–82 (winter) Precipitation had been adequate, and temperatures were mild. Cattle herds increased, and ranchers profited (Gordon et al. 1974: 93–94).

1881–82 A bridge over the Rio Grande was constructed west of Albuquerque at the site of a former pontoon bridge. The flood of May 1891 washed away this bridge (Simmons 1982: 278).

1882 (pre) The west side of Santo Domingo Pueblo had been destroyed by Rio Grande floods. New houses were being built on the east side of the village. Two dikes had been built to keep out floodwaters (Lange and Riley 1966:

98). The bridge at Cochiti had previously been destroyed by a flood on the Rio Grande, and the bridge at Santo Domingo was also damaged. A pueblo ruin in the east part of Bernalillo also had been destroyed by a Rio Grande flood (Lange and Riley 1966: 316, 248).

1882 (July 13) The Santa Fe River, carrying high water, flooded part of the valley across the Rio Grande from Cochiti (Lange and Riley 1966: 39).

1882 The Rio Grande was cutting into Cochiti Pueblo farmlands along the east bank of the Rio Grande. One resident commented that "it would be much better if the River would eat the pueblo than to have it eat up its lands. The pueblo would soon be built elsewhere" (Lange 1959: 37).

1882 A. Bandelier recorded a group of penitentes at the Cochiti Pueblo church playing musical instruments, chanting, and singing in a performance believed to make clouds form to produce rain (Lange 1959: 24).

1882 Below-average precipitation was recorded for New Mexico (Denevan 1967: 701; Follett 1898: 3).

1882–83 (winter) This was the coldest such season during the mining boom at Kingston (Weigle and White 1988: 324).

1882–83 Livestock losses were high due to severe weather in northwest New Mexico (Brugge 1980: 104).

1880s (early) A flock of sheep owned by Don Jose Leandro Perea were killed by a blizzard while grazing between Placitas and Bernalillo. He sent word to local residents by runners that they could have the frozen meat of the dead sheep if they would bring him the pelts (Batchen 1972: 69).

1883 (June) A drought struck the Santa Fe-Espanola area (Chappell 1969: 15).

1883 A drought impacted the overstocked cattle and sheep (Gordon et al. 1974: 94).

1883 A drought in the Acoma area caused the Pueblos to suffer (Minge 1976: 71).

1884 Overgrazed ranges in the Albuquerque area experienced a severe drought. Too many cattle had glutted the market, and 1882 prices of $6.40 per hundred weight dropped to $1.00 in 1887 (Oppenheimer 1962: 31).

1884 (winter-spring) Snows were heavy and continued through April, producing good summer grass and crops (Brugge 1980: 115).

1884 (April or May) The Rio Grande at Del Norte flooded; residents of the valley reported that it was the largest flood they had experienced (Follett 1898: 90).

1884 (May-June) A Rio Grande flood occurred from Cochiti to San Marcial, drowning several people, destroying buildings, and damaging farm fields extensively. An above-normal snowpack in the San Juan Mountains in Colorado was the cause (Carter 1953: 16–21, 117; Simmons 1982: 298–299).

1884 (June) The Rio Grande cut through the acequia at Los Lentes and into the old riverbed east of Los Pinos and Peralta for about 2 years. This old bed was first cut in 1828 by a flood of the Rio Grande (U.S. Court of Private Land Claims 1899: 24–26). This flood, about 100,000 cfs, damaged virtually every village from Albuquerque south to El Paso; several people were killed. Damage to agricultural fields was extensive as well (Carter 1953: 16–21, 117). The Rio Grande flood left standing water up to 5 feet deep from Los Pinos to Tome (Taylor 1989: 4). The Tome church was destroyed in the flood. Valencia was totally abandoned (Carter 1953: 117; Kight 1981: n.p.). C. Aragon "drowned behind El Cerro" near Tome during the flood (Baca and Baca 1994: 75).

1884 (late June) As the flood was subsiding, the Rio Grande was observed to be encroaching "upon its western bank" south of Alamillo but cutting eastward above the settlement (Lange and Riley 1970: 331–332).

1884 (June 30) Bandelier found the "lower parts of Socorro" inundated by floodwaters, and he described the area between Lemitar and Alamillo as "the main washout-currents and counter-currents are rushing back and forth, under and around the track [railroad]" (Lange and Riley 1970: 331).

1884 (July 2) Bandelier wrote "At San Felipe the water had risen but little, but at Santo Domingo it reached the foot of the bluff on which the western tiers of houses stand. It looks rather threatening" (Kessell 1980: 131).

1884 (July 2) Continued flooding had caused extensive damage in the Rio Abajo and had interrupted work and social activities. Alameda, Bernalillo, and other communities were seriously flooded (Lange and Riley 1970: 332).

1884 When the Rio Grande shifted its course west between Los Lentes and Los Lunas during the flood, the river cut the acequia madre and left it on the east side of the river. Three other ditches "moved" from west of the river to the east side (Wozniak 1987). Portions of the Valencia church were destroyed. Father Ralliere ordered members to move the santos and church furnishings at Tome to a safer location. Two feet of water damaged the walls of the nave, which subsequently had to be rebuilt (Kessell 1980: 151–152). The flood "destroyed the channels behind the Cerro [to the north] and made a marsh of 22 feet deep" (Ellis and Baca 1957: 24).

1884 This was an El Nino year (Quinn et al. 1987: 14451).

1884–85 (both springs) The flooding Rio Grande destroyed homes and fields at Chamberino in Dona Ana County. Afterward, dikes were built around the village (Want 1964: 175).

1884–85 Floods washed out the railbed and bridges along the uncompleted section of the Denver and Rio Grande Chili Line. Also, ties along the route were rotting (Chappell 1969: 15).

1885 (early spring) "Piling revetment and embankments were constructed at several locations between Isleta and Los Lunas" (Carter 1953: 46–47).

1885 (May 11) Above-normal runoff resulted from rain on the Sandia Bajada, east of Albuquerque (Carter 1953: 27).

1885 (June) Another flood, which was almost as severe as the one of the previous year, caused major damage in the Rio Abajo (Carter 1953: 187; Simmons 1982: 301).

1885 (July 19) Runoff from rains over the Tonque Arroyo watershed washed out a section of railroad track above Bernalillo, causing a train wreck. Two railroad employees were killed and three seriously injured. Four other rainstorms over the remainder of the summer caused flood damage in the Middle Valley (Carter 1953: 27–28).

1885 (winter) A heavy snowfall on Cumbres Pass prevented the passage of trains for 3 months (Barry and Bradley 1972: 295).

1885 The Rio Grande flooded at San Marcial (Follett 1898: 90).

1885 A drought, accompanied by high temperatures and hot winds, caused a crop failure in the Rincon area. Also, the Rio Grande had changed its course recently. These two factors forced some settlers to leave the area (Schlissal et al. 1989: 148–149).

1885 W.C. Bishop, a Texas cattleman who was representative of those responsible for the abusive land practices in West Texas in recent years, leased the 32,000-acre Vigil grant on the Pajarito Plateau and stocked it with over 3,000 cattle. This number was 10 times the estimated carrying capacity; deterioration of the range grasses began. The severe winter of 1886–87 wiped out most of Bishop's herd, forcing him to return to Texas (Rothman 1989: 200–202).

1885–86 (winter) Cattle ranchers experienced heavy losses during unseasonably cold temperatures and blizzards (Sonnichsen 1980: 20).

1885–86 Overstocking and drought left the range in poor condition. The winter was severe, followed by a hot, dry summer that killed cattle and produced poor grazing conditions. Ranchers were forced to sell their cattle at low prices (Gordon et al. 1974: 95).

1885–91 The first flood-protection levees, drainage ditches, and rip-rap were constructed along the river between Alameda and Albuquerque. A substantial dike with planted willows was constructed along the riverside to act as a breakwater. The dike was also seeded with grass (Simmons: 1982: 301–302).

1886 (winter) Snowfall in the Rio Grande Valley at Del Norte was above normal (Follett 1898: 90).

1886 (April 18–20) Wind and rainstorms hit central and northern New Mexico. The Santa Fe River flooded on April 20th, and at least one bridge washed out (Lange et al. 1975: 144, 445).

1886 (May) A flood washed out the Isleta railroad bridge across the Rio Grande (Carter 1953: 29–31).

1886 (June) High daily temperatures averaged 100º F at Rincon (Schlissal et al. 1989: 159).

1886 (June 3) A large portion of Santo Domingo Pueblo was destroyed in a Rio Grande flood (Poore 1894: 109; White 1935: 12). The colonial church at the village described by Dominguez and the mound on which it was located were swept away in this flood. Bodies were washed from the cemetery and were seen floating down the river (Adams and Chavez 1956: 131, 137).

1886 (summer) The early part of this period was dry, and Hispanos and Navajos clashed over water rights in northwest New Mexico. Mid-August rains reduced the tension (Brugge 1980: 122).

1886 (September 7) A severe thunderstorm struck Santa Fe, causing flooding of the Santa Fe River. High winds and hail accompanied the storm (Lange et al. 1975: 175).

1886 (September 12) The Rio Grande was in flood below Albuquerque, washing away or damaging a large number of houses between Belen and Socorro. At Belen, a hailstorm also inflicted damage on crops as well as homes. Fifteen houses washed away at Socorro. Portions of the railroad and bridges were also wiped out on the Rio Salado and Rio Puerco-of-the-East crossings (Carter 1953: 228).

1886 (September) The Rio Grande flooded San Marcial (Follett 1898: 90), and the village of Bowling Green on the Rio Grande, Sierra County, was destroyed by a flood (Carter 1953: 232–233).

1886 An even more devastating flood than those of the previous years struck Chamberina, inundating the entire Mesilla Valley. The railroad tracks were washed out, irrigation ditches and fields destroyed, cemetery washed out, and most houses destroyed. A long lake, which remained extant for a number of years, was formed (Want 1964: 175–177).

1886–87 (winter) Severe winter weather destroyed cattle and sheep herds on the Pajarito Plateau (Rothman 1989: 201).

1886–1901 Rio Grande floods in Dona Ana County were not as severe as those of the 1870s and 1880–85 (Johansen 1948: 55).

1887 (May 25–29) A rising Rio Grande caused erosion along about a mile of the east bank of the river at Barelas. A section of road was washed out, and three ranches were damaged (Carter 1953: 32).

1887–96 Exploitation of water resources were reexamined by the Federal Government during this drought period. Most homesteaders failed at dry farming, and ranchers suffered severe losses (Clark 1987: 58).

1887–88 (summers, winters) Severe droughts and cold winters with snow caused heavy losses of sheep in the Albuquerque area. Recent overgrazing and the dry conditions decimated the grasslands (Oppenheimer 1962: 30).

1888 (pre) The Rio Grande at El Paso went dry at intervals of about 10 years (Clark 1978: 73).

1888 (late April-early May) A rise in the level of the Rio Grande inundated part of Socorro. The high water was partially due to the above-average flow of the Chama (Carter 1953: 32–33).

1888 (summer) The Rio Grande at Socorro was dry due to upstream use (Hedke 1925: 26).

1888 (August) The depth of the Rio Grande at Las Cruces dropped from about 6 feet to a dry channel in a 2-week period (Schlissel et al. 1989: 160).

1888 (winter) A blizzard almost wiped out the large herds of pronghorns on the San Augustine Plain (Cleaveland 1941: 25).

1888 The U.S. Geological Survey established the Embudo streamflow gauging station, the first such facility in the country (Baker et al. 1973: 102).

1888 Stream flows, owing to droughts, had become more intermittent or reduced in volume in Bernalillo, Rio Arriba, and Sierra counties than in the preceding 2 decades. Flooding also increased, perhaps due to extensive clearcutting of upland forests and overgrazing of rangelands (Ensign 1888: 142, 145, 147).

1888 Recent droughts and blizzards caused the U.S. Congress to authorize surveys for irrigable lands and reservoir sites in the West by the U.S. Geological Survey (Wozniak 1987).

1888–98 The Rio Grande at El Paso was dry every year but two (Clark 1978: 73).

1889 (summer) The Rio Grande below Isleta dried up due to the drought and to a great increase in irrigation activity in the San Luis Valley. This surge in water use was related to the arrival of the Denver and Rio Grande Railroad (Carter 1953: 262; Clark 1978: 89).

1889 Precipitation was below normal for the year in New Mexico (Denevan 1967: 701).

1889 (ca.) The flooding Rio Grande destroyed most of Isleta's fields below the village and on the west side of the river (Poore 1894: 113).

1889–92 A drought, combined with cattle grazing, "did irreparable damage to the grass cover" (Wilson 1975: 105).

1880s In an attempt to alleviate the flooding of Albuquerque, the Santa Fe Railroad built a drainage ditch parallel to their tracks. A canal was dug from the ditch through town to the Rio Grande to carry off floodwater (Oppenheimer 1962: 36).

1880s (late) Partly as a result of drought, blizzards, overgrazing, and other environmental factors, the cattle industry in New Mexico rapidly declined (Baydo 1970: 134).

1880s–1920s Railroad companies, doctors, and immigration officials promoted the climate as therapy for tuberculosis, asthma, and hay fever (Fox 1983: 218).

1890 Santo Domingo Pueblo was damaged by flooding, and residents would not plant their fields on the floodplain because of their concern of more high water (White 1935: 20–21).

1890 Some ranchers, responding to ongoing drought conditions, drilled more wells, used deep plowing, planted alfalfa, and constructed irrigation systems (Baydo 1970: 221–222).

1890–91 Drought and epidemics of smallpox and diphtheria struck Acoma, causing a decline in population (Minge 1976: 72).

1890–92 Precipitation was below normal the first year, and summer rains for the following 2 years were sparse (Brown 1983: 41).

1891 This was an El Nino year (Quinn et al. 1987: 14451).

1890–1935 The rangelands of northwestern New Mexico supported two types of climax vegetation: a pinyon-juniper / sagebrush or grassland association found on rougher sections and foothills and a "pure grassland" association found on open, rolling areas. Since that time, grazing, wood cutting, and periodic droughts have caused sagebrush to invade and increase in both plant communities and pinyon-juniper to decrease in overall extent. Three other invader species—walking stick cholla, rabbitbrush, and yucca—were totally absent or present in small numbers, whereas today they are common in some areas of the region (Gross 1973: 44–47)

1890–1935 The mean annual streamflow depletion between Otowi Bridge and San Marcial was estimated at 586,000 acre-feet. The mean annual depletion was estimated at 580,000 acre-feet (Thomas et al. 1963: D7-D8).

1891 (February) Deep snow on Navajo rangelands resulted in livestock losses (Brugge 1980: 149).

1891 (May) A major flood on the Rio Grande struck from Albuquerque to Valencia. The bridge at Albuquerque was destroyed. A newspaper reported on damage at Valencia"...about sixty houses were washed away. Not a house is left standing." The new bridge at Los Lunas washed away. South of Albuquerque the river was shifting eastward, and at Valencia the river cut a new channel through the abandoned homes of the community's south plaza (Carter 1953: 306, 315–316).

1891 (July 1) The U.S. Weather Bureau was established in the Department of Agriculture (Bradley 1976: 12).

1891 (July 15) After the flood destroyed the corn, wheat, and oats, Los Lunas farmers planted beans with anticipation of a bigger profit than they would have received on the first crops (Carter 1953: 331).

1891 (summer) The Rio Grande flow was above-average or average from Embudo to San Marcial (Follett 1898: 90).

1891 New earthen dikes to prevent flooding were constructed near Alameda (Carter 1953: 49).

1891–93 A severe drought in New Mexico caused the deaths of thousands of cattle (Humphrey 1987: 420; Mangum 1990: 63).

1891–1900 Based on tree-ring evidence, dry conditions existed (Fritts 1991: 157).

1892 (summer) Rainfall was below normal (Baisan 1994: 3).

1892 The Rio Grande at Los Lunas was dry (Hedke 1925: 26).

1892–93 (winter-spring) Four to 5 feet of snow covered Arroyo Hondo Canyon through May (Pearson 1986: 24–25).

1892–93 A severe drought and overgrazed ranges resulted in heavy livestock losses (Cooper 1960: 135).

1892–96 This was a dry period in the Middle Rio Grande Valley (Thomas et al. 1963: D4).

1892 (to early 1900s) Owing to the state's clean air and virtual perennial sunshine, many easterners with an assortment of respiratory ailments moved to New Mexico (Simmons 1982: 315).

1892–1904 The Southwest, including the Middle and Upper Rio Grande Basin, experienced a severe drought, the worst since the advent of scientific record keeping. The drought conditions resulted in an "embargo" being placed on new irrigation projects in the Upper Rio Grande Basin (Dortignac 1956: 33; Gatewood et al. 1964: B13; Thomas et al. 1963: D4, H16).

1890s (early) About three million acres of land, forfeited by the Atlantic and Pacific Railroad, could not be sold, in part, because of the scarcity of water due to drought (Westphall 1965: 92–93).

1890s (early) A drought began in the Rio Abajo that especially impacted the area from Mesilla to El Paso. Effects of the drought were experienced until 1904 (Wozniak 1987).

1893 (pre) Isleta Pueblo and the Spanish community of Valencia had attempted to "boom and dike" the Rio Grande, but a spring flood wiped out their work (Poore 1894: 113).

1893 Blowing sand along the Jemez River was causing problems, for example, filling irrigation ditches, for Santa Ana Pueblo. Pueblo ranches on the Rio Grande produced good and abundant corn crops, most of which were ground by hand over the winter (Poore 1894: 109).

1893–1904 Available surface water in the Middle Rio Grande Valley was low (Hedke 1925: 12).

1893–1938 The average annual precipitation for Albuquerque was 8.23 inches (Taft 1980: 1).

1893–1950 There were 23 days of 100º F or more recorded for Albuquerque (Liles 1994: 83).

1893–1978 (November, January) These were the driest 2 months in Albuquerque (Taft 1980: 14).

1893–94 Precipitation was below normal for New Mexico (Tuan et al. 1973: 58).

1893–1994 Albuquerque's average, annual precipitation was 8.46 inches (Liles 1994: 9–10).

1893–1994 Average annual snowfall at Albuquerque was 9.3 inches (Liles 1994: 42).

1893–1994 Five of the warmest 10 years for Albuquerque occurred after 1977 (Liles 1994: 53).

1893–1994 The average annual temperature for this period at Albuquerque was 55.9º F. The temperature at Albuquerque was at least 100° in 43 of these 102 years, for a 43 percent occurrence. For 1951–94 the occurrence was 188 times for this 44-year period, an average of 4.3 times a year (Liles 1994: 84).

1894 This was a dry year in Navajo country (Gregory 1916: 52).

1895 (January) The Territorial Legislative Assembly passed legislation enabling the publication of a Monthly Weather Review (Tuan et al. 1973: 12).

1895 (winter) Snowfall was below normal in the Zuni-Bluewater area (Follett 1898: 84).

1895 (July 30) Runoff from a thunderstorm in Blue Canyon, west of Socorro, flooded the town, causing severe property damage and loss of life. In the lower section of town the water reached a height of 4 feet (Conron 1980: 31).

1895 The period of open-range ranching in New Mexico ended, partly as a result of inclement weather and overgrazing due to overstocking (Baydo 1970: 224–228).

1895 A new church at Santo Domingo, to replace the old one that washed away in June 1886, was begun on high ground to the east of the pueblo (Kessell 1980: 133).

1895–96 (winter) Wine on the altar of the Isleta church froze (Ayer 1965: 263).

1895–1907 The Middle Rio Grande was dry during irrigation seasons (Hedke 1925: 34).

1895–1924 (September) Available irrigation water was below the annual demand of 50,000 acre-feet in the Middle Rio Grande Valley (Hedke 1924: 27–28).

1890s (mid) Another dam was built below the original one on the headwaters of the Santa Fe River. The reservoir provided adequate water for Santa Fe residents for the remaining years of the territorial period (Clark 1987: 33).

1896 (summer) A drought struck the Jicarilla Apache reservation (Tiller 1992: 130).

1896 (summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).

1896 The ongoing drought generated an embargo on new irrigation in the Upper Rio Grande Basin by the Territorial Engineer (Thomas 1963: H16).

1896 A flood carried away the gauge at the U.S. Geological Survey flow measurement station near San Marcial (Follansbee and Dean 1915: 141).

1896 This was a very dry year (Ellis 1974: 235).

1896 Older residents of Del Norte, Colorado, reported this to be the driest year in memory. The flow of the Rio Grande at Del Norte was the smallest remembered by local residents. There was a shortage of irrigation water along the Rio Chama Valley, but it did not diminish crop production. Residents of Pena Blanca reported the Rio Grande flow the lowest in memory (Follett 1898: 86, 91).

1896 Only a trace of snowfall was measured in Albuquerque during this year (Liles 1994: 41).

1896–1931 Twelve diversion works and ditches washed out in the Rio Puerco drainage. Eleven of these were built in 1872; the other was built some time prior to this date (Maes and Fisher 1937: 28).

1897 The Upper Rio Grande Basin received “an excessive snowfall before May,” and snow depth ranged “from 112 to 188 percent of normal” (Yeo 1943: 29).

1897 This was a wet year in the Middle Rio Grande Valley (Thomas et al. 1963: D4).

1897 A major Rio Grande flood washed out many of the vineyards around El Paso, ending the productive grape-based industry (Sonnichsen 1968: 384).

1897 The total annual flow at the Otowi Bridge gauging station far exceeded the norm (Crawford et al. 1993: 18).

1897 A drought struck the Durango (Colorado) and Chaco Canyon areas, and crops failed (Gillmor and Wetherill 1965: 47, 64).

1897–1907 The Rio Grande was dry every irrigation season at San Marcial (Hedke 1925: 30).

1898 (December-January 1899) Some 500 sheep out of 2,500 head froze to death in the upper Rio Puerco-of-the-East valley (Maes and Fisher 1937: 18).

1898–1904 This was a dry period in the Middle Rio Grande Valley (Thomas et al. 1963: D4).

1898–1905 The Rio Grande channel was aggrading, and the rising silt caused spring floods to get increasingly closer to New Town, Albuquerque (Balcomb 1980: 14).

1899 (summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).

1899 Legislation was passed that authorized towns of the “first class” to issue bonds for construction embankments, drainage ditches, and other facilities to prevent flood destruction of municipal property (Clark 1987: 31–32).

1899–1900 This was an El Nino year (Quinn et al. 1987: 14451).

1890s This was a dry period for the Tijeras Canyon area (Cordell 1980: 65).

1890s A prolonged drought damaged crops and rangeland in the El Paso area (Sonnichsen 1968: 382).

1890s	Following the big die-off of cattle due to drought, blizzards, and overgrazing, wolf populations increased as a result of having this surplus carrion to eat (Brown 1983: 42).
1890s–1904	Based on tree-ring data, this was the most severe drought of the 19th century (D'Arrigo and Jacoby 1991: 95, 97).
1800s	(late) Residents of Adelino, across and down the river from Tome, would take a santo of San Juan to the river to "look" at the dry sand in hopes he would bring rain (Ellis 1955: 106).
1800s	(late) Intense rains in the Old Town area created "mud puddles large enough to attract ducks and hopeful hunters" (Browne 1973: 116).
1800s	(late) A flood destroyed the ruins of a late prehistoric pueblo at Bernalillo (Lange and Riley 1966: 316).
1800s late	Livestock overgrazing on the mesa above Placitas (Sandoval County) denuded the vegetation, which contributed to flash floods. These runoffs eroded soil and created deep arroyos. Residents of Placitas were forced to resettle because of flooding and gullying (Johansen 1948: 54).
1800s	(late) When the Rio Grande was too high to wade across, boats were used to cross the river at Belen (Espinosa and Chavez n.d.: 175).
1900	(summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).
1900	(summer) Only 0.32 inches of precipitation were recorded in Albuquerque, the lowest record ever for this period (Liles 1994: 33).
1900	A flood of just under 16,000 cfs occurred on the lower Jemez River (U.S. Geological Survey 1994).
1900	(and 1904, 1906, 1909) Intense rain storms washed out the Bluewater Land and Development Company dam, but the Mormon colony persevered (Mangum 1990: 65).
1900–01	A drought in the El Paso area caused water shortages and changing agricultural practices, which put a large number of Mexican workers out of work (Sonnichsen 1968: 384).
1900–10	Many of the would-be dry farmers left the state, primarily due to drought (Clark 1987: 171).
1900–20	Thousands of health-seekers flocked to new spas, hospitals, and sanatoriums in New Mexico. Most of these individuals were suffering from tuberculosis. The state's "fresh" air, high altitude, and high incidence of sunshine were thought to be healing (Fox 1983: 218–219).
1901–04	A severe drought caused starvation among cattle herds in New Mexico (Branson 1985: 16).
1901–10	Based on tree-ring evidence, regional temperatures varied during the seasons but were generally cooler than the mean values for the rest of the century. Also, total precipitation for the decade was generally above 20th century decadal averages (Fritts 1991: 159).
1901–48	Business for the Gross-Blackwell Company fluctuated due to the undependable supply of their main commercial goods—pinyon nuts, Navajo wool, and cattle hides. Availability of these goods was due in part to climatic shifts (Kelly 1972: 184–185).
1902	(January 31-May 19) No measurable precipitation fell at Albuquerque (Liles 1994: 6).
1902	Floodwater broke through the Alameda dike and levees and threatened Albuquerque and satellite communities. A farmer alerted firemen, policemen, and volunteers in time to shore up the breaks, which precluded flooding in Albuquerque (Simmons 1982: 301–302).
1902	(June 30) The lowest flow ever at Embudo on the Rio Grande, 130 cfs, was recorded (Beal and Gold 1987: 99).
1902	(summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).
1902	This was a dry year, and coupled with overgrazing, it resulted in range disputes between Navajos, Hispanos, and Anglos in northwest New Mexico (Brugge 1980: 179).
1902–03	Severe drought conditions and receipt of limited water from the Rio Grande in northern Mexico caused residents and officials to complain to the International Boundary and Water Commission (Bullard and Wells 1992: 16).
1902–04	Floods along the Rio Grande in Dona Ana County forced the residents of Berino to move their village to higher ground (Johansen 1948: 55).
1903	(winter) Heavy snows and abnormally low temperatures caused suffering among the Navajos and large livestock losses (Brugge 1980: 192).
1903	(March 20-July 22) There was no flow in the Rio Grande streambed at San Marcial (Yeo 1943: 31).
1903	(late May-mid June) Rain occurred over lower elevations and snow in the higher elevations. Combined with melt runoff from the deep winter snow, two flood peaks occurred in the Middle Basin (Brugge 1980: 192–194; Sullivan 1924: 11–12; Yeo 1943: 29).
1903	(June 19) The Rio Grande peak flood flow was recorded at 16,200 cfs (Beal and Gold 1987: 99).
1903 June	(to August 1904) Less than one-half inch of precipitation fell on the Estancia Valley. Sheep and other livestock were seriously affected (Towne and Wentworth 1946: 252).

1903 (August 18) An intense rain fell on the arroyo system west of Socorro, and resulting runoff destroyed or damaged three bridges, the Magdalena road, and a number of houses (Yeo 1943: 31).

1903 A Rio Grande flood of 19,300 cfs broke through the dike at Alameda, flooding the valley and destroying the settlement (Sargeant 1987: 36). The chapel of La Natividad de Maria Santisima at Alameda was destroyed in the flood; a new church soon replaced the old structure (Steele 1983: 29).

1903 (September 22-January 9, 1904) This was the longest period of no precipitation ever recorded at Albuquerque (Taft 1980: 1).

1903 There was a drought in the Isleta Pueblo-Valencia-Tome area, and the Rio Grande was dry in March. After this time it only ran at intervals, then dried up again (Ellis and Baca 1957: 15).

1903–04 Precipitation during these 2 years was substantially below normal (Tuan et al. 1973: 57). This major drought caused losses in livestock (Simmons 1988: 12).

1904 (pre) Burros, or levees, were constructed in Chical, Bosque de los Pinos, Los Chavez, Valencia, La Constancia, and Tome to prevent flooding. The burro at Tome held when a flood struck (Ellis and Baca 1957: 17).

1904 (summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).

1904 (summer) During the continuing drought, Navajos had to travel long distances in search of grass for their sheep herds. Some were gone for 6 weeks (Gillmor and Wetherill 1965: 64).

1904 (August 15) Ofelio Tapia, probably from Tome, was killed by lightning while herding livestock on the San Agustin Plains (Baca and Baca 1994: 139).

1904 (September 26–30) Intense rainfall over all but the extreme western portion of New Mexico resulted in widespread flooding. The most extensive flood damage occurred on the eastern slopes and in the valleys of the Sangre de Cristo Mountains, especially at the confluence of the Mora and Sapello rivers. One newspaper reported "The whole track [Santa Fe Railroad] was lifted bodily out of the long, narrow, winding box canyon and hurled two miles further down on the Shoemaker Ranch." Loss of topsoil, loss of tree stands, and gullying were severe in this location as well. Natural revegetation of floodplains and slopes did not occur for several years. A flood destroyed a school building near Watrous. Eight people were drowned at Springer, eight at Watrous, and four at Chaperito (Barker 1953: 191–193; Church and Church 1974: 9; Perrigo 1982: 87–88).

1904 (September 29) A major flood also occurred along the northern Rio Grande. Streamflow of the Rio Chama probably exceeded 15,000 cfs (Beal and Gold 1987: 99; U.S. Geological Survey 1994).

1904 (September 29 or 30) A flood on the Santa Fe River probably exceeded 1,000 cfs (U.S. Geological Survey 1994).

1904 (September 29 and October 8) Heavy rains caused the Rio Grande to overflow at the Chical Farm just south of Isleta Pueblo and at Valencia, where 25 houses were inundated (Ellis and Baca 1957: 15).

1904 (September) A flash flood swept away the large bathhouse at Hot Springs, damaged homes, and destroyed the grandstand at the race track in Las Vegas (Perrigo 1982: 25, 45, 87–88).

1904 (September-October) Disastrous flooding struck at various locations around the New Mexico Territory. Many lives were lost, and rail lines were washed out, disrupting the shipment of livestock and goods (Grubbs 1961: 288; Workers of the Writers' Program 1940: 79).

1904 (October 11) A peak discharge of 50,000 cfs occurred on the Rio Puerco (Snead and Reynolds 1986: 57).

1904 (fall) A major flood along most of the Rio Grande destroyed almost all of the field crops, vineyards, and orchards (Murphy 1905: 149).

1904 (fall) Only four structures were left standing after the Corrales flood. The large house of Teofilo Perea, Sr. and the Fernando Armijo house were the only Corrales homes to survive the flood. Village residents fled to the sandhills west of the village, where they excavated dugouts or erected tents for housing. The Corrales bridge was washed away, and a new bridge was not built until 1912. The large amount of silt in the channel raised the streambed and water table in the agricultural fields along the river, creating marshy or swampy conditions (Eisenstadt 1980: 5–6, 13).

1904 (fall During the flood the village of Los Ranchos in Albuquerque's North Valley was destroyed, as were crops and livestock (Sargeant and Davis 1986: 105–106).

1904 The annual Rio Grande flow at the Otowi Bridge gauging station was considerably above average (Crawford et al. 1993: 18).

1904 Navajo crop production was severely reduced by the drought (Brugge 1980: 196).

1904 (post) Mining at Bland ended, primarily due to lack of adequate water (Pickens 1980: 13).

1904–05 (winter) Forty percent of the sheep in northern New Mexico died during this abnormally severe weather period (Grubbs 1961: 287–288; Workers of the Writer's Program 1940: 79).

1904–05 (winter-early spring) Snowfall on the Upper Rio Grande watershed was "very heavy," and temperatures were generally below normal. Rains were also exceptionally heavy. The average annual precipitation statewide exceeded 20 inches (Tuan et al. 1973: 57–59). Runoff records indicate that precipitation was above normal (Gatewood et al. 1964: B34).

1905 (May 20–23) A Rio Grande flood completely inundated Tome and washed out the Los Lunas-Valencia bridge. Water was more than 6 feet deep in the church, causing considerable damage. Water from the Rio Grande flood ran "along the highway, which became an arroyo impossible for travel." Celso Salazar was able to remain in his home owing to the dike he had built north of his residence. The Territorial Legislature passed an act creating the River Commission which had responsibility for flood control on the Rio Grande. Burros, or dikes, were built at Valencia and Tome. The flood broke through the burro at Tome, inundating some 25 houses. Residents of the village fled to the foothills, where some stayed for 47 days. A number of the refugees stayed at Ranchos and Cerro, near the base of Tome Hill. Some 7,600 persons in the area were made homeless by the flood (Ellis and Baca 1957: 17–19; Gallegos 1970: 69; Hodge et al. 1945: 258; Kessell 1980: 152; Sanchez 1989).

1905 (May 20-June 10) A flood of about 14,000 cfs occurred along the northern Rio Grande (Beal and Gold 1987: 99).

1905 A large flood on the Rio Grande destroyed many houses at Isleta, drowned three people, and led to the building of a bridge across the river (Parsons 1974: 208).

1905 The Rio Grande flood flow at Otowi was 19,500 cfs, while at San Marcial it was 29,000 cfs a few days later (Bureau of Agricultural Economics 1941: 22).

1905 The drought of the previous year and competition over water motivated some Navajos on the eastern part of the reservation to construct reservoirs (Brugge 1980: 199).

1905–20 This period of above-average precipitation resulted in good crops and grass in some areas but extensive soil erosion due to runoff on lands already impacted by overgrazing and logging. Topsoil losses were especially prevalent on areas such as the Pajarito Plateau (Rothman 1989: 205, 1992: 178).

1906 (early May to mid June) Intense, widespread rains in northern and central New Mexico caused moderate flooding from Lobatos to San Marcial. Peak flow at the former was 8,000 cfs and more than 10,000 cfs at the latter (Yeo 1943: 44).

1906 (August) The channel of the Rio Grande at the Alameda-Corrales ford was running full from recent rains (Schmedding 1974: 133–134).

1906 (November 2) Heavy rains caused the wreck of a train near Sevilleta south of Antonito. A number of passengers and train crew were injured (Chappell 1969: 33).

1906 The water treaty with Mexico was prompted by the recent drought. The water treaty between the United States and Mexico guaranteed that Mexico would receive 60,000 acre-feet of water from the Rio Grande to the head of the acequia madre in Juarez. In years of shortage both countries would receive an equal amount of the available water (Bullard and Wells 1992: 16). Also, planning to construct the Elephant Butte Reservoir was begun (Thomas et al. 1963: D–116).

1906–07 Precipitation was above normal for New Mexico (Tuan et al. 1973: 58).

1907 (December 10) A storm scattered a flock of yearling lambs at San Raphael, and about 150 were taken by coyotes (Bailey 1971: 320).

1907 A state law was passed providing for a territorial engineer, a water code, and a reconstituted board of water commissioners. Hydrographic surveys of the state were soon begun (Clark 1987: 118–123).

1907–08 A major drought caused losses in livestock (Simmons 1988: 12).

1907–10 Drought conditions prevailed in central New Mexico (Manthey 1977: 8).

1907–16 Based on tree-ring evidence, precipitation during this period was the second-highest amount since the beginning of the reconstructed record (Fritts 1991: 160).

1908 The Rio Grande was dry just below Cochiti Pueblo (Harrington 1916: 101).

1908–17 Based on tree-ring evidence, the 10-year average temperature was lower during this period "than at any other 10-year period since 1602" (Fritts 1991: 160).

1909 (May) A Rio Grande flood swept away a long sandbar island near Isleta Pueblo, drowning most of a sheep flock and stranding several herders. About half of the three-quarter-mile-long island was washed away (Yeo 1943: 50).

1909 (spring-early summer) A drought caused Navajos to plant only about half of the fields normally cultivated. Also, overgrazing and droughts were causing Navajos to "move frequently" in search of adequate grass and water by this year (Brugge 1980: 226, 229).

1909 Homestead farmers located north of Gran Quivira had poor crop harvests (Huntington 1914: 86).

1909 A major rainstorm destroyed the church at Nambe Pueblo, a structure built in about 1729 (Speirs 1979: 318).

1909–10 Precipitation was below normal, and about 90 percent of the *Gutierrezia* and other plants of the "mesa formation" died. In June of the following year, the summer rains began, and the surviving plants were "thrifty" and showed "abundant bloom" (Watson 1912: 202–203).

1910 (summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).

1910 Drought and repeated crop failures drove out 50–75% of the homesteaders in the Estancia Valley (Tainter and Levine 1987: 128–129).

1910 Precipitation was below normal for New Mexico (Tuan et al. 1973: 57–58).

1910 The least annual rainfall ever recorded for New Mexico, only 1 inch, occurred at Hermanas (Taft 1980: 13).

1910 Hispanics in northern New Mexico generally reported that the weather was becoming increasingly drier in each succeeding year (Hewett et al. 1913: 48).

1910–12 An abnormally high number of fires occurred (Swetnam and Betancourt 1990: 1018).

1910–19 This was the coldest decade between the 1890s and the 1980s at Albuquerque (Liles 1994: 53).

1911 (May 8-June 2) A Rio Grande flood from Otowi Bridge to San Marcial occurred. Its flow peaked at 10,800 cfs at Buckman and 15,270 at San Marcial (Yeo 1943: 50–51).

1911 (late July-early August) There was no rain in the Tome area, and the Rio Grande was almost dry (Ellis and Baca 1957: 271–272).

1911 (August 18) It had not rained in a month, and the Rio Grande was dry at Tome (Ellis and Baca 1957: 271–272).

1911 (October 4 or 5) A flood on the Chama River was greater than the floods of September 1904 or May 1920 (U.S. Geological Survey 1994). It caused property damage as far downstream as Albuquerque (McDonald 1985: 122).

1911 (October 4–11) Intense rains caused a major flood along the Rio Grande from Del Norte, Colorado, to San Marcial. Flows peaked at 14,000 cfs at Del Norte, and the flood near Buckman caused "considerable change" in the river (Follansbee and Dean 1915: 120; Yeo 1943: 51–52).

1911 (October 7 to 14) Rains produced peak flows on the Rio Grande, from San Marcial to El Paso, at 9,000–11,000 plus cfs. Damage was widespread (Yeo 1943: 51).

1911 Following the flood that damaged San Marcial, the State Engineer's Office constructed a levee to protect the community (Calkins 1937: 7).

1911 Good crops were produced statewide owing to above-normal precipitation (Pynch 1911: 148; Tuan et al. 1973: 53, 58).

1911 A flood on Santa Clara Creek washed away Pueblo houses, drowned livestock, and buried fields under deep layers of gravel (Ellis 1978: 60–61).

1911 The average annual flow of the Rio Grande at the Otowi bridge gauging station exceeded the high flows of 1897, 1904, and 1905 (Crawford et al. 1993: 18).

1911–12 (winter) The highest snowfall ever recorded for this season, 483 inches, occurred at the Anchor Mine near Taos (Burdett et al. 1990: 10).

1911 (post) Personnel from the State Engineer's Office constructed a levee to protect San Marcial from floods (Calkins 1937: 7–8).

1912 A Rio Grande flood flow peaked at 29,000 cfs at Otowi (Bureau of Agricultural Economics 1941: 22).

1912 The irrigation dam on the Rio Puerco at Cabezon washed out (Maes and Fisher 1937: 24).

1912 A soil survey in 1912 indicated that the water table in the Middle Rio Grande Valley stood at 6 inches to 6 feet, with an average of 23 inches. This waterlogging was due, in part, to long-term irrigation and a rising water table (Clark 1987: 205).

1912 This was the coldest year ever recorded in Albuquerque; the annual mean temperature was 51.6º F (Liles 1994: 52).

1913 (summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).

1913 A Rio Grande flood destroyed the Rincon post office (Patton 1993: 8A).

1913 Good range conditions, owing to above-normal precipitation, were a factor in Navajo acquisition of better breeding sheep, goats, cattle, and stallions (Brugge 1980: 292).

1913–42 The average annual runoff of the Rio Chama at Chamita was 483,300 cfs (Pillow and DeVancy 1947: 5).

1914–15 (winter) Severe weather killed 30 percent of the ewes in the Espanola area. Sheep raisers in the Jemez Mountains area suffered heavy losses also (Grubbs 1961: 274–285, 287–288).

1915 This was an El Nino year (Betancourt et al. 1993: 46).

1915–16 (winter) Heavy snow interrupted many activities in northern New Mexico. High-elevation mountain settlements were virtually isolated (Pearson 1986: 124).

1915–18 Drought and overgrazing in the lowlands brought intensive grazing to higher mountain elevations and put increasing numbers of livestock in grizzly bear habitat. Predation on cattle and sheep by the bears resulted (Brown 1985: 131).

1916 (March) The Rio Grande was "running full" at Las Cruces (Henderson 1983: 67).

1916 (spring-summer) Dry conditions prevailed, especially north of Chaco, so most Navajo herds were grazed to the south, where grass was relatively good. Water, however, was lacking (Brugge 1980: 298).

1916–19 Two droughts and a severe winter during this period caused major losses in New Mexico livestock. The most severe dry period was in 1917–18, followed by a hard winter (Mortensen 1983: 12).

1917 (summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).

1917 Only 3.29 inches of precipitation were recorded in Albuquerque, the driest year on record (Liles 1994: 2; Thorn et al. 1993: 16).

1917–18 (April) A number of New Mexico ranchers moved their cattle out of state because of the drought (Hagy 1951: 29).

1917–18 During the drought, which was causing hardship for the livestock industry, the governor committed to support leasing of public lands for grazing (Clark 1987: 147).

1917–18 The demand for beef during World War I caused cattle prices to soar, and in response ranchers increased the grazing pressure on their rangelands. Grasses were decimated, exposing large areas to water and wind erosion (Sanchez 1992: 2).

1918 (summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).

1918 Runoff from a rain storm ran down Central Avenue, washing out the railroad tracks (Oppenheimer 1962: 41).

1918 (fall and winter) New Mexico experienced the coldest winter for the past 25 years. Temperatures at Gallup dropped to –30° F. This severe cold period, combined with the Spanish influenza of October and November, made this one of the hardest periods in the history of New Mexico (Melzer 1982: 221).

1918 During this drought year mesquite died, and the prickly pear cactus, used as emergency food for cattle, was depleted (Cabeza de Baca 1954: 175).

1918 Annual precipitation was below normal for New Mexico (Tuan et al. 1973: 58).

1918–19 (fall-winter) A severe cold period struck the Pajarito Plateau-Jemez Mountains area. Snows covered the winter ranges beginning in October and extending into April. An estimated 10 percent of the cattle herds were lost; many were saved by feeding them hay (Church and Church 1974: 12). Frank Bond experienced severe losses of sheep in the area due to the inclement weather (Scurlock 1981a: 144).

1918 (to early 1920s) Post World War I recession and several years of drought resulted in hard times for dry farmers and livestock raisers, leading to bank failures across New Mexico (Kelly 1972: 144).

1918–33 There were no days of 100° F or more recorded for Albuquerque (Liles 1994: 83).

1919 (winter-spring) The preceding drought, severe cold, and deep snow resulted in the estimated death of 15,000 sheep in the Chaco area. Horses and cattle were also lost; hay prices soared to 50 cents a ton (Brugge 1980: 310–311).

1919 (summer) The snows of the previous winter and seasonal rains resulted in good crops for Navajos (Brugge 1980: 311).

1919 (summer) The Rio Grande at San Marcial was dry (Sullivan 1924: 11).

1919 This was one of the wettest years in central New Mexico during this century (Dahm and Moore 1994: 2).

1920 (spring) Cold weather, cutworms, and prairie dogs caused extensive damage to young crop plants on the eastern Navajo reservation. Fields had to be replanted once or twice (Brugge 1980: 312).

1920 (May 22) A maximum discharge of 9,000 cfs was measured on the Rio Chama below the later El Vado Dam (U.S. Geological Survey 1994).

1920 A flood on the Rio Grande was the greatest since at least 1884, and probably so until the 1941 flood. Discharge on May 23 at the Otowi Bridge, near San Ildefonso Pueblo, was 24,400 cfs. A flood on the Rio Grande destroyed the bridge at Espanola (Beal and Gold 1987: 125; Liles 1978: 7–1).

1920 The flood damaged parts of Albuquerque and the Valencia church (Kessell 1980: 152; Rodey and Burkholder 1927: 17). The nave and facade of the Tome church collapsed in the flood (Kessell 1980: 152). San Marcial was also damaged in the high water, and most residents were forced to leave the area. Waterlogging of field soils was a factor in this abandonment (Calkins 1937: 8, 13–17).

1920 Following the flood, the State Engineer's Office again had to do more levee work (Calkins 1937: 7–8).

1920–25 Dry conditions had an adverse impact on some cattle-raising operations (Hagy 1951: 29, 32–33). The cattle industry in present Valencia County was severely affected by overgrazing and drought conditions in the area (New Mexico Historical Records Survey 1940: 24).

1920–40 Droughts, especially the one in the 1930s, were a factor in the economic decline of the Las Vegas area. All of the nearby small communities lost population during this period, and Las Vegas gained only 800 persons (Perrigo 1982: 64–65).

1900s (early) A number of high-runoff years in the Upper Rio Grande Basin probably accelerated soil erosion on a deteriorating watershed (Crawford et al. 1993:24).

1921 (June 3) A flood on the Rio Grande peaked at 17,400 cfs at Buckman and 19,360 cfs at San Marcial (Rodey and Burkholder 1927: 16).

1921 Drought and high winds contributed to intense, widespread fires in the region (Baker et al. 1988: 110).

1921–25 Precipitation in the Albuquerque basin was 18 percent below normal (Kernodle et al. 1995: 16).

1921–19 Homesteaders settled an area west of La Madera, but droughts forced them to abandon their homesteads. The government subsequently bought this submarginal land area (Gjevre 1975: 28).

1922 (fall) Continuing drought conditions caused some ranchers to ship their cattle to Mexico for winter grazing (Hagy 1951: 32).

1922 A Hispanic homesteader's crop failed in the Sandia foothills due to lack of adequate precipitation (Davis 1986: 103).

1922 No rain was recorded for 11 months of this year in the Los Alamos area. Livestock had to be fed supplementally (Church and Church 1974: 12).

1922 A drought struck following overstocking during World War I, and little range grass was available for the cattle. The loss in the calf crop was severe. Many starving animals were moved to Mexico; other ranchers failed (Kelley 1988: 3–20; Mortensen 1983: 12).

1922 The Rio Grande at San Marcial was dry for 150 days of the year (Hedke 1925: 13).

1922 (May to winter 1923) Precipitation was light, and livestock suffered and crops were reduced. Overgrazing, including usurpation of Navajo rangeland by Anglos, was a factor in stock loss (Brugge 1980: 326).

1920s (early) The great depression started early in Las Vegas and was exacerbated by severe droughts in the area (Perrigo 1982: 62–63).

1900s (early) A number of high-runoff years in the Upper Rio Grande Basin probably accelerated soil erosion on a deteriorating watershed (Crawford et al. 1993: 24).

1923 The average annual flow of the Rio Chama was 364,000 acre-feet (Sullivan 1924: 9).

1923 Aldo Leopold hypothesized that the drought caused a scarcity of quail in New Mexico (Brown and Carmony 1995: 108, 111).

1923 (late summer to February 1924) Precipitation was above normal over much of the state (Mortensen 1983: 16).

1924 (summer) A violent hailstorm in the Lemitar-Socorro area destroyed structures, crops ready for harvest, and small livestock such as goats and sheep (Scurlock 1982a: 14).

1924 (September to July 1925) Dry conditions prevailed (Mortensen 1983: 16).

1924 In this drought year precipitation was just over 50 percent of the normal. Drought conditions led to some ranchers sending their starving herds to better rangeland in Mexico. When the precipitation pattern shifted to wetter years, the grass had been overgrazed and cut-up by livestock hooves (Calvin 1968: 25, 276).

1924 The Magdalena stock driveway was used for unlawful grazing of animals, causing grass shortage for legal herds using the 2- to 4-mile corridor (Mortensen 1983: 11).

1924–25 (winter) The snowpack was unusually deep on the Carson National Forest (Tucker 1992: 7).

1924–32 Density of black grama grass on New Mexico ranges increased until the drought in subsequent years reversed this process (Gatewood et al. 1964: B43).

1925 The condition of rangelands became acute by this year due to the drought and overgrazing. Ranchers joined U.S. forest rangers in rounding up thousands of wild horses on national forest lands. These were sold to reduction plants in El Paso and Gallup, where they were slaughtered and ground into fertilizer and pet food (Wyman 1945: 159–160).

1925 (fall-winter) A good pinyon nut crop and mild weather allowed Navajos to carry out extensive collecting in the Mount Taylor area. Nuts sold for 15 to 20 cents a pound (Brugge 1980: 354).

1925 (late) A pony truss bridge was constructed across the Rio Grande on Highway 74 so that San Juan Pueblos and others could reach their farmlands on the west side of the river during high water over the old ford (Rae et al. 1987: 40).

1925–26 Reduction of forage plants due to drought resulted in grizzly bear and black bear predation on livestock (Brown 1985: 150–152).

1925–1930s An extended drought, including high winds and dust clouds, struck east-central New Mexico. Many livestock ranchers suffered heavy losses, a factor in the cessation of sheep raising (Griego 1981: 66–67, 69).

1926 (August) A flood along the Galisteo drainage destroyed acequias at Colorado Plaza, Ortiz, Los Cerrillos, and Tejon (Cooperrider and Hendricks 1937: 15).

1925–26 This was an El Nino year for the New Mexico (Betancourt et al. 1993: 46; Molles and Dahm 1990: 71).

1926 Annual water loss due to evaporation in the Middle Rio Grande Valley was estimated at 500,000 acre-feet (Rodey and Burkholder 1927: 20).

1926 or 27 The San Luis irrigation ditch on the Puerco was destroyed by a flood (Widdison 1959: 276–277).

1926 (winter–1927) Owing to favorable weather, the regional winter wheat crop harvest for 1926 was 4,876,000 bushels. A drought the following year resulted in a decrease to 150,000 bushels (Roberts and Roberts 1986: 286–287).

1926–27 Severe flooding of the Lower Rio Grande was caused, in part, by removal of plant cover due to overgrazing (Ligon 1927: 42).

1927 Construction of Bluewater dam and reservoir, with a capacity of 46,000 acre-feet, was completed (Thomas et al. 1963: D12).

1928 (winter) Severe winter weather resulted in the loss of almost 50 percent of the Hispanic-owned sheep in northern New Mexico (Forrest 1989: 140). Almost one-half of the sheep in the Cuba-Cabezon-Casa Salazar area froze to death (Maes and Fisher 1937: 20).

1928 (March 13) Congress authorized the Secretary of the Interior to enter into a contract with the Middle Rio Grande Conservancy District for participation in its $10 million program of drainage, flood control, rehabilitation of irrigation systems and farmland, and general conservation (Strauss 1947: 133–134).

1928 (summer) This was a hot, dry period (Clark 1987: 228).

1928 Farmers in the Guadalupe area, Sandoval County, began to experience water shortages (Garcia 1992: 101).

1929 (August 12–13) Torrential rains on the Rio Puerco and Rio Salado watersheds and other Rio Grande tributaries around Socorro resulted in a major flood that impacted San Acacia, San Antonio, Val Verde, La Mesa, and San Marcial, where the peak flow reached 24,000 cfs. A flood of 30,600 cfs occurred near the mouth of the Rio Puerco. (Harper et al. 1943: 33–34; Heath 1983: 333; U.S. Geological Survey 1994).

1929 (August 12–13 to September 23–24) A flood on the Rio Grande caused widespread damage from Lemitar to San Marcial. The latter was virtually destroyed (Scurlock 1982: 13; Wozniak 1987). These floods deposited sediments on the Rio Grande floodplain that were several inches to more than 7 feet deep. The town of San Marcial "became partially buried with fine sand and a number of buildings collapsed. . . . The railroads, roads, ditches, and dikes were washed out or buried in many places" (Poulson and Fitzpatrick ca. 1930: 2–3).

1929 (August-September) The Middle Rio Grande floods were caused by intense rains on the main stem and tributary drainages (Nelson 1946: 16).

1929 (September 23) A flood on the Santa Fe River may have exceeded 1,500 cfs (U.S. Geological Survey 1994).

1929 (September 23) The greatest flood since about 1880 occurred on the Rio Puerco, near its mouth. The discharge was estimated at 35,000 to 37,700 cfs (Heath 1983: 333; U.S. Geological Survey 1994).

1929 (September) Heavy rains over the Upper and Middle Rio Grande watershed caused another major flood, which "originated largely on impoverished range lands" (Cooperrider and Hendricks 1937: 31). The flood damaged much of Bernalillo and destroyed the plaza. Ditches, known as des aguas, were dug to carry away the flood water (Bowen and Sacca

1971: 53; Olson 1976: 73). Inundation of parts of Bernalillo virtually destroyed all of the region's crops. San Marcial, San Acacia, and San Antonio were all but destroyed (Bowen and Sacca 1971: 53; Calkins 1937: 9–11; Harper et al. 1943: 34).

1929 (fall) A total of 5.61 inches of precipitation was recorded in Albuquerque, the most ever for this period (Liles 1994: 34).

1929 The Teofilo Perea house in Corrales, one of only two houses in the village to survive the 1904 flood, was destroyed in this flood (Eisenstadt 1980: 6).

1929 Students from the University of New Mexico helped erect earthen dikes in the north 2nd–4th streets and Candelaria-Griegos areas (Fish 1993, personal communication).

1929 The Santa Cruz dam was built on the Santa Cruz River; the reservoir had a capacity of 4,500 acre-feet (Gatewood et al. 1964: B45).

1929–30 Precipitation was above normal (Tuan et al. 1973: 58).

1929–30 Fourteen bridges along the Santa Fe Northwestern rail line between Bernalillo and the Canon de San Diego land grant washed out (Glover 1990: 26).

1929, 1931 Floods on the Rio Salado destroyed the Santa Rita ditch (Cooperrider and Hendricks 1937: 14–15).

1920s The community of Paraje was impacted by the Rio Grande, which has been cutting eastward since abandonment of the site. Many of the historic structures were destroyed (Boyd 1984: 4).

1920s The temperatures for this decade were below normal (Tuan et al. 1973: 72), and dry conditions generally prevailed (Rothman 1992: 179).

1920s The railway embankment without drain openings at Vado caused serious flooding of agricultural fields (Mock 1985: 10).

1920s (late) (to 1930) Runoff from torrential rains washed away irrigation dams on the Rio Puerco-of-the-East. This factor and the 1930s drought forced many residents of the valley to abandon their villages, farms, and ranches (Garcia 1992: 6, 84–85, 91).

1920s–50s (summers) Albuquerque and Santa Fe temperatures trended upward (Tuan et al. 1973: 76–77, 78).

1930 (pre) High spring winds caused problems of drifting sand and moisture loss in soils in central Socorro County (Poulson and Fitzpatrick ca. 1930: 4).

1930 (July) This was the wettest July ever scientifically recorded for New Mexico (Tuan et al. 1973: 145).

1930–35 Homesteaders in western Socorro county, discovering that the climate was too dry and cold for the growing of sufficient crops, turned to other ways of making a living. They picked pinyon nuts and hunted pronghorns, deer, and rabbits; trapped coyotes, bobcats, badgers, and skunks; and captured wild horses (Kelley 1988: 3–23).

1930–37 Waterlogging caused by repeated floods and a rising water table related to an aggrading Rio Grande resulted in the abandonment of some 60 percent of the farmland in the San Marcial area (Calkins 1937: 13–18).

1931 (April) A hailstorm near Pietown forced the plane carrying a document from President Herbert Hoover to the Governor of New Mexico to make a forced landing (Speakman 1965: 36).

1931 (September) Heavy rains caused a flood on the upper Rio Puerco drainage, which caused damage to roads and bridges in the Cuba Valley (Cooperrider and Hendricks 1937: 76).

1931–32 (winter) Heavy snows and cold temperatures caused loss of human life, as well as livestock, in the study region (Bennett 1932: 27; Rothman 1982: 179).

1931–60 The average annual precipitation at Sandia Crest and South Sandia Peak was 25 inches (Taft 1980: 20).

1932 (April-September) The Santa Fe Northern Railroad line, taking over the Cuba Extension Railway, was washed out by rains (Glover 1990: 56).

1932 The government bought 15,000 sheep for the Jicarilla Apache to replace their losses during the preceding severe winter (Brugge 1980: 430; Tiller 1983: 454).

1932 This was an El Nino year (Quinn et al. 1987: 14451).

1932–33 (winter) Unusually severe weather caused the death of almost 70 percent of the Jicarilla Apache sheep. This ended a 12-year period of economic prosperity derived from sheep raising on the reservation (Tiller 1983: 454).

1932–38 An extended drought spurred the comprehensive Rio Grande Joint Investigation and led to the Rio Grande Compact between Colorado, New Mexico, and Texas (Thomas 1963: H16). The drought, coupled with overgrazing on the Acoma reservation, resulted in the loss of livestock (Minge 1976: 90).

1933 (September) Rainfall increased on the Navajo reservation, and many roads were washed out (Brugge 1980: 425).

1933 (winter) A large number of Navajos who were collecting pinyon nuts on the Zuni Pueblo reservation were trapped by a severe snowstorm and had to be rescued (Castetter 1935: 40).

1933 During this relatively dry year the Ilfeld-Moulton Company of Albuquerque had to send 46,000 sheep to Durango, Mexico, when adjacent states, also suffering from the drought, would not allow them to be driven across their borders (Towne and Wentworth 1945: 253).

1933 or 34 The Rio Grande flooded the North Valley of Albuquerque, east to Rio Grande Boulevard (Sargeant and Davis 1986: 105).

1933–34 The drought and erosion at Abiquiu reduced the former livestock herds, which numbered in the thousands (Weigle 1975: 156).

1934 Under the Drought Relief Service Program the U.S. Government began buying cattle on overgrazed, drought-stricken rangelands (Limerick 1987: 88).

1934 El Vado dam and reservoir were built on the Rio Chama; capacity was 197,500 acre-feet (Gatewood et al. 1964: B45).

1934–35 (winter) This was a "wet" period in northwestern New Mexico (Brugge 1980: 434).

1934–35 There was little grass on the Tome grant for the cattle to graze during the drought. They were sold by local ranchers and farmers at $5 a head (Salazar 1995).

1934–37 Precipitation was below normal, which caused a severe drought in the study region (Tuan et al. 1973: 58).

1934–82 Peak flows of the Rio Puerco averaged 9,082 cfs, while those of the Rio Grande at Bernardo averaged 5,664 cfs (Crawford et al. 1993: 53).

1935 (August 21) Heavy rainfall on the headwaters of the Rio Puerco and Rio San Jose produced major flooding. A peak flow of 28,000 cfs was recorded on the Rio Puerco (Heath 1983: 333).

1935 During the extended drought, especially that of the Dust Bowl, the Soil Conservation Service was established by Congress to research soil erosion and promote soil rehabilitation (Udall 1963: 144).

1935 Trees on the mountain slopes around Truchas were dying as a result of the two previous dry years. At El Guache, on the Chama River, three seasonal cuttings of 3 tons per acre dropped to two cuttings with a decreased yield per acre. The grama-dominated grasslands in the Chama River Basin had been replaced by ring muhly grass, snakeweed, and rabbitbrush due to overgrazing. Topsoil was being lost to wind and water action, and arroyos were cutting into hillsides. Some residents reported that overgrazing caused a reduction in streamflow and an increase in heavy floods. Others reported that precipitation had been decreasing each year (Weigle 1975: 115, 136, 145, 159).

1935 The ongoing drought was a factor in the bringing of a suit against the state and the Middle Rio Grande District by water users in southern New Mexico for impairment of water rights below Elephant Butte Reservoir (Clark 1987: 218).

1935 Depredation on livestock by predators increased, due in part to the drought (Brown 1985: 157).

1935 By this year the U.S. Resettlement Administration had relocated 9,600 New Mexican settlers because of the Dust Bowl (Flores 1990: 153).

1935–36 As a result of the Dust Bowl, the newly formed Soil Conservation Service promoted contour planting and terracing. The agency also recommended that 5 million acres, or 78 percent of the total acreage under cultivation at the beginning of the drought, which were submarginal farmlands, should be revegetated in grass (Hurt 1979: 149).

1935 (post) Native grasses were cut for "hay" during wet years in northern New Mexico. The hay was stored for later use as feed during droughts or deep snows (Kelly 1972: 195).

1930s (mid) Due to overgrazing and the drought, Acoma Pueblo rangelands deteriorated, and severe erosion ensued. Supplemental feeding of livestock was initiated. Farmlands and crop production also declined, forcing residents to acquire some of their food from outside sources (Reynolds 1986: 282).

1936 (August 4) A general rainstorm over the Rio Puerco watershed produced a peak flow of 24,000 cfs (Heath 1983: 333).

1936 (August 5) A flow of 27,400 cfs was recorded for the Rio Grande at San Acacia (Beal and Gold 1988: 196).

1936 The Flood Control Act of 1936 declared that the Federal Government had responsibility to control floods on navigable rivers and runoff-caused erosion on smaller streams in cooperation with state and local governments. This act established for the first time an integrated flood-control policy and laid the groundwork for the greatest public works program ever undertaken by the U.S. Government (Buchanan 1988: 33; Clark 1987: 259–260).

1936 (to early 1937) The irrigation dam on the Rio Puerco washed out at San Luis, and the last of the old irrigation dams on the Rio Puerco washed out at Guadalupe. The river channel was widening and deepening relatively rapidly, and the silt load was "tremendous" (Maes and Fisher 1937: 7, 24).

1937 (January) Some 300 Navajos picking pinyon nuts in the Zuni Mountains were trapped by heavy snow. They were rescued by Bureau of Indian Affairs personnel (Brugge 1980: 447).

1937 (August 10) This was the latest date of 100º F recorded in a year at Albuquerque (Taft 1979: 3).

1937 (September 1–3) Flooding along the Middle Rio Grande Valley washed out levees in a number of locations (Happ 1944: 4). The flood broke through a levee below the San Marcial bridge and damaged the wagon bridge at the village. Farmlands were also damaged (Happ 1943: 1).

1937 Another major flood destroyed the last irrigation facilities at San Marcial (Calkins 1937: 18).

1938 The Rio Grande Compact was initiated, providing for the apportionment of water among three major divisions of the Rio Grande—the San Luis Valley, the upper and middle reaches of the river, and the lands served by Elephant Butte Reservoir in southern New Mexico and west Texas (Thomas 1963: H18).

1939 Runoff from a heavy rainfall on the Sandia Mountains rushed down arroyos on the bajada and into the North Valley from Alameda south to downtown Albuquerque. Pine trees were washed from the west side of the Sandias onto Edith and North 2nd in the Alameda area, and residents collected them for fuelwood (Sargeant and Davis 1986: 106–107).

1939 (to early 1940) A drought struck the Rio Grande Basin (Thomas et al. 1963: D4).

1930s (late) A levee system to help control floods was constructed throughout much of the Middle Rio Grande Conservancy District (Bullard and Wells 1992: 47).

1930s (late) El Vado dam was constructed on the Chama River as a flood control structure (Welsh 1987: 140).

1930s (late) Following the warm Dust Bowl conditions, temperatures were cool (Tuan et al. 1973: 72, 78).

1930s (late) (to 1941) The Work Projects Administration constructed small retention and diversion dams in rural New Mexico communities to prevent flooding (Welsh 1987: 110).

1940 (pre) An archeological village site above Zia Pueblo was severely damaged by floods of the Jemez River (White 1962: 19).

1940 (pre) Older residents of El Cerrito no longer grew wheat due to less annual precipitation than "in the past when rainfall was heavier...." (Leonard 1970: 60).

1940 (March 3) The heaviest, short-term New Mexico snow on record, 14 inches, fell on Santa Fe in 5 hours (Long 1975: 13–14).

1940 (August-May 1941) Heavy rains fell during this period, with 29 inches falling in Bernalillo during the 1941 period. This was the worst flood in the town since the late 1800s; the Sisters of Lorretto convent was destroyed. The valley from Cochiti Pueblo to Albuquerque was flooded (Olson 1976: 73, 90).

1940 (November) A period of abnormally heavy rain and snow began. This El Nino year ended in late October of 1941 (Quinn et al. 1987: 14451; Tuan et al. 1973: 143).

1940 (December-February 1941) Cool temperatures and about 200 percent above-normal precipitation occurred (Tuan et al. 1973: 144).

1940–41 (winter) Runoff from the heavy snowpack in the Jemez Mountains severely damaged the rail line in Guadalupe Canyon, logging truck roads, and bridges. The New Mexico Timber Company decided to abandon the rail line and to use trucks solely for hauling logs to their Bernalillo mill (Scurlock 1981a: 151).

1941 (spring) The weather was cold and windy, and dust storms occurred. Precipitation was about 1.55 inches above average (Tuan et al. 1973: 144).

1941 (spring) This was the wettest period ever recorded, 5.27 inches, for Albuquerque (Liles 1994: 32).

1941 (May) (early to late) The most severe flood since at least 1890 occurred on the Jemez River near Jemez Pueblo (U.S. Geological Survey 1994). The Guadalupe and Jemez rivers flooded and washed out 3 miles of track of the Santa Fe Northwestern Railroad. Several bridges were damaged as well (Myrick 1970: 176). The Rio Grande flood damaged bridges, dams, and phone lines in the Santa Ana-Bernalillo area. Pueblo refugees, who moved to schools during the flood, were struck by measles and pneumonia (Bayer et al. 1994: 241). The highest daily mean flow since late 1939, 5,980 cfs, occurred on the lower Rio Puerco (U.S. Geological Survey 1994). Due to the highest snowmelt runoff and spring rains ever recorded in recent history (Kelley 1969: 17; Tuan et al. 1973: 143–145), a Rio Grande flood inundated more than 50,000 acres of land in the Upper and Middle basins (Vlasich 1980: 34).

1941 (May) The greatest monthly rainfall (16.21 inches) ever recorded in New Mexico occurred at Portales (Taft 1980: 12).

1941 (June-July) Killing frosts were reported at many weather stations and other locations. July was the coolest ever recorded and included more frosts (Tuan et al. 1973: 145).

1941 (August) Crops such as potatoes and beans were damaged by frost in mountain basins (Tuan et al. 1973: 145).

1941 (September 20) A heavy rain on the Calabasillas Arroyo northwest of Albuquerque caused the deposition of 250 acre-feet of sand and other sediments, with a depth of up to 9 feet in the Rio Grande (Tuan 1966: 594).

1941 Part of the northeast wall of Valencia Church collapsed due to spring floods and summer rains. The north wall subsequently collapsed, and the structure was completely razed and rebuilt on a concrete foundation using the original floor plan (Taylor 1989: 29).

1941 The most precipitation ever recorded in New Mexico in a year fell; the statewide average was 28.24 inches. The most overcast days ever were also experienced (Tuan et al. 1973: 143). The largest amount of annual precipitation ever recorded, 62.45 inches, fell at White Tail, Otero County (Taft 1980: 12, 143).

1941 The fewest acres burned in the Southwest in recent history was probably due to the El Nino year (Swetnam and Betancourt 1990: 11).

1941 The annual runoff flow of the Rio Grande at the Otowi Bridge gauging station was the highest in this century (Crawford et al. 1993: 18).

1941–70 The average annual precipitation for Albuquerque was 7.77 inches (Taft 1980: 1).

1942 (April 17–25) The flow of the Rio Grande peaked at 19,600 cfs at Albuquerque as a result of heavy snows and rain on the upper watershed. Some flood conditions existed south to San Marcial until June 6. Runoff for the remainder of the year was above normal (Happ ca. 1942: 2–5). A maximum discharge of 21,000 cfs occurred on the Rio Grande floodway near Bernardo (U.S. Geological Survey 1994).

1942 The annual flow of the Rio Grande at the Otowi Bridge gauging station was the third largest in this century (Crawford et al. 1993: 18).

1942–43 (winter) Snowfall was below normal, which resulted in limited spring runoff and fire danger all summer (Welsh 1987: 87).

1942–46 Central New Mexico experienced a drought (Manthey 1977: 8).

1942 (late) (to 1948) Precipitation was below normal, and crops, cattle, and range plants suffered heavy losses (Gatewood et al. 1964: B43-B44; Tuan et al. 1973: 58).

1943 (May 24) The lowest mean flow since 1936, 0.0 cfs, on the lower Jemez River occurred (U.S. Geological Survey 1994).

1943 (summer) The weather was hot and dry, and grasshoppers damaged crops in the Los Alamos-San Ildefonso area (Church 1960: 124).

1943 (December 9) Wind speed reached 90 miles per hour at Albuquerque. The highest gusts ever recorded were measured at 124 mph in December 1987 (Liles 1994: 3; Taft 1980: 1).

1943 This was a La Nina year (Betancourt et al. 1993: 46).

1943–44 (winter) Temperatures plunged to as low as –28° F, and more than 5 feet of snow accumulated at Los Alamos (Welsh 1987: 87).

1943–56 This was the longest dry period in the last 100 years for New Mexico. Average annual precipitation was 8.98 inches, or 77 percent of the average (Tuan et al. 1973: 59).

1943–56 During this generally extended dry period, the San Luis Valley, and the Upper and Middle Rio Grande divisions, failed to deliver water to the Elephant Butte Reservoir, which was set forth in the Rio Grande Compact of 1938 (Thomas 1963: H18).

1944 Precipitation was below normal for much of the state (Mortensen 1983: 37; Tuan et al. 1973: 58).

1945 (winter-spring 1946) This was a dry period for the Los Alamos-San Ildefonso area (Church 1960: 132).

1945–48 Precipitation was below normal statewide (Mortensen 1983: 37; Tuan et al. 1973: 58).

1946 In New Mexico and across the Southwest, extreme dryness resulted in forest fires, lack of adequate grazing for livestock, and municipal and agricultural water shortages. As a result of drought, streams were drying up in the Sangre de Cristo Mountains and elsewhere, conditions that adversely affected wildlife. Deer were suffering from inadequate forage, trout were easy prey for predators, and many game birds probably did not nest the following year (Calvin 1948: xv-xvi).

1948 (January) Several snow storms left a relatively deep snowpack on the Pajarito Plateau. Night temperatures commonly fell to –15° F (Church 1960: 138).

1948 Congress passed the Flood Control Act of 1948, which authorized the Chamita Dam above Espanola, the Jemez Canyon Dam above Bernalillo, and other flood protection facilities in the Middle Rio Grande Valley (Welsh 1987: 114, 166).

1948–49 (summers) Santa Fe recorded substantially above-normal precipitation (Tuan et al. 1973: 54).

1949 Precipitation was just above normal for the region (Tuan et al. 1973: 58).

1940s Streams on the west side of the Sangre de Cristo Range carried twice as much water as they did in the 1980s. This higher runoff was due to slopes with little or no vegetation that could no longer "hold" some of the water (deBuys 1985: 229).

1950 (spring-summer) This was an abnormally dry period in the Jemez Mountains area (Church 1960: 144–145).

1950 (July 24) Runoff from a severe rain storm in the northeast heights of Albuquerque flooded 200 houses and caused $250,000 damage in the North 2nd–4th streets at the Menaul area (Kelley 1982: 20).

1950 Congress enacted the Rio Grande Floodway as part of the Middle Rio Grande Project. Private and state levees and dams were targeted for reconstruction from Velarde to Elephant Butte Reservoir (Welsh 1987: 166).

1950 This was a La Nina year (Betancourt et al. 1993: 46).

1950 Only a trace of snow was recorded for this year in Albuquerque, a record matched only in 1896 (Liles 1994: 41).

1950 (and 1953, 1954, 1956) These were four of the ten driest years in Albuquerque since 1892. The annual precipitation amounts were 4.10, 5.08, 4.51, and 4.06 respectively (Liles 1941: 9).

1950–51 The Public Service Co. of New Mexico acquired the Agua Pura Water Co. of Las Vegas and constructed a second large reservoir to be supplied with water from the Gallinas River, but the ensuing drought forced the company to drill four deep wells as backup during extended dry periods (Perrigo 1982: 191–192).

1950–52 To control flooding and sedimentation, the Jemez dam and reservoir were constructed above Bernalillo on the Jemez River (Welsh 1987: 117–118).

1950–55 The number of irrigated acres in the state decreased by 24 percent, while the number of irrigated acres from wells increased by 48 percent due to the ongoing drought (Gatewood et al. 1964: B–44).

1950–56 An extended drought, the most severe since the inception of scientific recording of weather data, impacted the region's agricultural and ranch industries (Manthey 1977: 8; Tuan et al. 1973: 58–60, 147–156). The drought severely affected the amount of available surface water, and the use of groundwater sources increased over normal usage (Thomas 1963: H–16).

1951 (February 1) The lowest temperature ever recorded, –50° F, occurred at Gavilon in Rio Arriba County (Burdett et al. 1990: 10; Tuan et al. 1973: 67).

1951 (July 24–25) A flash flood destroyed the San Luis irrigation dam on the Rio Puerco (Widdison 1959: 277).

1951 The Bureau of Reclamation and Corps of Engineers began to install the first of 100,000 jetties along the Middle Rio Grande Valley (Bullard and Wells 1992: 50).

1951 Water rationing went into effect in Santa Fe, and six wells were subsequently drilled to meet demand (Gatewood et al. 1964: B–44).

1951–55 The extended drought in northern New Mexico caused the premature sale of thousands of cattle by ranchers, which negatively affected the local economy. Fishing waters dried up, and residents had to significantly reduce water use (Perrigo 1982: 198).

1951–56 The drought and water demands by a growing population in the Middle Rio Grande Valley prevented the delivery of scheduled water to Elephant Butte Reservoir (Welsh 1987: 132). Most water users along the river were able to continue farming during the drought through development of groundwater sources. Many small subsistence farmers along tributary streams and narrow creek bottoms, however, were forced out of agriculture. Also, the drying of streams and reservoirs caused the loss of many fish (Gatewood et al. 1964: B–44; Thomas et al. 1963: D24).

1951–56 There was no pinyon nut crop due to the extended drought in the Cochiti Pueblo area (Lange 1959: 122, 145).

1952 (April) This was the windiest month ever recorded in Santa Fe, and the lilacs did not bloom until mid May. The high winds created dust storms over the town (Scott 1976: 62).

1952 (June) Runoff from the west face of the Sandia Mountains caused an estimated $348,000 flood damage to homes and businesses in Albuquerque (Welsh 1987: 167).

1952 (July) The Chama River at Abiquiu flooded, with the highest flow ever recorded (McDonald 1985: 122).

1950s (early) Precipitation was much below normal at Tijeras Canyon (Cordell 1980: 64–65).

1953 Senators Clinton P. Anderson and Francis Case of South Dakota sponsored legislation to encourage experimentation in rain making and created the Advisory Committee on Weather Control (Clark 1987: 414).

1953–56 A federal drought relief program was in operation in New Mexico. Cheap feed, extended government credit, and reduced freight rates on cattle and feed were the main elements of this program (Mortensen 1983: 37).

1954 The Flood Control Act included authorization of two diversion canals that would carry runoff from summer rain from the west slopes of the Sandia Mountains (Welsh 1987: 167).

1954 This was the warmest year recorded in Albuquerque since 1893, with a mean annual temperature of 59.5° F. The average annual temperature to 1994 was 55.9° F (Liles 1994: 52).

1955 This was a La Nina year (Betancourt et al. 1993: 46).

1956 (March) A combination of dry topsoil and high winds produced the most severe dust storms in the region since the 1930s (Tuan et al. 1973: 107).

1956 (March) This was the driest month ever recorded for Albuquerque (Tuan et al. 1973: 107).

1956 (spring-summer) Near the end of the 6-year drought the leaves of aspens in the Sangre de Cristos were stripped by Great Basin caterpillars. Reservoirs in the region were dry or low, and severe dust storms occurred (Powell 1976: 91, 102).

1956 (summer) Costilla, Santa Cruz, and El Vado reservoirs were all dry as a result of the drought (Gatewood et al. 1964: B45).

1956 This was the driest year in New Mexico since scientific records have been kept. It marked the climax of a long dry period that began about 1943 (Tuan et al. 1973: 107).

1956 This was the driest year ever recorded for Albuquerque. On March 15 and 17 temperatures were above normal when cold fronts passed through the area. Accompanying gusty winds produced severe dust storms. Wind speeds of 50 mph were reached over the city. At Sandia Crest gusts reached 100 mph (Tuan et al. 1973: 107, 109).

1956 As much as 60 percent of New Mexico's crops failed due to the drought (Gatewood et al. 1964: B–43).

1957 (March 22–25) The worst blizzard on record for the Albuquerque area was accompanied by snow drifts up to 10 feet high. Transportation was halted, and some area communities were isolated by the storm (Liles 1994: 3).

1957 (August 15) While the feast day dance (rain) at Zia Pueblo was underway, a heavy rain fell in mid afternoon (White 1962: 273).

1957 (October) Some 4 inches of precipitation fell on the San Luis experimental watershed on the Rio Puerco (Dortignac 1960: 49).

1957 Due in part to the extended drought, cattle prices were 57 percent less than the price per head had been 5 years earlier (Mortensen 1983: 37).

1957 The Santa Fe River flooded, causing property damage in Santa Fe (Welsh 1987: 208).

1957 (late) (to 1958) Following the preceding drought, precipitation was above normal (Tuan et al. 1973: 57).

1958 (December 29) The greatest 24-hour snowfall (30 inches) ever recorded in New Mexico occurred at the Sandia Crest (Burdett et al. 1990: 10; Taft 1980: 10).

1958 The levee-riverside drains in the Albuquerque area were reconstructed by the U.S. Army Corps of Engineers. Operation and maintenance of the system were transferred to the Middle Rio Grande Conservancy District (Bullard and Wells 1992: 47).

1958 The highest mean daily flow on the lower Jemez River since March 1936, 3,640 cfs, occurred (U.S. Geological Survey 1994).

1958 This was a wet year in New Mexico (Molles and Dahm 1990: 71).

1959 (December) The highest December snowfall ever in Albuquerque, 14.7 inches, was recorded (Liles 1994: 42).

1959 (late) (to 1960s) Precipitation was below normal in New Mexico (Tuan et al. 1974: 57).

1959 Construction on the Heron Dam was begun on the Chama River near Tierra Amarilla by the Corps of Engineers (Welsh 1987: 133–134).

1960 The Flood Control Act directed the U.S. Corps of Engineers to construct Galisteo Dam (Welsh 1987: 149).

1961 (December-February 1964) Some sunshine was recorded for every day during this period at Albuquerque (Tuan et al. 1973: 100).

1962 The Bureau of Reclamation was authorized by congressional act to construct the San Juan-Chama Transmountain Diversion Project. About 110,000 acre-feet of water would be diverted from the upper tributaries of the San Juan River, across the continental divide, and into the Rio Grande drainage (Bullard and Wells 1992: 20).

1963 (January 13) An unofficial low temperature (–57° F) for New Mexico was recorded near Gallup (Tuan et al. 1973: 67).

1963 (March 15) Winds on the Sandia Crest attained speeds of 80 mph, with gusts exceeding 100 mph (Tuan et al. 1973: 109).

1963 (August 10) Between 6 and 9 p.m., 2.5 inches of rain fell on Albuquerque, causing flood damages of $2 million (Tuan et al. 1973: 39).

1963 The Albuquerque Metropolitan Arroyo Flood Control Authority was created to study and alleviate the problem of urban flooding from unregulated, ephemeral tributaries of the Rio Grande (Bullard and Wells 1992: 22).

1963 Abiquiu Dam was completed on the Chama River (Welsh 1987: 134).

1965 The legislature declared that “the State of New Mexico claims the right to all moisture in the atmosphere which would fall so as to become a part of the natural streams or percolated water of New Mexico, for use in accordance with its laws” (Clark 1987: 373).

1967 (August 10) Widespread thunderstorms produced peak discharges of 7,610 cfs on the Rio Grande near Bernardo and 12,600 cfs on the Rio Puerco (Heath 1983: 334).

1968 Another flood along the river in Santa Fe washed away bridges and utility lines and flooded some local residences, causing $400,000 in damages in Santa Fe (Kutz 1989: 11; Welsh 1987: 208).

1971 (January 7) The lowest temperature ever recorded for Albuquerque, –17° F, occurred (Taft 1980: 9).

1971 This was a La Nina year (Crawford et al. 1993: 16; Fairchild-Parks et al. 1995).

1973 This was an El Nino year (Crawford et al. 1993: 16).

1973–94 There were 128 days when the temperature was 100° F or more in Albuquerque. From 1893 to 1972 the total number of days was only 83 (Liles 1994: 83).

1974 (June 28) The temperature reached 105° F in Albuquerque (Taft 1980: 13).

1975 This was a La Nina year (Crawford et al. 1993: 16).

1976 (October 8) This is the earliest fall freeze date ever recorded for Albuquerque (Taft 1980: 5).

1980 This was a dry year in the study region (Crawford et al. 1993: 16).

1980 Albuquerque recorded 90°+ F temperatures for a record 64 consecutive days and 100° F or higher for a record 9 consecutive days (Liles 1994: 1).

1982 This was an El Nino year (Crawford et al. 1993: 16).

1985 This was an El Nino year (Crawford et al. 1993: 16).

1987 This was an El Nino year (Crawford et al. 1993: 16).

1989 This was the eighth-driest year in Albuquerque (Liles 1994: 9).

1980s This was the hottest decade on record for Albuquerque (Liles 1994: 53).

1990–94 Average annual precipitation for Albuquerque was 10.82 inches, 2.36 inches above the 1892–1994 average (Liles 1994: 9).

1994 (June 27) The highest temperature ever experienced in Albuquerque, 107° F, was recorded (Liles 1994: 84).

CHAPTER 3

HUMAN SETTLEMENT PATTERNS, POPULATIONS, AND RESOURCE USE

This chapter presents an overview, in three main sections, of the ways in which each of the three major ecocultures of the area has adapted to the various ecosystems of the Middle Rio Grande Basin. These groups consist of the American Indians, Hispanos, and Anglo-Americans. Within the American Indian grouping, four specific groups—the Pueblo, Navajo, Apache, and Ute—are discussed in the context of their interactions with the environment (Fig. 15). The Hispanic population is discussed as a single group, although the population was actually composed of several groups, notably the Hispanos from Spain or Mexico, the genizaros (Hispanicized Indians from Plains and other regional groups), mestizos (Hispano-Indio "mix"), and mulatos (Hispano-Black "mix"). Their views and uses of the land and water were all very similar. Anglo-Americans could also be broken into groups, such as Mormon, but no such distinction is made here.

In general, as Euro-Americans arrived and their populations grew, and as their new technology was introduced, modification of the physical and biological environment increased over time. Since the late 19th century, the Anglo views, markedly different from the Native and Spanish American views, have been dominant and therefore most influential. This chapter not only documents the chronological evolution of these various environmental adaptations, but also offers a basis for understanding the impact, change, and resulting resource management strategies caused by these differing adaptations, which are addressed in Chapters 4, 5, and 6.

NATIVE AMERICAN SETTLEMENT, POPULATION, AND RESOURCE USE, 1400s–1960

Native American Environmental Views

The Pueblo, Navajo, and Apache groups in the region had developed traditional views toward the physical and biological world quite different from those of the Hispanos and Anglos, whose historical views were derived from western European experiences. Popovi Da, former governor of San Ildefonso Pueblo, commented on the Native American view of their place in the biological world:

> The Indian's vital, organic attitude towards man's place within the framework of other living creatures has an impact on his actions, thinking, reasoning, judgment, and his ideas of enjoyment, as well as his education and government (Hughes 1983: 9).

This philosophy permeated all aspects of traditional Pueblo life; ecology was not a separate attitude toward life but was interrelated with everything else in life.

Another perspective on Native Americans was given by Vecsey and Venables (1980: 23):

> To say that Indians existed in harmony with nature is a half-truth. Indians were both a part of nature and apart from nature in their own world view. They utilized the environment extensively, realized the differences between human and nonhuman persons, and felt guilt for their exploitation of nature's life-giving life. Indian environmental religions were means of idealizing and attempting to attain a goal of harmony with nature, for both participatory and manipulative reasons, but inherent in their religions was the understanding that they were not in fact at perfect harmony with nature.

To understand a group's view of the environment, one must examine their cultural elements, such as religion, government, music, and so forth. Perhaps religion is the best expression of Pueblo attitudes toward and use of environmental resources. Traditional Pueblo religion is a complex set of beliefs and practices that permeates every aspect of an individual's life. For the Pueblo the basic concern is maintaining a continual harmonious relationship with the physical and biological world, or universe, through ritual and ceremony. Another significant aspect of Pueblo religion is its explicit cosmological and philosophical system, sometimes called world view, lifeway, or life-road (Beck and Walters 1977: 9; Ortiz 1969: 4; Sando 1992: 30).

Symbols in Pueblo religion are frequent and significant. Kachinas include corn mothers, corn, mothers for life, plants, animals, foreign tribes, and a number of other symbols. Cardinal directions are associated with mountains, animals, and colors. The four sacred mountains mark the boundaries of center place, which the Pueblos found after emerging from the underworld. The center is the open community space within the village, where ritual dances

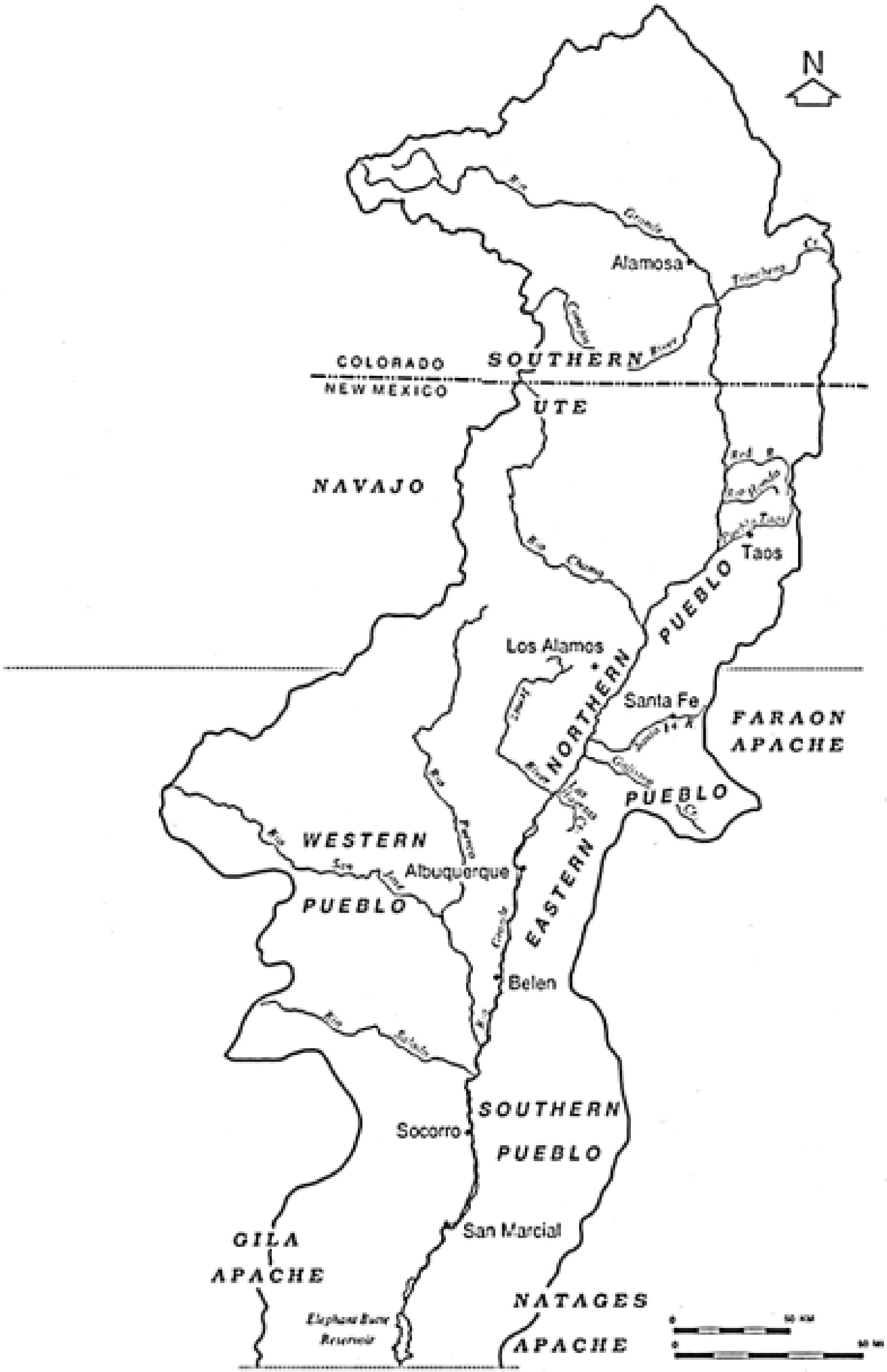

Figure 15—General locations of Pueblo and nomadic Native American groups 1598–1680.

and other communal activities take place. Around this space is another space, enclosed by the four mountains and the horizon, where sky and earth meet. This boundary is denoted by markers consisting of inconspicuous stones or groups of stones. Within this cosmos are other sacred places—hills, mesas, caves, lakes, springs, streams, and for some, refuse mounds. Spirits are believed to be residents on or in these natural features, and shrines are usually present at these locales (Ortiz 1969: 19–21; Swentzell 1985).

Unusual landscapes in the region, such as El Malpais in Cibola County, have long been used for religious activities by the Zuni, Acoma, and Laguna Pueblos, as well as the Ramah Navajo. Shrines are represented archeologically; all three Pueblo groups maintain shrines there today. Other traditional, religious uses of the area include pilgrimages, collecting materials for religious use, and collecting medicinal plants. The basaltic flow itself is considered to be the blood of a mythical giant killed by the Hero Twins (Holmes 1989: 21–22).

The conception of this universe also included a religious perception of the sky with its meteorological and astronomical phenomena such as clouds, lightning, and the solstices. Celestial bodies were named and perceived as anthropomorphic (Hewett and Dutton 1945: 22–29).

Traditional rituals and ceremonies include oratories, prayers, songs, dances, pilgrimages, sacrificial retreats, and other expressions, performed individually or communally. These may be quests for rains, bountiful crops, and game; perpetuation of "natural" and astronomical cycles; and other observances that occur during the annual, ritual calendar of events, or "cycle of works" (Sando 1992: 31–32).

Due to Spanish domination and influence, Pueblos have also been nominally Roman Catholic for almost 400 years. They maintain this religious duality through a process that has been called "compartmentalization." The two religions are each distinct socio-ceremonial systems, although there has been integration through sharing or relating to various components, some of which are sacred or "holy" water, religious objects (kachinas and santos), sacred structures (kivas and churches), sacred spaces, and religious leaders ("medicine" men and priests). Catholic elements that the Pueblos have generally accepted are Sunday worship, confirmation, baptism, weddings, and celebration of saints' days, Christmas, and Easter. Social dances in the churches and on the plazas dominate these latter three celebrations (Dozier 1983: 185–186; Sando 1992: 32–33, 169–170).

Pueblo Settlement Patterns and Land Use

The major, historic Pueblo villages along the Rio Grande and its tributaries generally had their beginnings in the early to mid 1300s (Fig. 16). Movement from smaller sites into larger sites where populations consolidated occurred after 1400 and before 1540. The largest villages contained 1,000 to 2,000 rooms, maximum sizes for prehistoric or historic pueblos. This growth appears to have been correlated with the increasing development of floodwater and irrigation farming on floodplains (Dozier 1983: 41, Stuart 1986: 89–90).

The historic Tewa, Tiwa, Keresan, and Piro pueblos were located along the banks of the Rio Grande or tributary drainages on slightly elevated land on floodplains or on terraces or points of land adjacent to them. Many of the pueblos, including those that have survived until today (Table 20), are located at confluences of the Rio Grande and perennial or semi-perennial tributaries. Proximity to water for domestic use and farming and proximity to fertile soils were clearly determinants in locating villages. As pueblos grew in size in the late prehistoric period and as competition for arable lands accelerated during the colonial period, agricultural production shifted to more distant fields, where male residents worked long days and stayed overnight in small one- or two-room dwellings, referred to as field houses, during the farming season (Stewart 1985: 92–96).

Prior to Spanish arrival in the study region, the abandonment of aboriginal villages and population movement to another more favorable environmental site or area was a relatively common adaptive strategy, particularly in marginal areas of limited environmental resources, particularly water or arable soils. Fluctuating climatic conditions, particularly drought, were a primary cause of abandonment (Fosberg 1979: 166–167; Kelley 1952: 382–385; Zubrow 1974: 25, 64). Abandonment was also caused, in part or in

Table 20—Siting of extant Rio Grande Basin pueblos.

Pueblo	Drainage	Elevation (feet)
Taos	Rio Pueblo de Taos	7,050
Picuris	Rio Penasco	8,400
San Juan	Confluence of Rio Grande and Chama River	5,800
Santa Clara	Rio Grande and Santa Clara Creek	5,600
San Ildefonso	Rio Grande and Pojoaque Creek	5,560
Tesuque	Rio Tesuque	6,800
Nambe	Nambe River and Pojoaque Creek	6,095
Pojoaque	Pojoaque Creek	5,845
Cochiti	Rio Grande and Santa Fe River	5,600
Santo Domingo	Rio Grande and Galisteo Creek	5,190
San Felipe	Rio Grande and Tonque Arroyo	5,700
Santa Ana	Rio Grande and north bank of Jemez River	5,340
Zia	Jemez River	5,450
Jemez	Jemez River	5,600
Sandia	Rio Grande and Sandia Wash	5,030
Isleta	Rio Grande and Hell Canyon Wash	4,880
Laguna	Rio San Jose and Encinal Creek	5,795
Acoma	(near) Acoma Creek	7,000

Source: Burdett et al. 1990: 33, 34, 44–46, 56–57; Stubbs 1950: 23–90

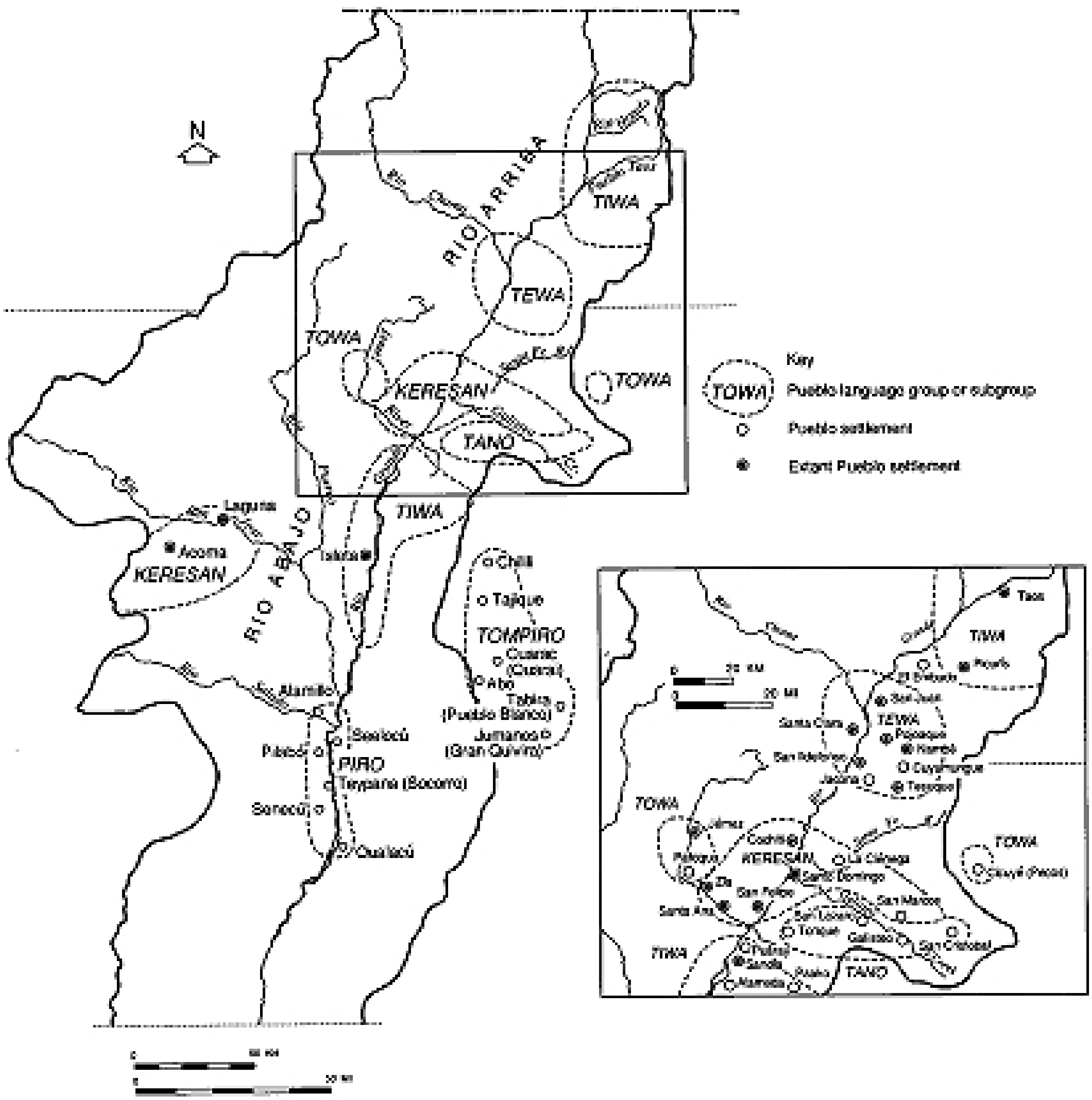

Figure 16—Major historic Pueblo language groups and villages, 1598–1680.

totality, by flooding, epidemic diseases, raids, warfare, and political and social pressures exerted by the Spanish (Schroeder 1968: 291, 303–304). During extended drought periods, the Pueblo would sometimes rely more heavily on hunting, gathering, and trade for subsistence (Upham 1984: 248–251). The length of the drought seems to have determined whether the abandonment was temporary or permanent. Earls (1985: 162) stated

> A drought three years or less does not appear to have caused the inhabitants to abandon their villages. A drought three years or more did cause some abandonment, usually temporary movement to other villages. Prolonged droughts of 5–10 years caused permanent abandonment.

Dobyns (1983: 310–11) and Palkovich (1985: 418) suggested the following as four major elements common to abandonment, migration, and survival strategy:

1. abandonment of settlements located in marginally productive environmental niches,
2. migration to environments that were more productive in terms of the basic subsistence technology of the peoples involved,
3. amalgamation of survivors of abandoned settlements into a diminished number of continuing or new ones, in an attempt to maintain a number of inhabitants culturally defined as proper by each group, and
4. amalgamation of survivors of diverse lineage and even ethnic origins into a diminished number of polities, resulting in
   a. intermarriages, further diluting and erasing earlier ethnic distinctions,
   b. adoption of locally determinant group languages, reducing linguistic diversity, and
   c. sometimes very rapid changes in many conventional understandings formerly shared for the purpose of adjusting to the survival demands of quickly altering man:land ratios, colonial manipulation or domination, and so forth.

The Pueblo and other Native Americans also employed relocation to higher, wetter (and cooler) sites as a survival strategy in extreme droughts. A change to colder temperature regimes would sometimes cause movement to lower, warmer locations. The movement of Pueblo peoples from the Pajarito Plateau to the lower canyons, such as Frijoles, or even the Rio Grande Valley, is one example. Contrastingly, during warmer-than-normal periods, groups sometimes moved to higher, cooler locations (Stuart 1985: 91–92).

The total number of occupied Pueblo villages at the beginning of the historic period may have been as high as 134. The maximum number of residents in each pueblo was 800–1,000. With Spanish invasion and occupation, this settlement system was disrupted, and a number of pueblos were abandoned. By the early 1600s, about half of these villages had been abandoned (Schroeder 1979: 254), and the remaining Pueblo settlements were restricted to four square leagues each (6.75 square miles) for farming and other resource uses. Some 90 missions were established in as many pueblos, and Pueblo men and boys were required to herd livestock, farm, and collect firewood for the missionaries. Civil authorities required them to work hides, collect pinyon nuts and salt, and weave blankets and garments (Dozier 1983: 46–49; Simmons 1979a: 181–183). As a rule, distant field houses and agricultural plots were ignored during the farming season.

In the Rio Arriba, Taos and Picuris, both northern Tiwa-speaking pueblos, have been occupied throughout the historic period. Apparently no other pueblos in this Tiwa area were occupied at the time of Spanish contact (Schroeder 1979: 251; Fig. 16).

Of 12 extant Tewa villages in the Upper Rio Grande Drainage around 1600, only eight remained occupied in 1630. Of this number, six have survived until today (Fig. 16): San Juan, Santa Clara, Pojoaque, Nambe, Tesuque, and San Ildefonso. Ten large upland Keres village sites were abandoned by 1630; seven Keres towns continued to be occupied: Cochiti, Santo Domingo, San Felipe, Santa Ana, Zia, Laguna (Fig. 17), and Acoma. Coronado recorded seven Tewa-speaking villages in the Jemez Mountains; only one, Jemez Pueblo, has survived until today. Among the Tiwas, five large pueblos were abandoned by 1650, while eight survived until 1680. The only two surviving Southern Tiwa villages are Sandia and Isleta (Fig. 16). In all, some 20 large floodplain villages were abandoned between 1540 and 1680 in the Rio Abajo (Dryeson 1971: 89–92; Schroeder 1979: 238–239, 242–247).

As noted, availability of adequate, proximate surface water was a primary determinant in siting of villages and farmlands, as evidenced by the 18 extant pueblos in the Middle and Upper basins (Table 20). This dependence on water for personal consumption, farming, and livestock raising is also documented by the archeological and archival records. For example, the Tano Pueblos lived in seven early historic villages located near springs and marshes along Galisteo Creek or its tributaries (Fig. 16). The Tano abandoned the area by the late 1600s, primarily due to drought and nomadic Indian raids (Schroeder 1979: 238–239, 247–248).

To the south, at the north end and on the east side of the Sandia Mountains, there was another small cluster of 7–10 pueblos. They, too, were located near springs or arroyos. These pueblos have been referred to as the "Ubates" (Schroeder 1979: 248–250).

Farther south, in the Salinas Province, there were up to 18 Tompiro pueblos recorded between 1581 and 1598

Figure 17—View northeast of Laguna Pueblo and landscape. Ben Wittick photo, ca.1883. Courtesy School of American Research and Museum of New Mexico, Santa Fe (negative no. 16051).

(Fig. 16). These were located in upland pinyon-juniper or juniper-grassland savannah, near springs or small ephemeral streams on the south and east sides of the Manzano Mountains. Some of the pueblos depended on wells for their domestic water supply. Here, more dependence was placed on rainfall, which was higher than that of the Rio Grande Valley. The saline lakes of the Estancia Valley lay to the east. During droughts, which brought Apache raids and famine, surface water was virtually nonexistent. By the 1660s only six pueblos were occupied, and within a decade only two remained. These last two were abandoned sometime before the Pueblo Revolt; refugees from all of the Tompiro villages joined with Piros along the Rio Grande (Schroeder 1979: 237, 239–241).

To the west, along the middle Rio Puerco and Rio San Jose, were the pueblos and fields of Laguna and Acoma. Along with Zuni Pueblo, farther to the west and outside the Middle Basin, these villages are referred to as the Western Pueblo. Laguna Pueblo (1699), as the name suggests, was also located near a small lake, now dry. Acoma was located on a mesa with springs at its base and potholes on top in which rain or snowmelt collected. A nearby creek also provided water. The Navajo also lived along the Puerco from the mid 1700s to mid 1800s, hunting and gathering and practicing limited farming. Utilization of springs and runoff water was the key to the successful raising of crops in the area (Schroeder 1979: 239, 245–246; Scurlock 1990a: 320).

Ten ancestral villages located across the Piro, or Southern, Pueblo region (Fig. 16) continued to be occupied in the 16th century, but nine other sites were abandoned and new villages established. Most of these pueblos were located on gravel benches and low alluvial banks adjacent to the river. Settlements placed away from the Rio Grande floodplain were situated on mesas, ridges, or in one instance, on an open alluvial flat at the mouth of a canyon. Village plans consisted of large plaza communities, which were common in the preceding century, or small pueblos of variable forms and 8–36 rooms, which have been called the "colonial style." Construction techniques included puddled-coursed adobe, cobble masonry, and rock-block masonry. At a few sites adobe blocks were set on a masonry base (Marshall and Walt 1984: 139–140).

With the establishment of four Spanish mission churches at Piro villages and four estancias, or large ranches, there was major impact on the Pueblo residents. In addition to experiencing a severe decline in population as indicated above, large portions of various ancestral villages were abandoned, and some groups moved to new sites. A relatively large number of Piro, about one-third of the total population, moved to three upland sites in the Magdalena area, perhaps as a strategy to remove themselves from the devastating European diseases along the Rio Grande and to afford stronger protection from raiding Apaches or Spaniards (Marshall and Walt 1984: 141).

Following the reconquest of the Pueblos by the Spanish in 1692–96, the new government forced the indigenous population into large villages rather than the smaller, dispersed settlement clusters prevalent in the pre-revolt period (A.D. 1540–1680). This may have been an important factor in the spreading of European diseases among the Pueblo. Near the end of the 1700s, the total population had declined to 9,453. This decrease continued throughout the next century, but at a lesser rate (Palkovich 1985: 403, 410–413).

In the early 1800s there were only 20 pueblos (not counting the satellite villages of Laguna) within the Rio Grande drainage. By the 1830s, this number had decreased to 18, the current number (Fig. 16). Agricultural and grazing lands were lost to Spanish-speaking squatters in the 1700s and 1800s, even though this practice was illegal. Only the highest of officials could authorize the sale of Indian lands. Local officials did, however, allow Hispanics to obtain holdings on Pueblo lands in some instances (Brayer 1939: 16–19). Most of this acreage, about 10 percent of Pueblo holdings, was choice, irrigable land (Simmons 1979b: 214–216).

The U.S. Surveyor-General approved the Pueblo land grants in 1852 and recommended congressional confirmation. Ten years after the signing of the Treaty of Guadalupe Hidalgo, Congress, in 1858, confirmed 35 land grants, totalling 700,000 acres, which had been made by the Spanish to the Pueblo. President Lincoln issued patents to the Pueblos for these grants. Subsequently, territorial officials considered these lands to be disposable property that could be purchased by non-Indians. Following litigation, the Supreme Court ruled in 1876 that the Pueblos had undisputed title to their lands and could dispose of them as they wished; they would not be protected by the Federal Government. This led to usurpation of some Indian land by dishonest non-Indians (Brayer 1939: 21; Sando 1992: 110, 112; Simmons 1979b: 214). Trespass also continued on Pueblo lands. Legislation in the late 19th and early 20th centuries established that the Pueblos were wards of the U.S. Government, which had a trusteeship relationship and jurisdiction over Pueblo land and water. As wards, the Pueblos could not alienate their lands without approval of the government. The government recognized that the Pueblo had "a communal title to their lands" (Sando 1992: 112–122).

Since the late 1700s, and especially after 1859, most of the Pueblos have significantly increased their land holdings (Table 21). Between 1877 and 1933, the Pueblos obtained new lands through acts of Congress, executive order, and community and individual initiative. Much of this land was overgrazed, depleted rangeland. By 1944 the Pueblos, exclusive of Zuni, owned just over 1,000,000 acres, of which 19,022 were agricultural, and the remainder were used for grazing. At Santa Ana, new farmlands were acquired to provide basic subsistence needs and trade surpluses (Aberle 1948: 11, 84; Dozier 1983: 109).

The Santa Fe Railroad acquired rights-of-way across Pueblo lands in the late 19th century (Fig. 18). Some of this land was good agricultural acreage, especially at Laguna. The railroad also employed hundreds of Pueblos, taking them away from traditional agricultural pursuits (Ortiz 1980: 111).

The influx of Anglo settlers in the late 1800s resulted in increased competition for water rights and arable land in the region. In the Winters v. United States case, the Supreme Court ruled that Indians "had prior and paramount rights to all of the water they needed in the present and future." And, "in times of shortage, Indian rights had to be honored before the claims of other users" (Bayer et al. 1994: 239). The loss of productive land in the Middle Valley due to waterlogging, high water tables, and salinization was also a problem. These pressures and hardships led to impoverishment and dependency for the subsistence farmers among the Pueblo and Hispano populations. The 1930s drought compounded their problems, and many were forced to leave or sell their farms and livestock and to find low-paying jobs as laborers away from the reservation or village. Some had to go out of state to find employment. For other Pueblos, crafts work supplemented, or eventually replaced, subsistence agriculture (Ortiz 1980: 109–111).

Navajo, Apache, Southern Ute Settlement Patterns and Land Use

In general, nomadic groups in the region—the Navajo, Apache, and Ute—selected campsites near surface water, fuelwood, and grass for their livestock, and in locations protected from adverse weather. Summer camps of the Apache or Navajo practicing agriculture were near plots of arable soils, and hunting and gathering camps were located near the specific resources sought (Jorgensen 1983: 687–688; Scurlock 1991a: 27).

In the historic colonial period, Navajos lived in the environment formerly occupied by Pueblo Indians from the

Table 21—Pueblo land/grazing holdings, 1858–1990.

Pueblo	Year	Acreage
Taos	1858	15,400
	1924	47,334
	1990[a]	95,341
Picuris	1858	14,959
	1939	15,359
	1990[a]	14,947
San Juan	1858	12,213
	1939	20,584
	1990[a]	12,236
Santa Clara	1858	12,224
	1905	45,742
	1990[a]	45,828
San Ildefonso	1858	15,413
	1929	19,844
	1990[a]	26,198
Pojoaque	1858	11,593
	1944	11,593
	1990[a]	11,601
Nambe	1858	12,560
	1902	18,788
	1990[a]	19,124
Tesuque	1858	16,706
	1937	17,024
	1990[a]	16,813
Cochiti	1858	22,763
	1938	26,491
	1990[a]	50,681
Santo Domingo	1858	65,571
	1905	66,231
	1990[a]	71,093
San Felipe	1858	30,285
	1902	43,201
	1942	51,211
	1990[a]	48,930
Santa Ana	1869	15,406
	1939	19,136
	1990[a]	61,931
Zia	1858	16,282
	1924	16,669
	1938	57,807
	1990[a]	121,600
Jemez	1858	17,314
	1942	40,368
	1990	89,624
Sandia	1858	22,884
	1990[a]	22,870
Isleta	1858	109,362
	1938	192,813
	1990[a]	211,103
Laguna	1884	99,970
	1942	244,733
	1990[a]	484,495
Acoma	1858	94,159
	1917	153,844
	1942	88,197
	1990[a]	211,103

[a] *Does not include leased or fee lands.*
Sources: Aberle 1948: 69–83; Sando 1992: 275

Middle and Upper Rio Grande basins, primarily along the upper and middle Puerco and Chama rivers (Fig. 15). Although this area had limited and erratic precipitation, it was diverse enough to afford a relatively wide range of exploitable resources. Temporary camp sites were established near reliable surface water sources and close to potentially good hunting, farming, and plant-collecting areas (Bailey 1980: 40; Jorgensen 1983: 687). These sites were generally located at the upper edge of Great Basin grasslands or in the zone above, the pinyon-juniper woodlands on terraces, hills, and mesas. Some of these sites were temporary encampments at pronghorn (antelope) capture and kill sites or plant gathering-processing areas. Temporary shelters were constructed of forked-sticks, vertical posts, or brush (Scurlock 1990a: 38).

Navajos were practicing corn horticulture when first contacted by the Spanish in the late 1500s; they probably were cultivating beans and squash as well. Fields were located on alluvial plains or valleys, washes, or near springs. Floodwater farming was practiced along streams and arroyos that carried seasonal runoff, which was diverted to the fields. Flats and mesa tops were sometimes cultivated using dry-farming techniques (Scurlock 1990a: 38–39; Fig. 19).

Hunting was the most important Navajo method of food procurement in the early colonial period. Seasonal communal hunts of pronghorn, deer, perhaps bison (to the east), and small game, such as rabbits, were conducted. Pronghorn were driven into chute-and-pound enclosures. Later, Navajo raids on Spanish and Pueblo settlements to

Figure 18—View to west showing Pueblo men and their wagons, Santa Fe rail line (center), Santo Domingo Pueblo, and Rio Grande (line of trees above pueblo). Photo by John K. Hillers, ca. 1880. Courtesy Museum of New Mexico (negative no. 4359).

acquire livestock or produce increased. During times of peace, trading for these and other items was practiced. Limited fishing may have provided meat as well (Scurlock 1990a: 38–39).

Some of the early droughts and Spanish raids (1709-late 1740s) may have forced some Navajos to take refuge on the wetter northern and eastern slopes of Turquoise Peak (Mt. Taylor) in the Cebolleta-San Mateo ranges before the mid 18th century. Also, between 1725 and 1745, Navajos were attracted to the springs and small lakes in the valley between the Cebolleta uplands and Chacra Mesa (Scurlock 1990a: 65, 67, 75, 77).

The most severe drought years were in the late 1740s, when the entire region experienced meager crop yields, poor forage for sheep herds, and decimated native plant and animal populations. These environmental hardships, combined with those brought about by the Ute-Comanche raids, forced the Navajos to completely abandon the San Juan and Chama River basins by the early 1750s and to scatter to the southwest and west (Scurlock 1990a: 67).

For most of their pre-reservation existence, the Apaches were engaged in a predominantly seminomadic hunting and gathering subsistence pattern over much of the region (Fig. 15). Movement was correlated with the seasonal availability of resources, especially edible plants, and extended from the higher mountain ranges (such as the Faraon Apache in the Sandia Mountains), where they lived from late spring to early fall, to lowland camp areas in the late fall and winter (Gunnerson 1974: 240; Thomas 1940: 7). This annual round, or “winter below” as it has been called, ended in the mid to late 19th century with their placement on reservations (Scurlock 1991a: 37). As with the Navajo, raiding became more important to the Apaches through time as a means of obtaining food, sheep, horses, and mules.

Nicolas de Lafora, in 1766, described this subsistence pattern for the “Gileno” Apaches in southwestern New Mexico and southeastern Arizona:

> . . . live separately and wander about subsisting by hunting and gathering mescal through the

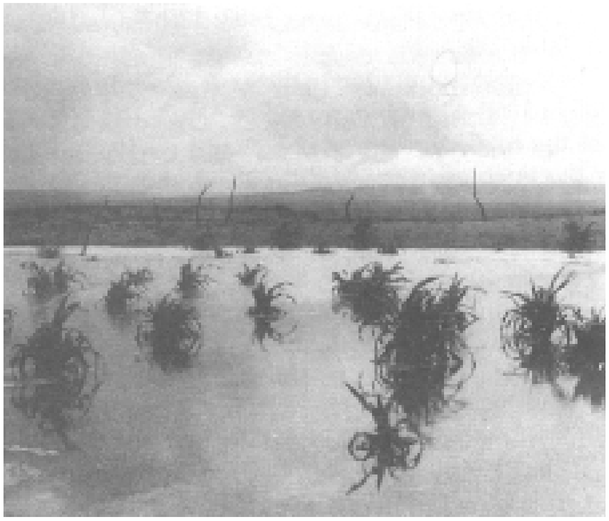

Figure 19—Pueblo floodwater corn field, Hopi, Arizona, ca. 1919. Photo by Wesley Bradfield, courtesy Museum of New Mexico, Santa Fe (negative no. 43289).

> sierras of El Hacha, La Boca, El Alamillo, San Policarpo, La Florida, El Tabaco, Corral de Piedras, El Quinteros, Santo Domingo, El Capulin, La Escondida, and the other intervening hills and rugged mountains. . . . All those Indians are in the neighborhood of the presidio of Janos, and their rancherias encircle it especially in winter when extreme cold forces them to abandon the sierras of El Cobre and Los Mimbres. There are also other Indians from the more northerly Gila. This group maintains a sort of capital in Los Mimbres mountains where their chief, Chafalote, stays with many families and horses as long as the season allows (Kinnaird 1967: 78–79).

The general region occupied by Ute and Southern Paiute Indians in the mid 1500s was referred to by the Spanish as Copala, the mythical home of the Aztecs. This same region, located west-northwest of the Middle and Upper basins, later became known as Teguayo. Onate, at San Gabriel-San Juan Pueblo, organized an expedition to explore this country, where he and other Spaniards thought they would find bountiful gold and silver. The expedition moved across western New Mexico and into central Arizona, where, not surprisingly, no such riches were found, but contacts were made with Indians, probably Utes or Paiutes, who said they were from Copala (Delaney 1974: 13–14; Milich 1966: 64–68, 114; Tyler 1954: 343).

Reference was made in a 1626 document to Capote Utes who had visited Jemez Pueblo a few years before the first Spanish colonists arrived at San Juan Pueblo in 1598. These Utes reportedly had reached the pueblo via the Chama River valley from their camps north of the San Juan River (Schroeder 1965: 54). Later in the historic period, the Capote, one of two bands of the Eastern Utes that ranged into the study region, lived in northern New Mexico, around later Chama and Tierra Amarilla, and southern Colorado, near the headwaters of the Rio Grande (Fig. 15). The other band, the Weeminuche, occupied the valleys of the San Juan River and its northern tributaries in northwestern New Mexico and adjacent southwestern Colorado into southeastern Utah (Delaney 1989: 6–7).

Before acquisition of the horse, Ute bands had been divided into smaller family units for much of the year so that they could more effectively procure food by hunting and gathering. Hunting and gathering would take place in the semiarid lower elevations of their territory in the spring, then move to the mountains in summer and early fall (Calloway et al. 1986: 336–337, 339; Delaney 1989: 7–8). From early spring to late fall the men would hunt deer, elk, pronghorn, and smaller mammals. The women would gather various edible grass seeds, wild fruit, and pinyon nuts. Occasionally they would cultivate corn, beans, and squash in high mountain valleys or meadows (Calloway et al. 1986: 343; Delaney 1974: 7–8).

Late in the fall, family units would begin to move out of the higher mountains into sheltered areas within the southern part of their territory for the winter months. This was a time for various social activities, culminating with the Bear Dance in early spring (Delaney 1989: 10–11).

The Utes probably obtained horses soon after 1670 from their encounters with the Spanish or from the Navajos or Apaches. This newly acquired mobility brought more changes for the Southern Utes. They were able to range farther (east) on communal buffalo hunts and trading expeditions, and raids could be executed with greater swiftness and efficiency. Individual bands apparently increased in size with this new ability to obtain subsistence resources (Delaney 1974: 11–12, 16; Roe 1955: 75; Schroeder 1965: 54).

Their new raiding capabilities also produced an increased frequency of attacks on northern Rio Grande communities, which apparently forced the Spanish to arrange a peace treaty with the Utes. This treaty seems to have been in effect until the Pueblo Revolt in 1680 (Schroeder 1965: 54).

Native American Populations and Disease

Fluctuations in Native American populations occurred due to birth rate, disease, famine, and warfare. Various infectious diseases, such as smallpox, were introduced early in the historic period by the Spaniards. Some researchers have suggested that this disease and perhaps others, such as whooping cough, measles, and chicken pox, were spread northward from Mexico through contact between regional Native American groups before first contact with Spaniards in 1540. With no immunity or effective treatment for these infectious maladies, native populations were dramatically impacted in the 17th and 18th centuries. During serious outbreaks of smallpox, such as those in 1719, 1733, 1738, 1747, 1749, 1780–81, and 1788–89, the mortality rate was as high as 50 percent of populations. As indicated previously, the forced concentration of Pueblo populations into large villages may have been a factor in this high percentage. In spite of the development and diffusion of a vaccine for this disease by the turn of the century, serious outbreaks occurred among the Pueblos in 1852, 1883, and 1898. The Navajo, various Apache groups, and the Southern Ute also experienced population declines during the historic period (Crosby 1973: 37–39, 42–43; Thornton 1987: 76–79, 99–102).

Historic figures of the total Pueblo population vary considerably for the early colonial period, depending on the observer. A detailed breakdown of 66 different population estimates from 1539–41 to 1910 was compiled and evaluated for accuracy by Palkovich (1985: 403–408). For the late 1500s-early 1600s these estimates range from 15,850 to 60,000. The actual number probably falls in between, but probably nearer the lower figure. The compiled figures were for 34 extant and extinct pueblos, some of which were or are out of the Basin, such as Zuni. The highest population estimate made by Onate (60,000), an estimate thought too high by many historians, was recently evaluated as relatively accurate by Palkovich (1985: 408); this estimate included Hopi villages as well. For the 17th century, a population estimate of 16,442 for the Pueblos made by Fray Bartolome Marquez is also viewed as reliable (Palkovich 1985: 408–409).

The 15th century Piro Pueblo, who inhabited the Rio Grande and major tributaries from south of Belen to below San Marcial, underwent a significant increase in population due to biological growth and emigrants from surrounding regions. Piros expanded onto elevated areas along the river floodplain and the west bank of the Rio Grande, mainly in the area below San Pedro Wash. Irrigation systems were developed to support nearby large villages. The estimated population at this time was 7,500 (Marshall and Walt 1984: 137–138, 140).

Piro population numbers recorded by early Spanish observers vary from 6,000 to 12,000; historians generally discount the first, which was an estimate by Espejo in 1583. Following Spanish settlement, a decrease in population began. In 1630 Fray Benavides recorded the figure of 6,000; the region was totally abandoned by 1680. This decline was due to Spanish pressures, drought-famine, European diseases, and raiding and warfare (Earls 1985: 126–127, 133, 149–150).

In 1680 the Pueblos probably numbered almost 17,000; European diseases, famine, and warfare were the principal causes of this decrease. By 1750 the Pueblo population declined to 12,000, while the nomad population stayed the same. By 1821 the Pueblo population had declined to about 5,000 (Dozier 1983: 130; Earls 1985: 124–125; Table 22).

The Pueblo population in the general study region was 5,400 in 1860–61 and increased to only 7,124 by 1904. By 1924 the total climbed to 10,565 and by 1964 to 20,822. For the Pueblos in the Middle Basin, the 1964 total was 16,817 (Hewett 1925: 1–2; Simmons 1979b: 221; Table 23).

Table 22—Pueblo population in the Middle Rio Grande Basin, 1680–1821.

	1680	1749	1798	1821
Galisteo	800	350	—[a]	—[a]
San Marcos	600	—[a]	—[a]	—[a]
Cochiti	300	521	505	339
Santo Domingo	150	40	1,483	726
San Felipe	300	400	282	310
Santa Ana	300	600	634	471
Zia	—	600	262	196
Jemez	5,000	574	272	330
Sandia	3,000	440	236	310
Alameda	1,500	—[a]	—[a]	—[a]
Laguna	—	228	802	779
Acoma	2,000	960	757	477
Isleta	2,000	500	479	511
Tajuique	300	—[a]	—[a]	—[a]
Totals	16,750	5,213	5,712	4,449

[a] *Abandoned.*
Sources: Palkovich 1985: 401; Simmons 1979a: 185

Table 23—Pueblo population in the Middle Rio Grande, 1904–1968.

Pueblo	1904	1924	1932	1942	1950	1968
Cochiti	217	267	295	346	497	707
Santo Domingo	846	1,054	862	1,017	1,106	2,248
San Felipe	489	526	555	697	784	1,542
Santa Ana	224	224	236	273	288	448
Zia	116	154	183	235	267	517
Jemez	498	580	641	767	883	1,707
Sandia	79	92	115	139	139	248
Isleta	979	1,003	1,077	1,304	1,470	2,449
Laguna	1,366	1,901	2,192	2,686	2,894	4,996
Acoma	734	955	1,073	1,322	1,447	2,688
Total	5,548	6,756	7,229	8,786	9,775	17,550

Sources: Dozier 1983: 122; Hewett 1925: 1–2

Native American Resource Use

Over time the Pueblos and other regional Native American groups developed strategies and institutions to ensure an adequate subsistence base. One strategy that evolved among the Pueblo prevented misuse of resources through regulation of overuse and depletion. Pueblo villages had societies that were responsible for the maintenance of different aspects of their eco-cultural world—weather, illness, agriculture, flora, and fauna. Another strategy was based on balanced reciprocity, in which mutual assistance and redistribution of food among all levels within the village, through rituals and barter for services performed, took place (Dozier 1983: 151–152; Ford 1972: 8–10; Friedlander and Pinyan 1980: 18).

Pueblo harvests of cultigens were supplemented by hunting of various vertebrate animals, gathering of an array of native food plants, collecting of a variety of invertebrate organisms, fishing, and trading with other aboriginal groups, especially for meat (Dozier 1983: 127–129; Earls 1985). An annual cycle of land use activities at Santa Ana and Cochiti, basically common to all basin Pueblos, follows (Bayer et al. 1994: 169–170; Lange 1959: 124–131; Table 24). The Navajo, Apache, and Southern Ute practiced horticulture but on a more limited scale.

Topographic variability as related to climate and resource availability was the key determinant of Pueblo and other Native American use of upland areas, generally above 7,000 feet. These higher altitudes were exploited for their fauna, flora, rocks, and minerals. Temporary or seasonal camps were generally near water, in protective cover, and near the target resource. For obvious reasons, impacts on biotic resources here were generally less than those at lower elevations, especially the intensively used riparian locations. Shrines were located on prominent topographic features, at springs or lakes, or at locales of mythological or actual events of significance.

Table 24—Annual cycle of Santa Ana and Cochiti land use.

Time	Activities
Late February or early March	Clean ditches, plow fields.
April–May	Plant and irrigate fields, water orchards, move flocks and herds onto mesa, Espiritu Santo tract, and east toward Placitas.
June–August	Tend fields and livestock. Hunt (communally) rabbits.
September–October	Harvest corn, wheat, melons, chiles, and fruit. Thresh wheat and carry crops back to old pueblo. Move livestock toward valley.
October–November	Hunt (communally) bison, deer, elk, pronghorn, and rabbits.
November	Process crops and store for winter.
December–February	Conduct religious ceremonies, produce arts and crafts, etc.

Source: Bayer et al. 1994: 169–170; Lange 1959: 124–131

Agriculture

All of the early historic Pueblo groups were primarily dependent on agriculture along the Rio Grande, its major tributaries and arroyos, and occasionally on alluvial fans for their subsistence base. At the time of Spanish exploration and early settlement, the Pueblos held most of the productive farmlands in northern and central New Mexico. Some Middle Rio Grande Pueblos did utilize ditch irrigation in the valley, albeit on a limited scale. In 1591 Spanish explorer Espejo noted that the Tewa Pueblo practiced irrigation agriculture (Schroeder and Matson 1965: 117). Also, the Pueblos were irrigating fields at the mouth of Las Huertas Creek in the late 1500s (Wozniak 1987).

Clark (1987: 71) described the early historic Pueblo method of irrigation farming:

> Apparently the common method of watering was periodic flooding of fields and certainly in advance of planting so that the plants could draw water from the soil during the early growing season. On streams of considerable size, normally there was no problem of supply during the spring because of melting snows which fed them. Water was simply conducted through wide but shallow canals from which it was diverted by laterals serving small plots. Later in the season, as the flow diminished, temporary check dams of logs, brush, mud, and stone retarded the flow, backing the water into the canals and into the fields.

Associated with this practice were "private irrigation organizations," which maintained ditches and other water control structures and controlled the times and amounts of water flows onto the fields. Their operations influenced how the Spanish formed irrigation associations in the frontier communities, especially those made up of genizaros (Ortiz 1980: 55–56).

Historic Pueblo field and irrigation systems, however, became more similar to the engineering and organization of the Spanish in the early colonial period. Ditches came from the Rio Grande or other perennial streams, springs, or cienegas and were laid out for gravity-flow of the water. Wing diversion dams were built of logs, rocks, or brush. The Spanish field system based on the "long lot," long, narrow plots that were an adaptation to local topographic and water resources and allowed maximum access to water, was never really adopted by the Pueblo (Carlson 1975: 53–54; Wozniak 1987). The Navajo selected locations for fields based on closeness to water, soil type, and levelness (Hill 1938: 26–27).

The limited Pueblo ditch farming along the upper and middle main stem of the Rio Grande in the early historic period was not as intensive as that practiced by the Spanish. The Spanish system, which the Pueblos basically adopted, involved the use of a network of ditches that carried water impounded by upstream diversion dams and whose flow was controlled by gates. More labor was required than that of floodwater farming, but average crop yields were higher, notably for the native corn and introduced wheat. The amount of irrigation possible was related to various climatic elements, and the amount temporally necessary was related to climatic variation. Irrigation often prevented starving or even a decrease in crop production; this was supplemented by trading for food with distant groups, as previously mentioned (Wozniak 1987; Zubrow 1974: 64).

Irrigation farming was less risky than floodwater or dry farming and generally ensured adequate crops. More intensive irrigation agriculture was required to grow Spanish wheat, barley, oats, and various fruit in the colonial period. Irrigation systems of the Pueblos remained essentially the same in organization and extent from 1846 to 1910. One reason for this was the decline in population until about 1900 (Wozniak 1987).

Estimates of the amount of land being cultivated by the Middle Rio Grande Valley Pueblos in the 16th century vary from 15,000 to 25,000 acres. With Spanish colonization beginning in 1598, the combined acreage steadily increased. By 1880 the amount of irrigated land began to decrease due to various environmental problems, but these were basically corrected by 1940. Some 20,696 acres were under cultivation by the Middle Valley Pueblos in 1945 (Harper et al. 1943: 51–52; Table 25; see Chapter 4).

The early historic Pueblos generally practiced floodwater farming, utilizing diversion structures, check dams, reservoirs, contour terraces, grid gardens, and gravel mulch gardens. All of these were elements of a soil and moisture conservation system that maximized effective use of surface water for crops in the semi-arid environment of the region (Cordell 1984: 203–204; Jorgensen 1983: 693, 696–697; Wozniak 1987).

The three major nomadic groups also engaged in floodwater farming but on a much smaller scale. Hydrologist Kirk Bryan (1929: 445) described the basic method of Native American floodwater farming in the Southwest:

> The areas utilized are variable in size and location, but each is chosen so that the local rainfall may be reinforced by the overflow of water derived from higher ground. The selection of a field involves an intimate knowledge of local conditions. The field must be flooded, but the sheet of water must not attain such velocity as to wash out the crop nor carry such a load of detritus as to bury the growing plants. Such conditions require a nice balance of forces that occur only under special conditions. Shrewd observations and good judgment are necessary in the selection of fields.

There are a number of archeological and early historical documented examples of this type of farming in the study region. In 1583 Espejo described sandy flats more than 2.5 miles wide on each bank of the Rio Grande, which were in cultivation by the Piro Pueblo. Other fields were under irrigation. Furthermore, some fields were located in or at the edge of marshes, probably to take advantage of the high water table (Earls 1985: 169–171, 180).

In the early to mid 1800s Cochiti still practiced floodwater farming at the mouth of arroyos, and the water was spread by the construction of diversion structures of logs, rocks, and brush. Probably more of this type of farming was done than that of irrigation before 1800. Dry farming was practiced at the base of the nearby Jemez Mountains. Floodwater farming at the pueblo had been largely abandoned by the late 1800s, although a few resident farmers practiced this technique until about 1930. Damaging floods were a factor in discontinuing this farming method. In 1890 small plots of 1.5–2.0 acres were planted on an island in the Rio Grande, a short distance below Cochiti (Lange 1959: 78–79).

In 1890 cultivated crops provided from 50 to 84 percent of the food consumed by the San Juan Puebloans (Ford 1972: 7). The amount produced for the late prehistoric period was below 50 percent. Surplus crops were stored to sustain them through one to three dry years in which cultigens would fail. Also, wild plants were collected and various animals hunted to supplement agricultural produce. Trade was another mechanism used to obtain food. Among the Pueblos, women "owned" the land, the seed, and the stored crops (Hughes 1983: 69).

Regional Pueblos were primarily cultivating corn, beans, and squash when first contacted by the Spanish. The Pueblos grew at least nine varieties of corn (Ford 1972: 7). Grain amaranth, bottle gourd, cotton, and common sunflowers were also grown, but these were of lesser importance (Nabhan 1979: 260–261). Of the cultigens introduced by the Spaniards, the Pueblos adapted chile, wheat,

Table 25—Middle Rio Grande Valley Pueblo irrigation, 1945.

Pueblo	Acreage	Avg. annual water diversion (acre-feet)
Cochiti	1,867	9,335
Santo Domingo	4,278	21,390
San Felipe	3,836	19,180
Santa Ana	1,114	5,570
Sandia	3,418	17,090
Isleta	6,183	30,915

Source: Nelson 1946: 74

cantaloupe, melon, peach, and apricot into their farming practice (Ford 1987: 76–82; Toll 1992; Table 26).

Pueblo irrigated lands and systems of the Middle Basin began to increase in acreage about 1905, when the U.S. Indian Irrigation Service initiated programs. The Middle Rio Grande Conservancy District program, including construction of irrigation dams and ditches, also reclaimed arable land. At Cochiti, irrigated lands increased from about 600 to 1,867 acres in 1950. Other valley Pueblos experienced similar expansion of irrigated lands (Lange 1959: 80; Nelson 1946: 74; Wozniak 1987).

The cycle of agricultural activities for each year was essentially the same for all of the historic Middle Rio Grande pueblos; Cochiti farm activities are listed in Table 27. Field preparation, irrigation, and sowing (of wheat) began in February and accelerated with planting of more crop types in March and early April and the planting of corn in mid to late April, with periodic irrigation and weeding from late spring and over most of the summer. Harvest occurred from mid July (grains) through mid October, followed by the "first fruits" ceremony on November 2.

Spanish livestock overgrazing on Pueblo and surrounding traditional use lands decimated cool-season, edible grasses. However, with a new, dependable, and nutritional wheat crop produced by irrigation, the Pueblos no longer needed to collect native grass seeds. Reliance on wheat and other introduced crops, as well as Spanish livestock, led to a decrease in Pueblo hunting of indigenous fauna

Table 26—Historic Native American cultigens.

Cultivated vegetables	Semi-cultivated vegetables
Maize (corn)—*Zea mays* (*Chapalote* and *Maiz de Ocho* vars.)	Devil's claw—*Proboscidea parviflora*
Cockscomb—*Amaranthus cruentus*	Wild potato—*Solanum* spp.
Grain amaranth—*A. hypochondriacus*	Zuni tomatillo—*Physalis philadelphica*
Calabasa verde—*Cucurbita mixta*	Goosefoot—*Chenopodium* spp.
Crook-neck squash—*C. moschata*	Rocky Mountain beeweed—*Cleome serrulata*
Pumpkin—*C. pepo*	Hopi black dye sunflower—*Heilanthus annuus*
Bottle gourd—*Lagenaria siceraria*	Common sunflower—*H. annuus*
Hopi short-stapled cotton—*Gossypium hirsutum*	
Lima Bean—*Phaseolus lunatus*	
Common bean—*P. vulgaris*	

Sources: Ford 1987; Hewett and Dutton 1945; Robbins et al. 1916

Table 27—Annual traditional farming activities, Cochiti Pueblo, 1880.

Season	Activity	Season	Activity
February	Sowing of wheat began. Clans assist with planting. Fields irrigated prior to sowing if ground is very dry.	July	Last weeding of fields. Wheat harvested just after July 14 feast day. Livestock brought from ranges to village to thresh wheat and other grains.
March	Completion of wheat sowing. Irrigation ditches cleaned. Spring dance just before or after cleaning to assure good crops.	August	Fields irrigated every 7 or 8 days. Threshing of grains continued.
April	Ground broken with plows and oxen. Planting of corn began after the 20th. Melons, watermelons, beans, squash, and chile subsequently planted. Clans assisted with planting. Irrigation prior to planting. Ground pulverized with shovel or hoe.	September	Harvesting of corn, beans, chile, peaches, etc. began. Cacique's field harvested ceremonially first. Clans assist in harvesting.
May-early June	Planting of corn completed. Punche (tobacco) planted.	October	Last cutting of alfalfa in early part of month. Harvesting of corn completed by mid-month.
June	Corn fields pulverized. Fields irrigated every 7 or 8 days.	November	All Souls' Day celebrated on the 2nd. The "offering of the first fruits," primicia, conducted at church. Feasts at homes. Gifts of food made to children.

Source: Lange 1959: 85–87, 88–99, 101–102, 329–333, 341–346, 362–364, 439 and collecting of other native plants (MacCameron 1994: 31, 36).

Livestock Raising

Although Coronado brought sheep, cattle, and horses with his expedition in 1540, and even left a few sheep with each of the two or three friars who chose to remain among the Pueblos in 1542, none of these animals appears to have survived. No livestock from later 16th century expeditions apparently survived either, until 1598, when Onate brought the first colonists and some 4,000 sheep, 1,000 cattle, 1,000 goats, and 150 horses. Some died from natural causes or were butchered en route, but many survived and represented the beginnings of livestock raising in New Mexico (Baxter 1987: 2–4).

The herds around the early Spanish and Pueblo settlements generally increased on lush grasses little grazed by wild mammals, and new herds of domesticated animals were brought to New Mexico by the missionary caravans. Flocks of sheep and other livestock were established at missions founded at the pueblos. By 1639 each priest possessed 1,000 to 2,000 sheep, considerably more than lay Hispanic citizens. Here the Pueblos were taught the fundamentals of livestock raising, and some readily incorporated the use of meat, hides, and wool into their subsistence living. However, the considerable labor expended by the Pueblos in caring for the mission stock fostered general resentment among some villagers (Arnon and Hill 1979: 304–305; Baxter 1987: 8; Campa 1987: 43–44).

Although the Spaniards prohibited the Pueblos and other Native Americans from using horses, the Apaches, Navajos, and Utes had acquired horses through raiding and trading by the 1620s–70s. At first they were used as food or beasts of burden, but it was not long until these groups were riding and successfully raising these animals. For the Pueblos, oxen became the favored animal for pulling the introduced plow and cart; mules and burros were adapted as pack animals. Livestock, primarily horses, were also used in threshing grains, a custom learned from the Spanish (Bailey 1980: 67, 69; Campa 1987: 44–45; Lange 1959: 98).

The Pueblos, in turn, introduced sheep and goats to the Navajo, perhaps through trade before the Pueblo Revolt, and certainly during the Spanish reconquest of 1692–96. As refugees fleeing from the Spanish army, the Jemez and other Pueblos lived with the Navajo. The latter, quickly learning to raise, eat, and shear the sheep and goats, incorporated these practices, which soon became a significant part of their new nomadic lifeway (Fig. 20). By 1700 the Navajo had at least 1,000 sheep (Bailey 1980: 66–69, 76–77).

Following resettlement, Spanish herds were again built up, and raids made on them by nomadic Indian groups were resumed to increase their own stocks. As a result, horses and mules, prized as mounts or food, were scarce in the Rio Grande settlements (Bancroft 1889: 276; Simmons 1985: 85). Sheep were a major target as well, and pueblos like Laguna lost many animals to raiders (Ellis 1979: 442). Overall numbers of livestock at some of the pueblos in the 18th century grew slowly, in spite of the raids and declining village populations due primarily to disease and warfare. A partial inventory of Santa Ana's livestock in 1763 indicated a diversity of domesticated animals: more than 67 cows, a number of calves, 29 oxen, 8 bulls, 50 sheep, 74 goats, 8 horses, 1 mare, 1 colt, 3 mules, and a number of pigs (Bayer et al. 1994: 80–81, 83).

The subjugation of nomadic groups by the army in the 1860s–70s and the opening of rail lines in the region led to a sharp rise in livestock numbers at some of the Pueblo villages and elsewhere in the region. For example, cattle herds increased five-fold between 1880 and 1890 on Santa Ana lands. Navajo sheep and goat herds also increased sharply after their resettlement on reservation lands. Some 1.5 million sheep were counted on reservation lands in 1885 (Bailey and Bailey 1986: 41; Bayer et al. 1994: 174, 176).

The number of Pueblo sheep in the region decreased by more than one-half between 1900 and 1930. Of all the pueblos in the basin, Laguna emerged in this century as the leading sheep raising village in terms of numbers. At Acoma and Zuni, sheep also were an important source of

Figure 20—Navajo shepherdess, 1887 (from Brooks 1887).

income. By 1935 there were 52,000 sheep on Laguna's rangelands. In this year the United Pueblos Agency implemented a grazing management plan based on carrying capacity of the land, which had been exceeded not only on Navajo and Laguna lands but also on all Pueblo lands. A controversial livestock reduction program soon followed (Aberle 1948: 19–20, 43; Ellis 1979: 443). Various organizations to administer livestock operations evolved among the Pueblos during the early to mid 20th century. Initially, the war captain was in charge of stock and the rangelands. Subsequently, sheep and cattle officers replaced the war captain at some villages. A cattle trust was established at Isleta, and eight holding groups for sheep and cattle were organized in 1943 (Aberle 1948: 32; Hoebel 1979: 410).

In recent years, livestock raising has grown as an important income through sales, as well as a food source for the Pueblos (Table 28), although sheep have all but disappeared. Among the Navajo, however, sheep, as well as goats, are a major source of income. Cattle represent a large percentage of the stock held by the Pueblos today.

Hunting and Gathering

Indigenous animals and plants were harvested for food, medicine, arts-crafts, and construction by all Native Americans throughout the protohistoric and historic periods. Even among the agriculturalists, such as the Pueblos, hunting and gathering have always been important due to partial or total crop losses related to drought, insect infestations, and raids (Fig. 21). The hunting and gathering system was based on three elements related to production, consumption, and redistribution: sexual division of labor (males hunted, females gathered), almost immediate consumption, and redistribution via kin connections within the group to which the producers and consumers belonged. These two activities involved extensive

Figure 21—Late prehistoric petroglyphs: Pueblo hunter (?) with lance, horned serpent, and rear paw print of a bear, Abo area. Photo by author.

Table 28—Pounds of meat sold and consumed, Acoma and Laguna, 1938–1943.

Livestock class	1938	1939	1940	1941	1942	1943
Cattle	387,031	349,350	398,195	487,899	438,092	431,097
Sheep	749,596	1,129,464	986,088	857,114	867,330	624,545
Swine	6,700	19,780	6,716	11,132	16,936	24,165
Poultry	9,808	11,440	5,626	13,818	14,473	21,970
Total	1,153,135	1,510,034	1,396,625	1,369,963	1,336,831	1,101,777

Source: Aberle 1948: 87

Table 29—Santa Clara use of mammals (non-food).

Mammals	Body part	Use
Buffalo	Hide	Robes, bedding, rugs
Deer	Hide	Clothing
Elk	Hide	Clothing
Pronghorn	Hide	Clothing
Bighorn sheep	Hide	Clothing
Bear	Hide	Robes, bedding, rugs
Jackrabbit	Hide	Robes, blankets
Cottontail	Hide	Robes, blankets
Mountain lion	Hide	Quivers
Bobcat	Hide	Clothing, robes, quivers
Wolf	Hide	Quivers
Gray fox	Hide	Ceremonial costumes
"Plains" fox	Hide	Ceremonial costumes
Beaver	Hide	Headbands, hats, hair ties, dance costumes
Porcupine	Quills	Needles, clothing decoration
Otter	Fur	Headbands, collars
Rock squirrel	Hide	Dolls
Chipmunk	Hide	Hair ties
Weasel	Hide	Hair braid wraps

Source: Hill 1982: 49–54

Figure 22—Drawing of a bison by a member of the Onate expedition, 1599.

utilization of landscape resources, with little labor expended, compared to irrigation agriculture.

Fauna

A wide range of large to medium-sized mammals were hunted by historic Pueblo and other groups in the region. Major species included buffalo, elk, deer (mule and white-tailed), pronghorn, and bighorn sheep. Bands of hunters traveled in the fall to hunt buffalo on the Llano Estacado to the east of the Basin (Fig. 22); these animals were important for meat and hides. Smaller meat and fur animals hunted, trapped, or snared were beaver, rabbit (cottontail and jackrabbit), prairie dog, squirrel (rock, ground, and tree), badger, weasel, and skunk (Basehart 1973: 148, 156; Hamilton 1975; Opler 1965: 316–327; Tiller 1983: 441). As an example, mammals used historically by Santa Clara Pueblo are listed in Table 29.

For centuries Pueblo Indians have maintained a close association with more than 200 species of indigenous birds, as well as macaws and parrots imported from Mexico. During this time birds were incorporated into virtually every aspect of community life. Various species of birds were associated with "sacred" directions. Birds were related to the sky, earth, sun, moon, snow, "life source," crop plants, water, seasons, rain, rainbows, and drought, death, day, dusk, night, agriculture, hunting, racing, war, purification, speech, and "balance of man and nature." Some 100 different birds, or their parts, were used in Pueblo ritual and ceremony. Birds also have an essential place in Pueblo myth and folklore (Tyler 1979: xii-xiii, 3–12).

Birds were taken with bow-and-arrow, traps, snares, and by hand. Eagles were taken from nests on cliffs or in trees when young, then caged and raised in the village. Cochiti and Jemez Pueblos captured adult eagles by hiding in a plant-covered pit with a tethered rabbit as bait next to the pit. When an eagle plunged and grasped the live bait, the hunter raised up and grasped the eagle by both legs, then covered the bird with a blanket or large skin (Tyler 1979: xiii, 53–58). Eagles were either kept in cages or tethered to a perch on roofs (Fig. 23).

In basic tasks such as planting a field or building a room, it was necessary to make a presentation of feathers from appropriate birds. Birds and feathers were also used in rituals that supported religious ceremonialism, and these became counters that ordered a complex symbol system. Certain birds were related to gods, acted as messengers between Pueblos and their gods, or represented signals between individuals. Bird designs were commonly used on pottery at Zuni, Acoma, and Zia. Domesticated turkeys, golden eagles, macaws, and parrots were commonly kept in villages. Their main use was providing skins or individual feathers; turkeys and golden eagles were sometimes killed for ritual sacrifice (Bunzel 1972: 24, 32, 93–128; Franklin 1968: 5–21; Tyler 1979: xi–15, 52–53, 54, 55).

Other major uses of feathers by the Pueblos included robes, blankets, clothing, hunting fetishes, corn fetishes, breath-feathers, prayer-sticks, ceremonial headdress, other religious paraphernalia, quivers, shield, mask and basket decoration, and arrow fletching (Hill 1982: 47–59; Table 30). Trade in feathers, especially those from macaws and parrots to the south, was widespread. Eagle claws and turkey feet were also used in paraphernalia. The live birds themselves were probably traded as well (Tyler 1979: 3–6, 44, 50, 52, 68, 91, 120, 170, 266).

A number of these birds were also used by the Apache and Navajo (Mayes et al. 1977: 5). The Western Apache ate wild turkeys, quail, dove, geese, ducks, some small birds, and various bird eggs (Buskirk 1986: 137–142). Vulture feathers were also used by the Mescalero for adornment and ritual use (Basehart 1973: 156; Opler 1965: 327–329).

The Navajo used feathers from various species of birds. The feathers of eagles, which were ritually hunted, and turkey feathers were used in fletching arrow shafts. Feath-

Figure 23—Pueblo man with tethered eagle on cage, 1887 (from Bulletin of the Bureau of American Ethnology 1887).

Table 30—Santa Clara use of bird feathers.

Birds	Use
Ducks	Arrow fletching, ceremonial paraphernalia, and costumes
Canada goose	Arrow fletching
Sandhill crane	Arrow fletching
Golden eagle	Arrow fletching, ceremonial paraphernalia, and dance costumes
Bald eagle	Arrow fletching, ceremonial paraphernalia, and dance costumes
Red-tailed hawk	Arrow fletching, dance costumes
Cooper's hawk	Arrow fletching, dance costumes
Sharp-shinned hawk	Arrow fletching, dance costumes
Turkey vulture	Arrow fletching, dance costumes
Blue grouse	Arrow fletching, ceremonial paraphernalia, and dance costumes
Wild turkey	Arrow fletching, ceremonial paraphernalia, and costumes
Scaled quail	Arrow fletching
Greater roadrunner	Ceremonial paraphernalia
Flycatcher	Ceremonial paraphernalia
Stellar's jay	Dance, hair ornament
Pinyon jay	Dance, hair ornament
Black-billed magpie	Dance, hair ornament
Scott's oriole	Ceremonials?
Bullock's oriole	Ceremonials?
Western tanager	Ceremonials?
Hepatic tanager	Ceremonials?
Yellow warbler	Ceremonials?
Grace's warbler	Ceremonials?
Yellow-breasted chat	Ceremonials?
Mountain bluebird	Ceremonials?
Western bluebird	Ceremonials?

Source: Hill 1982: 47–59

ers from both species were also used in decorating baskets, hats, masks, and other items. Hawk, crow, owl, bluebird, warbler, and other small birds were used in decorating ceremonial clothing and paraphernalia. Eagle claws were strung on necklaces (Kluckhohn et al. 1971: 415).

Most Pueblo groups and the Navajo and Apache groups generally did not eat reptiles, amphibians, fish, or mollusks until recent times. However, faunal remains from Piro archeological sites in the valley include snakes, turtles, and frogs, as well as gar and buffalo fish. Rattlesnakes were not killed by members of any of these groups. Live snakes were sometimes used in Pueblo ceremonies, and tortoise shells were used in making a rattle. Eel skins were used by the Tewa Pueblo for making leggings and moccasins (Basehart 1973: 12; Buskirk 1986: 142; Earls 1985: 264–265, 273; Hewett and Dutton 1945: 116–120; Opler 1965: 330–332).

Flora

Numerous plants were systematically collected for wild food and other uses by the Pueblos (Table 31). Some major foods included seeds or fruits from grasses, amaranths, pigweed, sunflower, hackberry, juniper, pinyon, prickly pear, and yucca. Medicinal or arts-crafts material sources were cottonwood, willow, mountain mahogany, Apache plume, and juniper.

Wild food plants represented in Piro Pueblo archeological sites include, in decreasing order of importance, yucca, prickly pear, hedgehog cactus, and mesquite. Cattail pollen was abundant, indicating that it was an important food. Pinyon nuts, a relatively important Pueblo and Spanish native food, have not been recovered archeologically from Piro sites, but have been recovered from other Pueblo sites in the Middle Valley north of Belen (Earls 1985: 268, 270). Fuel and construction woods used by all Pueblo groups were cottonwood, pinyon, willow, juniper, and saltbush. Mesquite and creosote bush were also used by the Piro (Earls 1985: 268, 270; Scurlock and Johnson 1993: 277–278).

Throughout the prehistoric and historic periods of the American Southwest, the various species of pinyon and juniper have been commonly used woods for heating and cooking fuel. Annual consumption of pinyon and juniper wood by a prehistoric Chaco Canyon family has been estimated to be 1.55 to 2.35 cords (Samuels and Betancourt 1982: 512; Weigle 1975: 13); this range was probably the same for late prehistoric-historic Pueblos. At the time of Spanish arrival in the 1500s, some northern Pueblos and other Native American groups were primarily using dead wood for fuel. With the introduction of the metal axe and increase in Rio Grande Basin populations of Spaniards, green pinyon and juniper were increasingly harvested for fuelwood. By 1800–50, live wood had been harvested around all of the northern Pueblos for some distance. In this century, some Pueblos have discouraged the cutting of green wood (Ford 1987: 74, 86; Hewett and Dutton 1945: 59; Hughes 1983: 5; Lange 1959: 145; Whiting 1966: 3, 62–63).

Several plants were important to the Apaches, Navajos, and Utes as food. These were, in decreasing order of importance, acorns, pinyon nuts, datil yucca fruit, and prickly pear tunas. Mescal, or agave, and mesquite beans were perhaps the most important wild food sources for Southern Apache bands. These wild food plants are perennial, which under normal climatic conditions would be available annually. Other food plants collected included sunflower seeds, walnuts, juniper berries, various other edible berries, grass seeds, roots, and green plants ("pot herbs"), as well as various other seeds. The Navajos' diet was made up of about 50–60 percent domestic plants (Scurlock 1990a: 39, 1991: 38–39).

Rocks and Minerals

A relatively large number of regional rocks and minerals were utilized in various ways by the Pueblo and other Native Americans. These uses included the manufacture of tools, weapons, jewelry, pottery, paint, plaster, and house construction (Table 32).

Table 31—Pueblo plant use.

Common English name	Scientific name	Medicinal	Food	Other
Willow	*Salix* spp.	X		X
Cottonwood	*Populus* spp.	X		X
Aspen	*Populus tremuloides*	X		X
Mint	*Labatiae* spp.	X		
Yerba buena	*Mentha spicata*	X	X	
Pennyroyal, poleo	*Mentha arvensis*	X		
Horehound	*Marrubium vulgare*	X		
Oregano	*Monarda methaefolia*	X	X	
Doveweed	*Croton texensis*	X		
Spurge	*Euphorbia serpyllifolia*	X		
Coyote gourd	*Cucurbita foetitissima*	X		
Mormon tea	*Ephedra* spp.	X		
Thistle, poppy	*Argemone* spp.	X		
Caltrop	*Kallstroemia hirsutima*	X		
Bearberry, Kinnikinnick	*Arctostaphylos uvaursa*	X	X	
Rabbitbrush	*Chrysothamnus* spp.	X		X
Dandelion	*Taraxacum officinale*	X	X	
Blanket flower	*Gaillardia* spp.	X		
Indian tea, cota	*Thelesperma* spp.	X	X	X
Western coneflower	*Rudbeckia* spp.	X		
Cutleaf coneflower	*Rudbeckia laciniata*	X	X	
Gumweed	*Grindelia squarrosa*	X		
Groundsel	*Senecio* spp.	X		
Sneezeweed	*Helenium* spp.	X		
Gay feather	*Liatris punctata*		X	X
Sunflower	*Helianthus annuus*	X	X	
Sagebrush	*Artemisia* spp.	X		X
Sand sagebrush	*Artemisia filifolia*	X		
Wormwood	*Artemisia rhizomata*	X		
Broomweed, snakeweed	*Gutierrezia sarothrae*	X		
Yarrow	*Achillea lanulosa*	X		X
Oak	*Quercus* spp.	X	X	X
Evening primrose	*Oenothera* spp.	X		
Paintbrush	*Castilleja* spp.	X		
Scarlet penstemon	*Penstemon barbatus*	X		
Elderberry	*Sambucus* spp.	X	X	X
Santa Fe phlox	*Phlox* spp.	X		
Rocky Mountain beeplant	*Cleome serrulata*	X	X	X
Creosote bush	*Larrea tridentata*	X		
Spider milkweed	*Asclepias asperula*	X		
Milkweed	*Asclepias* spp.	X		
Sand verbena	*Abronia fragrans*	X		
Skunkbush	*Rhus trilobata*	X		X
Wild flax	*Linum* spp.	X		X
Colorado four o'clock	*Mirabilis multiflora*	X		
Mustard	*Brassica* spp.	X		
Dogweed	*Dyssodia* spp.	X		
Barberry	*Mahonia repens*	X		
Oregon grape	*Mahonia repens*	X		X
Mountain mahogany	*Cercocarpus montanus*	X		X
Stickleaf	*Mentzelia* spp.	X		
Wild tobacco	*Nicotiana* spp.	X	X	
Mullein	*Verbascum thapsus*	X		
Meadow rue	*Thalictrum fendleri*	X		
Stonecrop	*Sedum* spp.	X		
Jimsonweed, sacred datura[a]	*Datura* spp.	X		X
Wolfberry	*Lycium pallidum*	X	X	
Purslane	*Portulaca oleracea*	X		
Western wallflower	*Erysimum capitatum*	X		
Water cress	*Rorippa nasturtium*	X	X	
Cow parsnip	*Heracleum lanatum*	X		
Wafer parsnip	*Cymopterus* spp.	X	X	

continued on next page

Table 31—Pueblo plant use (continued).

Common English name	Scientific name	Medicinal	Food	Other
Osha	*Ligusticum porteri*	X	X	X
Yerba mansa	*Anemopsis californica*	X		
Alfalfa	*Medicago sativa*	X		X
Bullrush	*Scirpus* spp.	X	X	
Cattail	*Typha latifolia*	X	X	
Prickly pear	*Opuntia* spp.	X	X	
Spiny hedgehog cactus	*Echinocereus triglochidiatus*	X	X	
Cholla, walkingstick	*Opuntia imbricata*	X	X	X
Four-wing saltbush	*Atriplex canescens*	X	X	X
Mallow	*Malva neglecta*	X		
Indian ricegrass	*Oryzopsis hymenoides*		X	
June grass	*Koeleria cristata*			X
Dock	*Rumex* spp.	X	X	X
Lambsquarters	*Chenopodium* spp.		X	X
Wormseed	*Chenopodium ambroisiodes*	X	X	
Onion, wild	*Allium* spp.	X	X	X
Ponderosa pine	*Pinus ponderosa*	X	X	X
Douglas fir	*Pseudotsuga douglasii*			X
Yucca	*Yucca elata, glauca, baccata*	X	X	X
Solomon's seal	*Smilacina amplexicaulus*	X		
Sego lily, mariposa lily	*Calochortus* spp.	X		
Wild lily of the valley	*Smilacina stellata*	X	X	
Baneberry[a]	*Actaea arguta*	X		
Boxelder	*Acer negundo*			X
Wild rose	*Rosa fendleri*	X	X	X
Wild strawberry	*Rosa fendleri*	X	X	
Chokecherry	*Prunus melanocarpa*	X	X	X
Wild plum	*Prunus americana*		X	
Apache plume	*Fallugia paradoxa*	X	X	
Deer's ears, green gentian[a]	*Swertia radiata*	X	X(?)	
Cranesbill	*Erodium cicutarium*	X		
Mountain and Richardson's geranium	*Geranium caespitosa, G. richardsonii*	X	X	X
Rocky Mountain iris[a]	*Iris missouriensis*	X		
Mountain lilac	*Ceanothus fendleri*	X	X	X
Scouring rush	*Equisetum*	X	X	
Spectacle pod	*Dithyrea wislizeni*	X		
Vervain	*Verbena macdougalii*	X		
Verbena	*Verbena* spp.	X		
Serviceberry	*Amelanchier prunifolia*		X	X
Hackberry	*Celtis reticulata*	X		
Puffballs	*Cyucoperdon* spp.	X		
Bracket fungus	*Polyporus halowii*	X		
Walnut	*Juglans major*	X	X	X
One-seed juniper	*Juniperus monosperma*	X	X	X
Rocky Mountain juniper	*Juniperus scopulorum*	X	X	X
Alligator juniper	*Juniperus deppeana*	X	X	
New Mexico locust	*Robinia neomexicana*	X	X	
Wild pea, peavine	*Lathyrus decaphyllus*	X		
Mesquite	*Prosopis glandulosa*		X	X
Screw bean, tornillo	*Strombocarpa pubenscens*		X	X
Indian potato	*Hoffmanseggia densiflora*	X		
Locoweed[a]	*Astragulus* spp.	X		
Vetch	*Vicia* spp.	X		
Sweet clover	*Melilotus* spp.		X	
Ground-cherry	*Physalis neo-mexicana*		X	
Wild potato	*Solanum fendler, S. Jamesii*	X		
Silverleaf nightshade	*Solanum elaeagnifolium*	X		X
Wild grape	*Vitis arizonica*	X		
Gooseberry	*Ribes leptanthum*	X		

[a] *Poisonous.*

Sources: Castetter 1935; Robbins et al. 1916

Several types of rocks that could be flaked to make tools and weapons were collected, including jasper, agate, chalcedony, chert, obsidian, quartz, and quartz sandstone. These materials were quarried from outcrops or gathered as surface nodules or cobbles. One of the best known quarry sites for siliceous stone in New Mexico is Cerro Pedernal, near Abiquiu. Quarrying was done with an assortment of stone tools. Cores or preforms were usually produced at the mine site, then transported back to activity areas or nearby campsites or farther, to base camps or villages, where complete tools or weapons were made (Bryan 1938; Christiansen 1974: 9; Warren 1974).

One of the minerals long mined in New Mexico for jewelry or other ornamentation is turquoise; the earliest archeological context has been dated to pre–700 A.D. Most of the turquoise recovered from Pueblo sites came from quarries and mines in the Cerrillos area. Two major periods of mining in the Cerrillos district occurred: late Pueblo II to early Pueblo III (A.D. 1000 to 1150 or 1200) and Pueblo IV (ca. AD 1350 to 1700). Of the two, archeological evidence indicates that the latter period was the most intensive one for Pueblo mining (Scurlock 1993b; Snow 1981; Warren and Mathien 1985; Fig. 24).

Other rocks and minerals were used in making jewelry, fetishes, paint, and inlay, including jet, quartz, azurite, galena, peridot, malachite, calcite, hematite, limonite, kaolinite, and gypsum (Ferguson and Hart 1985; Northrop 1959). Pueblo fetishes of a variety of mammals were, and are still, made; common mammals represented are mountain lion, bear, deer, elk, and badger. Stone was the most popular material from which fetishes were constructed, but bone, shell, wood, and clay (ceramic) were sometimes used (Scurlock 1993b; Tyler 1975: 22, 66–67, 233, 240).

Galena, or lead, was mined in the Cerrillos area, the San Pedro Mountains, at the north end of the Sandia Mountains, and in the Sangre de Cristo Mountains, north of Pecos Pueblo. Much of the lead mined from the early 1300s to about 1700 in the Pueblo region was used in producing a glaze to decorate ceramics. Between 1450 and the late 1500s, Tonque Pueblo, located east northeast of Bernalillo, produced most of the lead-glazed wares for the northern Rio Grande Pueblos (Scurlock 1993b; Warren 1969; Warren and Mathien 1985).

Navajos also made tools and weapons from chert, chalcedony, and obsidian. Turquoise, jet, and garnet were used for making jewelry. Rock-alum, and sometimes gypsum, were used as a mordant in a dye preparation. White clay, red ocher, and yellow ocher were used for dyes and paints (Kluckhohn et al. 1971: 418–419).

Clays used in making ceramics by various native groups usually came from deposits located relatively close to pottery-making centers, although in some instances they were imported. Sources were usually found in arroyo banks, canyon walls, or hillside outcrops; some of the better documented deposits are east of Acoma, between Truchas and Picuris Pueblo near Taos, and near Ramah. Temper of crushed rocks or coarse sand grains was usually added to the clay before firing. The pigment sources named above were used for monochrome or polychrome decorations (Dittert and Plog 1980: 17–19, 23; Friedlander and Pinyan 1980).

Salt was used throughout the prehistoric and historic periods and was harvested at several well-known loca-

Table 32—Pueblo use of rocks and minerals.

Rock/mineral	Location	Item
"Red clay"	Nambe area	Pottery
Clay	Truchas, Canada de Cochiti, Santa Fe Canyon	Pottery
Gypsum	La Bajada area	Whitewash, plaster
Volcanic sand/rock	Various locations near pueblos	Pottery temper
"Yellow stone"	Valle Grande	Pottery temper
Mica	Taos – Petaca area	Pottery paint
"Reddish sandstone"	Canada de Cochiti	Paint
Basalt	Jemez Mountains	Grinding implements, well foundations
"White mineral"	Jemez Mountains	Beads
Fibrolite	Sangre de Cristo Mountains	Axes
Obsidian	Jemez Mountains	Tools, weapons
Malachite	Jemez Mountains	Paint, jewelry
Copper	Abiquiu area Sandia Mountains Jemez Mountains Cerrillos Mountains	Paint, jewelry
Azurite	Jemez Mountains, Sandia Mountains, Nacimiento Mountains, Cerrillos Mountains	Paint, jewelry
Turquoise	Cerrillos	Jewelry, ornamentation

Sources: Friedlander and Pinyan 1980: 20–32; Riley 1987: 236–239, 267–277; Warren 1974

Figure 24—Prehistoric and early historic (?) Pueblo turquoise mine (upper left), Mount Chachahuitl. Photo by D. B. Sterrett, U.S. Geological Survey, 1911. USGS Photo Archives, Denver.

tions—Zuni Salt Lake, Estancia Valley saline lakes, and at the confluence of the Chama River and the Rio Grande. Salt was used in preserving meat, as a food seasoning, as a medicine, and for ritual purposes. Ceremonial pilgrimages to collect the salt at the above sites were made by the Pueblos, Navajos, and other Native American groups. The Cochitis collected the substance in loosely woven baskets, which allowed the water to drain through, then the salt was taken to shore and placed in sacks. At the Zuni Salt Lake, western Pueblos and Navajos collected throughout the historic period, and, for the Pueblos, in the later prehistoric as well. Navajos sometimes stored the salt in a pot with a flat stone lid, which was placed in a rock shelter. The salt was ground on a metate prior to use (Ferguson and Hart 1985; Hewett and Dutton 1945: 46–48).

Sandstone and limestone were commonly used in masonry construction by the Pueblos throughout their history. On the Pajarito Plateau, the softer tufa was a popular building material. The Navajos, and to a much lesser extent the Apaches, used sandstone or limestone in construction of houses, storage buildings, corrals, and other structures. Building stone was picked up or quarried from bedrock, outcrops, and sometimes from abandoned structures. Adobe became increasingly popular as a building material during the historic period (Nabokov and Easton 1989; Scurlock 1993b: 322, 334–335, 356, 364–370).

Resource Trade

During the historic period a variety of raw materials and handicrafts was exchanged between villages and camps of these regional groups: Navajo, Apache, Ute, Western Pueblos, Rio Grande Pueblos, and various Southern Plains tribes. Indigenous and exotic raw materials and cultivated plant products, animal byproducts, feathers, shells, rocks, minerals, and a variety of crafted items produced in one village were desired by another community "because they were not locally available or because they confirmed social bonds" (Scurlock

Table 33—Historic Native American trade items.

Item	Use
Cornmeal	Food
Barley flour	Food
Wheat	Food
Bread	Food
Beans	Food
Gourds	Food
Corn	Food
Chile	Food
Punche	Smoking tobacco
Sheep	Food, woven items
Woven kilts	Clothing, ceremonial
Belts	Clothing
Mantas	Clothing
Turquoise jewelry	Adornment
Twilled yucca baskets	Container, ceremonial
Willow wicker baskets	Container, ceremonial
Pottery	Container
Buckskins	Clothing, miscellaneous
Elkskins	Clothing, miscellaneous
Pronghorn skins	Clothing
Tallow	Candles
Osha	Medicine
Cachana	Amulet
Cottonwood	Drums
Mica	Pottery temper
Travertine	Fetishes
Kaolin	Pottery slip
Unidentified black mineral	Pottery paint
Shell	Beads

Sources: Ford 1983: 712–714; Lange 1959: 152; Scurlock 1990a: 39

1990: 39). Pottery, agricultural produce, horses, salt, and other items were produced and traded by the Pueblos. Buckskins, elk hides, otter skins, buffalo robes, shields, and pitch were acquired from the Utes. Navajos produced buckskin, basketry, and woven items, especially blankets, for trade. Deer, rabbit, and other animal meats were traded among all of these groups. Various minerals were also exchanged; alum was sought by the Spanish during this period (Delaney 1989: 12, 19, 1991: 38–39; Scurlock 1990a: 39; Table 33).

SPANISH EXPLORATION, SETTLEMENT, POPULATION, AND RESOURCE USE, 1540–1846

Exploration and settlement of New Mexico was part of Spain's expansion into the new world, which began in 1492. Three primary driving forces behind this national expansion were finding and mining of gold and silver, colonizing the new lands, and converting native peoples to Catholicism. These interrelated objectives of the Spanish conquest were carried out by men who embraced and introduced a new world view of "patron-client social relations, material wealth, iron tools, food markets, domesticated animals, Aristotelian logic, divine right and blessing" to New Mexico (Ford 1987: 73). This new system, and an array of new, highly infectious diseases, would result in relatively major changes in the Pueblo environment—the people, fauna and flora, surface water, and other components—over the two and a quarter centuries of the colonial period.

In addition to being driven by a desire for accumulating material wealth, the Spanish church and government pursued, with righteous zeal, a program of aggressive conversion of the region's Native Americans to Christianity. Believing that providence sided with them and that indigenous peoples in the New World were inferior, 16th century Spaniards led a moral crusade to spread Spanish culture, centered in Catholicism, to these pagans (Weber 1992: 21).

Weber (1992: 21) wrote this about the Spanish-Catholic view of the Native Americans and their environment at the time:

> Like other Christians, Spaniards understood that their god had given them 'dominion' over all creatures on the earth, including these infidels. The god of the Christians, according to their holiest text, had ordered them to 'be fruitful and multiply, and replenish the earth and subdue it, and have dominion over the fish of the sea, over the fowl of the air, and over every living thing that moveth upon the earth.'

Moreover, according to Weber (1992: 22, 48, 312), the Spanish believed their god was extraterrestrial and had created nature separate from themselves. Additionally, they regarded the natural environment as made up of various resources, which they could exploit as needed for themselves.

Spanish Exploration

Following the 1519–20 Spanish conquest of the Aztecs and their allies, colonization, complemented by the establishment of a missionary program, moved steadily northward from Mexico. By the mid 1500s, the frontera had reached what is now central and northwest Mexico, from where exploration and colonization of Nuevo Mexico, as it was soon to be called, was launched.

Spurred by stories of riches told by Cabeza de Vaca, who may have wandered along the present New Mexico-Chihuahua border in late 1535-early 1536, and supported by a viceroy eager to expand Spain's New World territory northward, the first of several 16th century entradas (expeditions) to the land of the Pueblo Indians, as the Spaniards came to call them, was initiated in 1539. An advance party of the expedition, led by Fray Marcos de Niza, reached the Zuni village of Hawikuh, one of the fabled Seven Cities of Cibola. The black leader of the vanguard, Esteban, who had been with Cabeza de Vaca, was killed by the Zunis. His Mexican Indian servants fled back to Niza, who was leading the main contingent. Fear for his own safety overcame his desire to visit one of the villages, so Niza, who had seen the village only from a distance, proceeded back to Mexico with reports as enthusiastically misleading as those of Cabeza de Vaca (Scurlock 1987: 92).

Soon a new Spanish expedition dedicated to finding gold and silver and to Christian crusading was organized under the leadership of Francisco Vasquez de Coronado. Entering New Mexico in July 1540 near the place of Esteban's death, Coronado, with some 300 Spaniards (including three women) and 800 Mexican Indian allies, began a 2-year exploration and military campaign against the Rio Grande Pueblos and Plains Apaches as far east as modern Kansas. Expedition headquarters during the severe winter of 1540–41 were made at Kuaua, a Tiguex pueblo on the west bank of the Rio del Norte near the modern community of Bernalillo. Coronado, faced with shortages of food, clothing, and fuel for heating in the extreme cold, began to appropriate these necessities from the inhabitants of nearby pueblos. This soon led to conflict and escalated to retaliatory raids by the Pueblos and sieges by the Spaniards until the Tiguex villages in the area were subjugated. Following a lengthy exploration onto the Great Plains and a second winter of hardship, the army broke camp on the Rio del Norte and returned to Mexico in 1542. Although the expedition was a failure from the viewpoint of those who had expected the discovery of vast mineral wealth in the region, information on the Pueblos and their water- and soil-rich river valley and flanking mountains with abundant game, forests, and grasslands piqued the interest of some Spaniards. The possibility that mineral riches might be found in the region also persisted (Scurlock 1987: 92).

In 1581 a Franciscan lay brother, Agustin Rodriguez, and a military captain, Francisco Sanchez Chamuscado, led a small party of Spaniards from the new mining frontier of southern Chihuahua on a more direct route to New Mexico, to La Junta on the Rio Grande, then upriver to El Paso, then northward to the Piro, Tiguex, and other Pueblo settlements. This river corridor was also a long-time natural route of movement for aboriginal peoples in the region. After exploring the Zuni area, the Galisteo Basin, and the plains east of the Pecos River, two friars elected to remain in the Tiguex Province pueblo of Puaray when the main body of the expedition returned to Mexico the following year (Scurlock 1987: 92).

A few months after the return of the Chamuscado-Rodriguez expedition, Antonio de Espejo, a wealthy rancher, organized an expedition ostensibly to rescue the two friars who had remained in New Mexico. Reaching New Mexico in late 1582, he learned of the death of the two priests. While visiting a number of northern pueblos, Espejo learned of mineral deposits in the region. These stories led him on a search for gold and silver as far west as present Prescott, Arizona, an area where he did find a little silver in copper outcrops. Returning to Mexico, Espejo embellished and exaggerated the information on the potential mineral riches of New Mexico (Scurlock 1987: 92).

As Spanish civil authorities began considering colonization of New Mexico, Gaspar Castano de Sosa, lieutenant governor and captain general of Nuevo Leon, led his own colonizing expedition of some 160 persons into the territory via the Rio Pecos and the Pecos Pueblo in late 1590-early 1591. After subduing the population at Pecos, Sosa led his party west to Santo Domingo Pueblo, where he hoped to begin a permanent settlement. Before the would-be colonists could become established, a contingent of soldiers from Mexico arrived, arrested them for undertaking the expedition without a royal license, and escorted Sosa's ill-fated party back to Mexico (Scurlock 1987: 92).

In 1593 Captain Francisco Leyva de Bonilla led another illegal expedition into New Mexico from Chihuahua. Forsaking his ostensible goal of campaigning against the Toboso, Gavilan, and other Mexican Indian groups who had been raiding ranchos and stealing livestock in northern Mexico, he marched as far north as San Ildefonso Pueblo. There his party spent at least a year committing depredations against the Pueblos, including the abduction of women as slaves. In 1594 the Bonilla expedition traveled eastward in hopes of rediscovering Coronado's Quivira (Kansas). On the Arkansas River, one of Captain Leyva's soldiers killed him and took command of the expedition. Not long afterward the Spanish forces were attacked by Wichita Indians; only a boy and a mulatto woman survived. Also surviving was the legend that the Spaniards had found large quantities of gold in the area (Scurlock 1987: 92).

Settlement Patterns

Following the five Spanish exploratory expeditions conducted in the region during the previous 58 years, Juan de Onate brought the first Hispanic settlers up the Rio del Norte to northern New Mexico in 1598, reaching San Juan Pueblo on the east bank of the river, just above the confluence with the Rio Chama. Here he founded the colony and the Spanish seat of government for the province of New Mexico. Subsequently, the capital, named San Gabriel, was moved to Yunge Pueblo, across the Rio Grande. Like those Spaniards before him, Onate did not find abundant precious minerals in the region, but he did carry out a relatively successful colonization and mission program of the Pueblo region over the next 9 years. In addition to religious activity, the basic purpose of the new seat of government and colony was to secure the Spanish frontier, which here marked the most northerly of settlements at that time, against indigenous or foreign threats. In the first few years of colonization, the Spanish settlers relied to a great extent on the Tewa Pueblos for housing and food production, primarily corn, and some wheat grown from seeds brought by Onate's expedition (Ford 1987: 74–75).

Spanish settlement subsequently spread southward down the river, into the Middle Rio Grande Valley at Cochiti and stretching as far south as the Socorro area (Fig. 25). The Spanish later named this reach Rio Abajo, and that above Cochiti, to Taos Pueblo, the Rio Arriba. The capital was moved from San Gabriel to Santa Fe in 1609–10. Missions reached the Bernalillo to Isleta section of the valley by the 1620s (Simmons 1982: 36–39). Estancias, or large ranches, or more rarely, haciendas, were established on some 35 encomiendas, formal grants of portions of Pueblo lands made to Spaniards who ostensibly were to care for these Indians. In return, they were to receive a tribute from residents of the nearby pueblo. Annual tribute was basically a manta (blanket) or a hide and a fanega (1.5 bushels) of corn from each Pueblo Indian (Ortiz 1980: 32). The encomenderos oversaw livestock raising, farming, and programs involving the Pueblos, whose villages were near the ranches. Although it was illegal, these Indians were commonly forced to work for the encomendero, as well as to pay tributes (Anderson 1985: 353–363).

Prior to the Pueblo revolt of 1680, there were 23 extant estancias or haciendas in the study region (Hackett and Shelby 1942: 228, 380). In addition, there were scattered settlements of ranchos, or small farms-livestock operations, which were basic subsistence units of the average colonists. Labores, square tracts measuring 1,000 varas on each side, were given to farmers. Also part of this early colonization were small (about 106 acres) land holdings known as caballerias, which cavalry men or officers received from the government. A foot soldier received about one-fifth of this acreage; this parcel was called a peonia (Carlson 1990: 6). Those who were primarily livestock raisers were granted at least a sitio, or a square league (about 6.76 square miles). Five sitios, about 34 square miles, composed an estancia or hacienda.

There were also 35 missions established at pueblos in the study region by the 1630s. The missionaries introduced stock raising, adobe brick construction, and new crafts, such as the weaving of wool on European looms and leather working, to Pueblo residents. Some were "employed" as livestock herders and gardeners (Dozier 1983: 49). This usurpation of Pueblo time and effort by missionaries and Spanish officials meant they had little or no time for work in their own fields or to hunt and gather (Jones 1979: 109–110; Simmons 1969: 10–11; Westphall 1983: 3–4, 8, 123–124).

As mentioned, the new Spanish province was divided into two administrative units, the Rio Arriba and the Rio Abajo. These two areas were also environmentally distinct; the upper river (Rio Arriba) extended from Taos to La Bajada near Cochiti Pueblo and consisted of higher, colder, and narrower valleys in the Rio Grande drainage. The lower river (Rio Abajo) reached from Cochiti to below Socorro and was lower in elevation, milder in climate, and richer in broad and fertile bottom land in the river valley than the first district. These basic differences in resources and climate determined that smaller and less influential land holders characterized the Rio Arriba, whereas larger land holders with considerably more socio-political power evolved in the Rio Abajo (Westphall 1983: 8–9).

The new colony was further divided into six rural districts, or alcaldias, each of which was administered by an alcalde mayor. His duties included overseeing the distribution and use of lands, waters, and laborers. Some alcaldes could not read or write, and therefore land and water transactions in their jurisdiction were not always recorded, which led to conflicts of ownership and use. They also illegally took Pueblo land and water and allowed Hispanic settlers to "squat" or otherwise use Pueblo lands (Tainter and Levine 1987: 89; Westphall 1983: 15, 112, 126).

As stated previously, the earliest communities and estancias were located at or near Pueblo villages, which in turn were situated along streams, on some of the best arable lands with dependable supply of surface water (Simmons 1969: 10). Poorer settlers lived in scattered ranchos, due in part to scarce arable lands in the Rio Arriba, located on or near irrigable streams or other surface water, such as springs or cienegas (marshes), with fields nearby. This settlement pattern was thus determined by the "lay of the land," especially in the Rio Arriba. Irrigation ditches, field locations, pastures, and the settler's home itself were laid out in relation to local topography, available water, vegetation types, and arable soils. Located immediately around the rancho home were outbuildings for food storage or livestock, irrigated gardens, orchards, and small meadows called vegas. Fields were generally located farther from the settler's house, and grazing lands still farther away. The topography of the land determined, in part, drainage, wind movement, and temperature variations, something the farmer-rancher had to know and understand if he were to successfully grow crops (Briggs and Van Ness 1987: 158–159, 181; MacCameron 1994: 27, 29; Simmons 1969: 13, 17).

A new seat of government, Santa Fe, was established in 1609–10 and declared a villa, or formal administrative town. About a century later, Santa Cruz and Albuquerque would be established with this designation (Jones 1979: 10–11, 115–118).

After Spanish reconquest of New Mexico in 1693–96, the capital was reestablished at Santa Fe, and some residents resettled old pueblo, estancia, and hacienda sites and fields. Resettlement was accomplished primarily through government land grants (Fig. 26). There were two basic types of land grants (mercedes reales) made to

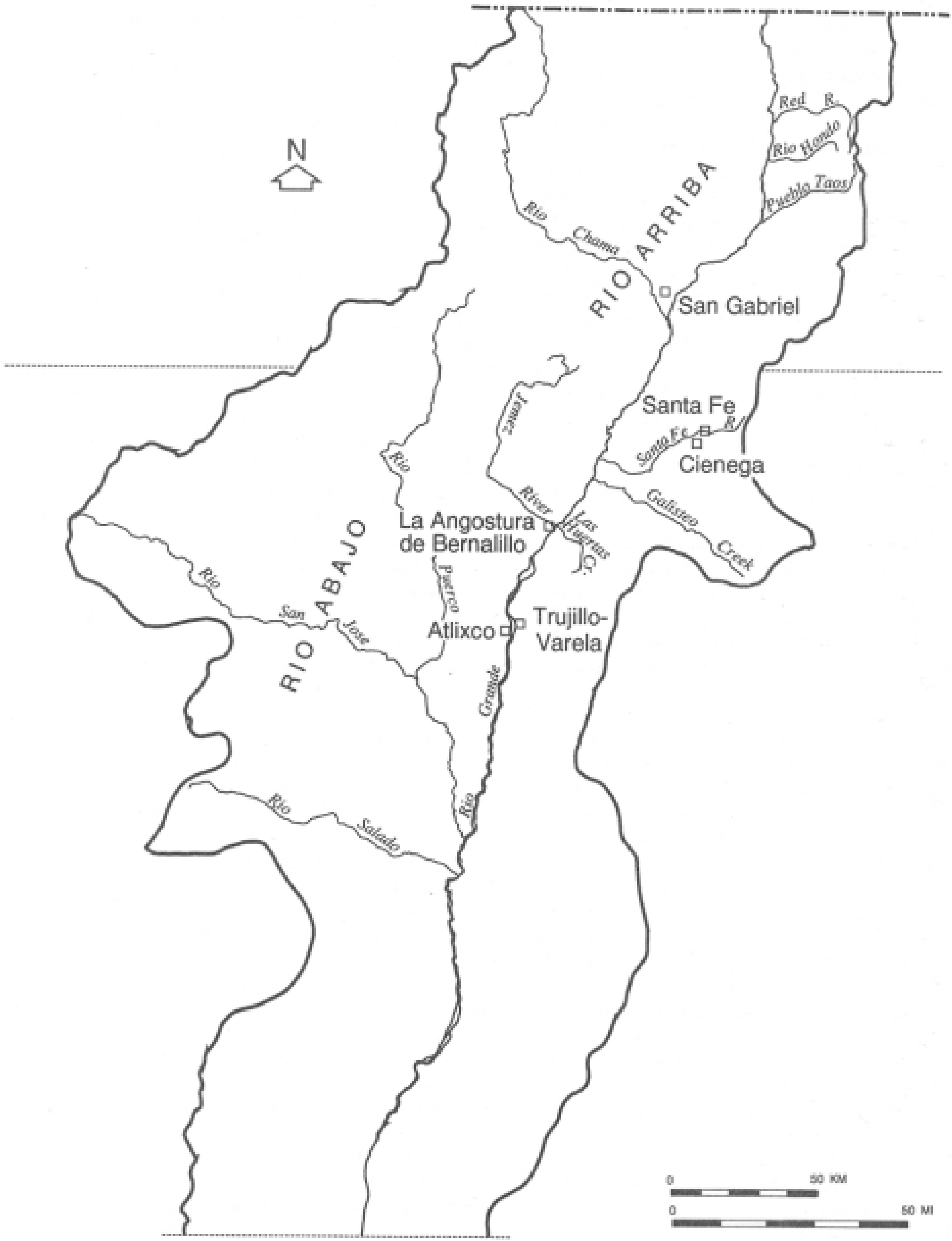

Figure 25—Some early Hispanic settlements, 1598–1680.

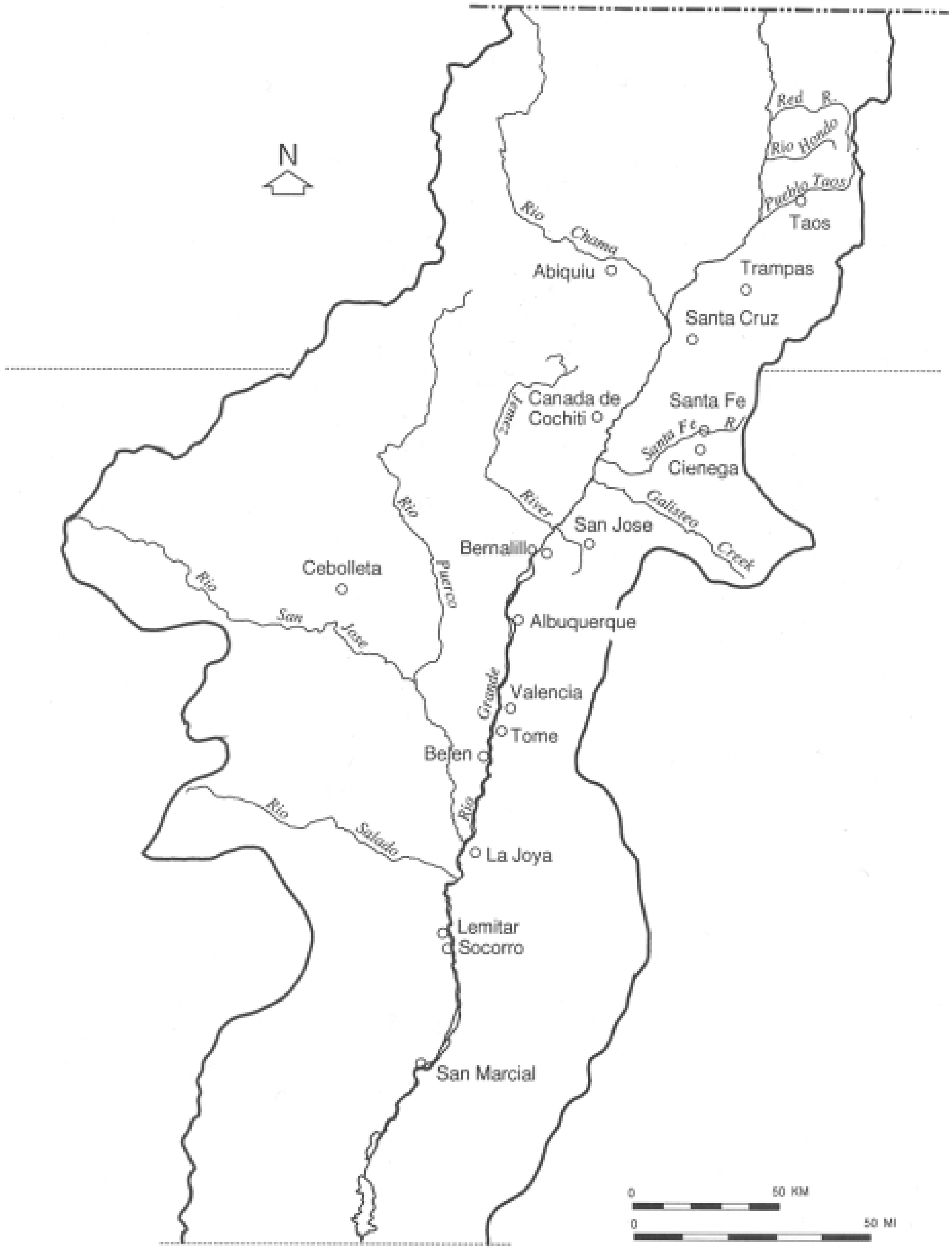

Figure 26—Major Hispano settlements, 1693–1821.

Spaniards in the 1700s-early 1800s—those to individual citizens and those to a group of settlers. These private individuals were usually prominent men who were former military personnel or their descendants to whom the government owed salary payments. These grants were given to foster and maintain a livestock industry, and owing to the relatively low carrying capacity of the land, they were large in size.

Private grants usually evolved to share some of the same settlement characteristics of communal grants through the giving of arable tracts by the private grantee to any newcomer or male coming of age who wanted farm and limited grazing land. Settlers shared produce with the grant owner, which generally limited them to a subsistence level of living (Carlson 1990: 9, 11).

The communal grants were generally given to poor, landless families. Agricultural villages, either in the form of fortified plazas or clusters of scattered ranchos, known as poblaciones, were spawned by these grants. This settlement pattern fulfilled the government's strategy of "establishing effective political control with an assumed defensive bulwark [better] than did the sparsely populated private grants" (Carlson 1990: 9). In all, there were 113 private and community grants, totalling 7,294,190 acres, given by the Spanish government between 1693 and 1821 (Westphall 1983: 11). Those granted in the Middle Rio Grande Basin between 1693 and 1846 are shown in Fig. 27 and listed in Table 34.

Land grants required the same basic ecological elements as the early settlements: arable soils, relatively abundant surface water, grazing lands, gathering and collecting areas for building materials, fuelwood, and medicinal and edible plants. Every land grant resident had communal rights to use pasture and wooded lands, collectively called ejidos. Residents could also hunt on these lands. Water holes, known as aguajes, springs, and all subsurface water (wells and springs) were also for communal use for watering livestock (Briggs and Van Ness 1987: 17–19; Carlson 1990: 32–33; Westphall 1983: 10). Following harvest, grazing of stubble on private farmlands was also a communal right. This system, which embraced the principle that no individual had the right to monopolize and use these natural resources, provided for community subsistence and individual well-being (Briggs and Van Ness 1983: 189; Westphall 1983: 198).

Prior to making a grant, a local administrator, the alcalde mayor, determined if the action would adversely affect any Pueblo settlement or third party, as well as the capacity of the land's resources (arable, grazing, and wood-producing) to support the proposed number of settlers. This system, although developed to ensure the economic survival of the colony, resulted in the long-term use or conservation of land and water in the region (MacCameron 1994: 29).

A third type of landholding prominent in this period was the small holding claim occupied by a ranchero. These were individual plots of land held by squatters on public or Pueblo lands. By 1846 there were more than 6,000 of these tracts in the region (Westphall 1983: 11, 193–194).

The historical relationship between Spaniards and the land is partially reflected in place names. Spanish laws of settlement, enacted in 1573, called for the naming of geographic features (Schroeder and Matson 1965: 5). Steele (1983: 293, 298–299) noted that the Spanish, by naming landscape features, "incorporated hitherto profane space into the sacred cosmos of order and beauty." Thus, these elements were elevated from the "natural world into their Spanish world." The function of a place name for a natural feature was to denominate and to dominate. Examples of common names of topographical or other ecological features include cuesta (slope) angostura (narrows), cieneguilla (little marsh), atrisco (place of the waters), and algodones (cotton fields). Settlements at or near these features commonly took that name.

Natural features or villages were also named for animals, such as mosca (fly), gallinas (turkeys), pajarito (little bird), ojo del oso (bear spring), and las nutrias (the beavers). Some locations or settlements were named for plants, such as Alameda (cottonwood grove), Jarales (willows or oshiers), and Pinos (pines) (Pearce 1965: 4, 75, 105, 113, 121; Steele 1983: 298–299). Native American names for geographical locations were generally retained, but they were frequently assimilated into Spanish sounds, syllables, and spelling. Examples include chaco, taken from the Navajo name chahatquel, meaning wash or river; nacimiento (nativity) from the Navajo name nazisetgo (gopher water); and Tesuque (the pueblo) from tat unge onwi (spotted dry place) from the Tewa Pueblo.

Spanish Population, Hygiene, and Disease

The first group of settlers, led by Onate in 1598, numbered 600–700 individuals; they lived at or around San Juan Pueblo. Death and desertion kept the growth rate relatively low in the early 1600s, but the Hispanic population, including "mixed bloods," did increase to about 2,900 by the 1670s (Table 35). These citizens were scattered from Taos to Socorro, west to Laguna-Acoma, and east to Gran Quivira and Quarai. Of this total, over 400 Spaniards were killed during the Pueblo Revolt of 1680 (Jones 1979: 119).

Vargas brought 100 soldiers and 70 families to resettle New Mexico beginning in 1693. By 1744, the estimated Hispanic population had grown to 505 families, totalling about 2,500 (Jones 1979: 120–123; Table 35). About 1,000 of these were residents of the Middle Basin in 1749 (Tjarks 1978: 60). By 1752 the total provincial population had more than doubled to 7,666; about 4,233 Hispanics were living in the Middle Basin in 1776 (Jones 1979: 61). In 1790, census figures vary from 9,172 to 15,000. For the Middle Rio Grande Basin there were minimally 5,991 persons of Spanish origin in 1790 (Jones 1979: 127; Tjarks 1978: 60–61; Table 35).

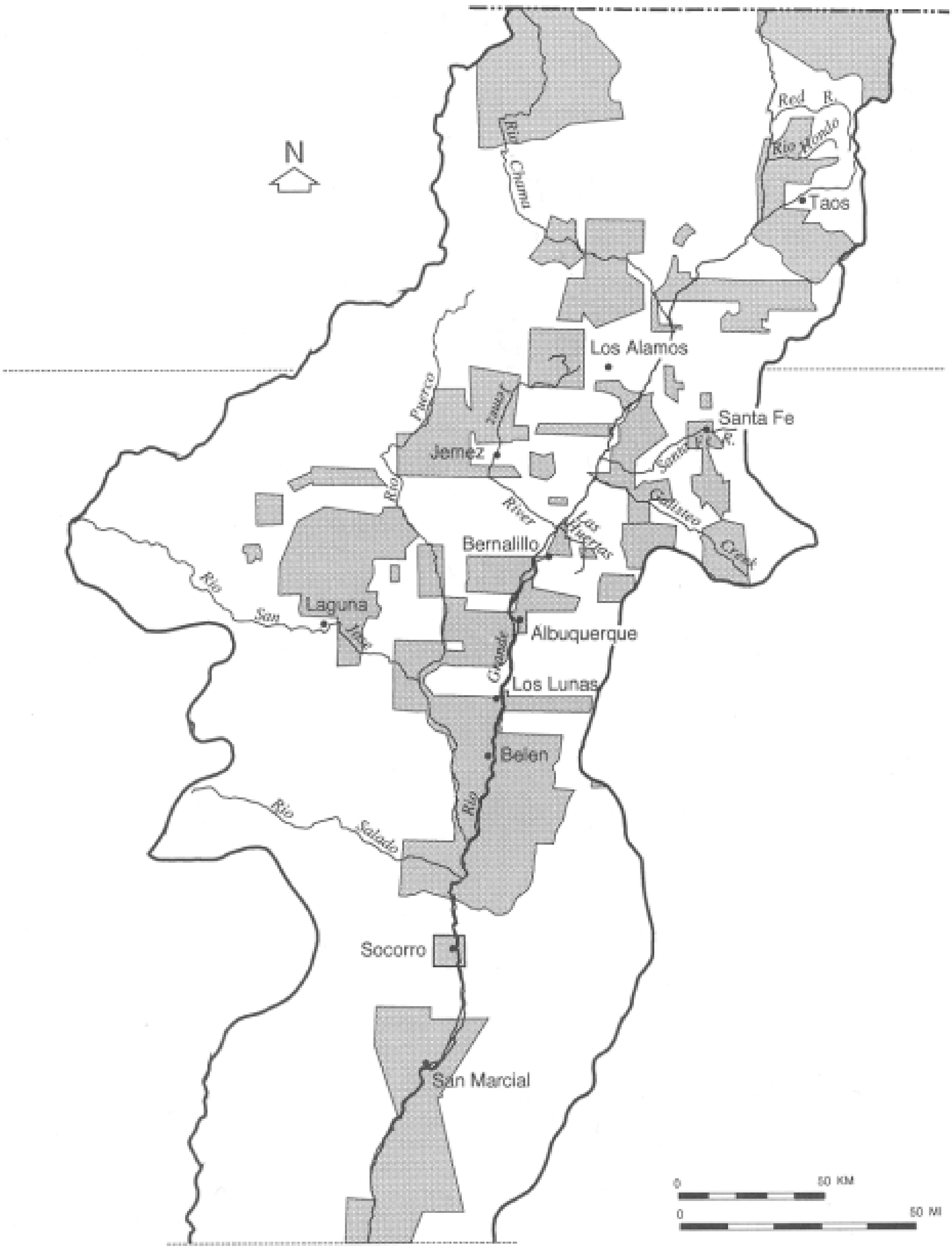

Figure 27—Spanish-Mexican land grants in the Middle Rio Grande Basin, 1693–1846.

Table 34—Private land grant claims in the Middle Rio Grande Basin, 1693–1846.

Date	Grant	Location
Northern Rio Abajo		
1700	Ranchos and other towns	North of Bernalillo
1701	Town of Bernalillo	North of Albuquerque
1710	Town of Alameda	South of Bernalillo
1728	Canada de Cochiti	North of Cochiti Pueblo
1742	Ramon Vigil	Frijoles Creek at Rio Grande
1742	Caja del Rio	Frijoles Creek at Rio Grande
1745	Angostura	North of Bernalillo
1754	Town of Pena Blanca	North of Galisteo Creek
1765	Las Huertas	East of Bernalillo
1766	Bosque Grande	South of Albuquerque
1768	Town of Atrisco	Southwest of Albuquerque
1819	Canon de Carnue	East of Albuquerque
1839	San Pedro	East of Bernalillo
1840	Town of Tejon	East of Las Huertas
Santa Fe area		
1693	Cieneguilla	Southwest of Santa Fe
1699	Juan de Mestas	Tesuque Valley
1699	Cuyamungue Pueblo	Tesuque Valley
1702	Jacona	Tesuque Valley
1715	Cienega	Southwest of Santa Fe
1731	Cuyamungue	Tesuque Valley
1731	Taloya Hill	East of Santa Fe
1742	Cerros Negros	East of Santa Fe
1744	Santiago Ramirez	East of Santa Fe
1752	Canon del Rio Tesuque	Tesuque Valley
1754	Las Truchas	Northeast of Santa Fe
1785	Canada de Los Alamos	South of Santa Fe
1806	Sierra Mosca	Northeast of Santa Fe
1808	Arroyo Hondo	North of Taos
1808	Sebastian de Vargas	South of Santa Fe
1820	Lady of Light	Southeast of Santa Fe
1820	Gotera	Southwest of Santa Fe
1844	Canon del Agua	Southwest of Santa Fe
1846	Sierra Mosca	Northeast of Santa Fe
Galisteo Basin		
1744	Aguilar	North of Galisteo Creek
1754	San Marcos Spring	North of Galisteo Creek
1782	Mesita de Juana Lopez	East of Santo Domingo Pueblo
1788	Cerrillos	North of Galisteo Creek
1814	Town of Galisteo	On Galisteo Creek
1827	San Cristobal	On San Cristobal Creek
1833	Ortiz Mine	South of Galisteo Creek
Rio Puerco Basin		
1753	San Fernando & San Blas	Straddles Rio Puerco
1762	Las Lagunitas	North of Salado Creek
1768	Santa Teresa de Jesus	North of Las Lagunitas
1769	Canada de los Apaches	Junction Rio Puerco and San Jose River
1769	Canada de los Alamos	West of Rio Puerco
1769	Agua Salada	South of Salado Creek
Rio San Jose Valley and Mount Taylor		
1767	San Miguel Spring	Northwest of Laguna Pueblo
1767	Nuestra Senora del Pilar	Northwest of Laguna Pueblo
1768	San Mateo Spring	Northwest of Laguna Pueblo
1769	Encinal	Northwest of Laguna Pueblo
1800	Town of Cebolleta	North of Laguna Pueblo
1834	Town of Cubero	West of Laguna Pueblo
Jemez Valley		
1768	Borrego Spring	East of Jemez Pueblo
1768	San Jose Spring	Northeast of Jemez Pueblo
1769	San Joaquin del Nacimiento	Northwest of Jemez Pueblo
1777	Town of Vallecito	Northeast of Jemez Pueblo
1786	Town of San Isidro	South of Jemez Pueblo
1788	Canon de San Diego	North of Jemez Pueblo
1798	Canon de San Diego	North of Jemez Pueblo
1807	Vallecito	Northeast of Jemez Pueblo
1809	San Isidro	South of Jemez Pueblo
1815	Espiritu Santo Spring	West of Jemez Pueblo
1860	Baca Location #1	Between Jemez Pueblo and Los Alamos
Southern Rio Abajo		
1716	San Clemente	West of Los Lunas
1718	Tajo	North of Isleta Pueblo
1739	Town of Tome	Southeast of Los Lunas
1740	Town of Belen	South of Los Lunas
1790	Santa Teresa	North of El Paso
1817	Town of Socorro	Around Socorro
1819	Pedro Armendariz	South of Socorro
1819	Town of Sevilleta	North of Socorro
1820	Pedro Armendariz	South of Socorro
1823	Town of Casa Colorado	South of Los Lunas
1825	San Lorenzo Arroyo	Northwest of Socorro
1826	San Antonito	South of Socorro
1839	Dona Ana Bend	North of Las Cruces
1845	Bosque del Apache	South of Socorro

Source: Sayles and Williams 1986

Spanish population growth in the 18th century was relatively slow due to deaths caused by various diseases and New Mexico's isolation, limited tillable soil, and lack of rich mineral deposits (Westphall 1983: 7). Hostile Indian groups and lack of adequate surface water were other factors.

As the regional settlement reached its maximum expansion to the north, east, and south in the mid 1700s, the government granted communal land along these frontier boundaries to genizaros, non-Pueblo Indians who had been converted to Christianity and who were the poorest class in the province. They provided some security against nomadic Indian raids; their communities commonly had to be abandoned then resettled one or more times due to attacks by the Comanche, Navajo, or Apache (Ortiz 1980: 47–48).

In 1817 the population, Spanish and mixed bloods, had increased to almost 28,000 (Table 35). Mixed bloods were

Table 35—Colonial Spanish population: Middle and Upper Rio Grande Basins (Rio Arriba – Rio Abajo).

Year	Population
1680	2,900
1744	2,500
1752	3,402
1789	13,982
1800	8,173
1810	26,926
1817	27,791

Source: Jones 1979: 119–131

called castas, colores quebrados, mestizos, coyotes, or lobos, depending largely on local use (Jones 1979: 129, 132). By 1846 the Hispanic population of the Middle Rio Grande Basin was about 54,000 (Harper et al. 1943: 57; Jones 1979: 129).

Hygiene practices were one cause of illness, which sometimes resulted in death, among settlers. Personal bathing and washing clothes were commonly done in irrigation ditches. Soaps used included those from local resources such as yucca or Apache plume root or plant ashes and tallow. These substances would have produced little water pollution. Refuse and dead animals were thrown in acequias, however, and did become a problem in some villages. Contaminated water from the ditches and food, bearing intestinal bacteria and protozoa, commonly caused infectious diarrhea, gastritis, and colic. Visitors or newcomers to New Mexico were especially prone to such ailments. Infectious diseases, such as diarrhea, increased in incidence during drought periods. The reduced water supply concentrated the infecting organism, and the associated limited food supply would cause malnutrition, which would decrease immunity to the agents (Kunitz 1976: 19). Respiratory infections were a common malady, especially in communal populations among the Pueblos and Hispanos. Colds were common, and whooping cough was prevalent among the young, as was measles (Simmons 1992: 208–209, 211–215).

Spanish Resource Use

Agricultural Fields and Irrigation Systems

In wider valleys, agricultural fields were long, narrow, generally rectangular in shape, and stretched from the higher edge of the floodplain to the lower, center of the valley, sometimes close to the stream that provided the necessary irrigation water. Alvar Carlson (1990: 31) wrote on the ecological uniqueness of these plots, which he called long-lots: ". . . [they] developed in the Rio Arriba apparently as a result of local assessments of physical conditions. They represent a practical and equitable method of partitioning irrigable land; antecedent of these riverine farms are not to be found in Spain, which did have communal grazing lands."

Irrigated fields were generally measured by varas (33.3 inches, or 2.8 feet); long-lots varied from 357 varas (1,000 feet) to 1,886 varas (5,300 feet) in length. The average width of these parcels was about 150 varas (420 feet). Allotted fields were controlled by the individual, but the construction and maintenance of the irrigation system was a community effort (Simmons 1969: 13–14; Westphall 1983: 199–200).

A main ditch, or the acequia madre, was dug from the water source above the village or rancho, usually created by damming a creek or spring (Figs. 28 and 29) with a brush, log, or stone diversion structure. Water from larger streams, such as the Rio Grande, was sometimes diverted into ditches by a wing dam. Ditch construction avoided removal of large trees and obstacles, which resulted in a winding configuration for this acequia. This ditch followed the Upper Valley edge contour to the long-lot (suerte). Water was released into the acequia at the dam, then moved by gravity flow through the ditch to gated laterals, or sangrias, which distributed the water over the fields. These acequias were also used to water livestock (Carlson 1990: 31–33, 36–37, 69–70; Westphall, 1983: 9, 183).

One of the best historic descriptions of acequia systems in New Mexico is that of W.W.H. Davis (1983: 196–197), who wrote

> The system of acequias, or irrigating ditches, is a subject so new to the American farmer, that an explanation at some length of the manner in which the land is cultivated by means of them may not be uninteresting. It must be borne in mind, as we have already remarked, that all the land capable of being farmed lies in the valleys through which runs a river or other stream large enough to supply the necessary quantity of water. Now, supposing the arable land to lie on both sides of the stream, as is the case of the valley of the [Rio Grande] Del Norte, the first thing for the proprietors to do is to dig a large ditch on each side of the river, called acequia madre, or mother ditch, from three to five yards wide, and from two to six feet deep, with strong banks. It is necessary to tap the river sufficiently high up, so that the level of the water in the acequia will always be above the land to be irrigated, else it could not be overflowed. The valleys are generally narrow, approached on either side by hills, and it is customary to cut the ditch along their base, when only one is required for a given tract of country, so that after the water shall have been distributed, the surplus can find its way back to the river. The main ditch is sometimes several miles in length, and resembles a miniature Erie Canal; and it is dug by the joint labor of all the proprietors along the line, each one being required

Figure 28—Hispanic farmer cleaning acequia, northern New Mexico, 1930s. Courtesy Museum of New Mexico, Santa Fe (negative no. 58870).

> to furnish a number of hands in proportion to his land to be irrigated.
>
> The acequia madre being completed, in the next place the inferior proprietors dig smaller ditches tapping the main one, for the overflow of their lands that lie adjacent to the point of junction. These are called contre acequias, or cross ditches. Still smaller ditches are constructed to convey the water on to the land of the individual owners, being always dug upon the highest part of that intended to be irrigated.

The irrigated field system served to integrate "man, land, and water over time and space" and "contributed enormously to the maintenance of ecological boundaries that correspond physically to the geographical limits of the microbasins drainage system" (Briggs and Van Ness 1987: 187). This system assured the individual farmer and his community of access to and virtual control over the local water supply. This configuration also ensured that population growth and close-knit social organizations were facilitated as well (Carlson 1990: 23). Diversion dam-acequia systems adequately provided a means of replenishing topsoils eroded by wind and water and nutrients used by crops; rich silt carried in the irrigation water was disseminated over the fields. Some low-lying fields and pastures were also subjected to the deposition of rich sediments carried by overbank flooding of area streams. Conversely, severe flooding washed out irrigation systems, damaged crops, and cut into fields. Like the Pueblo, however,

Figure 29—Stone dam-reservoir bed, Ojo del Oso, Placitas, Sandoval County. Photo by author.

Table 36—Irrigation in the Middle Rio Grande Valley.

Year	No. of ditches	Acres
1600	22	25,555
1700	61	73,580
1800	70	100,380
1850	80	123,315
1880	82	124,800
1910	79	45,220
1925	60	40,000
1950	?	172,400

Source: Sorenson and Linford 1967: 154, 156

the ranchero generally adapted to these vagaries successfully (Simmons 1991b: 71).

In 1600 there were an estimated 22 ditches, irrigating some 25,555 acres, in the Middle Valley (Table 36). Between 1600 and 1700, some 39 new ditches were constructed in the Middle Valley, bringing the total to 61 ditches irrigating about 73,580 acres. Over the next century there were 9 more ditches constructed and an additional 26,800 acres of irrigated land. By 1850 there were 10 more ditches and 22,935 more irrigated acres. The total number of ditches peaked at 82 in 1880, after which time there was a decline due to environmental problems—a rising water table, a build-up of salts in and waterlogging of soils, and a lack of sufficient water because of upstream diversions, mainly in the San Luis Basin of southern Colorado (Sorenson and Linford 1967: 154, 156).

Spanish Livestock Raising

The grazing of livestock began in the study region in late 1598, the year that Juan de Onate led the first Spanish settlers and 4,000 sheep, 1,000 cattle, 1,000 goats, and 150 mares with colts to the Upper Rio Grande Basin. Some of the wealthier individuals brought their own livestock as well. These parent flocks of early Spanish herds grew, and from these animals new livestock grazing operations were begun at a number of missions and other settlements in northern New Mexico. As early as 1630 overgrazing occurred at some of these locales (Baxter 1987: 4; Ford 1987: 85–86; Simmons 1991: 96).

As indicated, livestock raising became an important component of the subsistence economy of the average Hispanic settler. Sheep, goats, cattle, oxen, mules, horses, burros, and pigs provided meat, hides, wool, lard, and transportation. They also produced manure, which fertilized fields, and provided hoof action, which trampled grain on the threshing floor (Fig. 30). The average settler's herds and flocks were generally small (20–100 animals), while those of the wealthier land holders were large (several hundred to many thousands) (Briggs and Van Ness 1987: 188–189).

Sheep, not cattle, soon became the principal Spanish livestock raised in the region, for three primary reasons: (1) high protein meat, hides, and tongues of buffalo were commonly available through trade with the Indians or hunting on the eastern plains; (2) the nomadic Indian raiders preferred cattle to sheep; and (3) mining settlements in Chihuahua and Durango to the south provided a strong market for New Mexico sheep, which were annually driven down the Rio Grande Valley to these areas (Simmons 1988: 7). Also, the most popular breed of sheep, the churro, was well adapted for the semi-arid rangelands found in the region. Having the ability to obtain moisture from plants, this breed could survive drought conditions better than other sheep or cattle (Baxter 1987: 20). Their long, staple wool also provided protection against severe winter conditions.

The Spanish employed a transhumance system of livestock grazing based on seasonal availability of forage plants and water. Beginning in the spring, the sheep, goats, and cattle were moved from their lower, protected winter pastures and herded into the grant uplands, or commons, following the appearance of spring grasses and shrubs from the pinyon-juniper to the mixed conifer zone. By early summer the stock had been herded as high as subalpine meadows, or even up to the tundra above 12,500 feet in northern New Mexico. These uplands, with their understory and meadow grasses, were common lands shared by the Hispanic villagers. In the 18th century some land grants in northern New Mexico were made exclusively for the purpose of grazing livestock (Bailey 1980: 54; Briggs and Ness 1987: 160–161, 166–167, 189).

In general, livestock numbers increased over most of the 17th century and dropped sharply during the post revolt-reconquest period. The successful Pueblo Revolt of 1680, which drove the Spanish south to El Paso, interrupted the development of livestock raising in New Mexico for 13 years. In 1693 the Spaniards reoccupied New

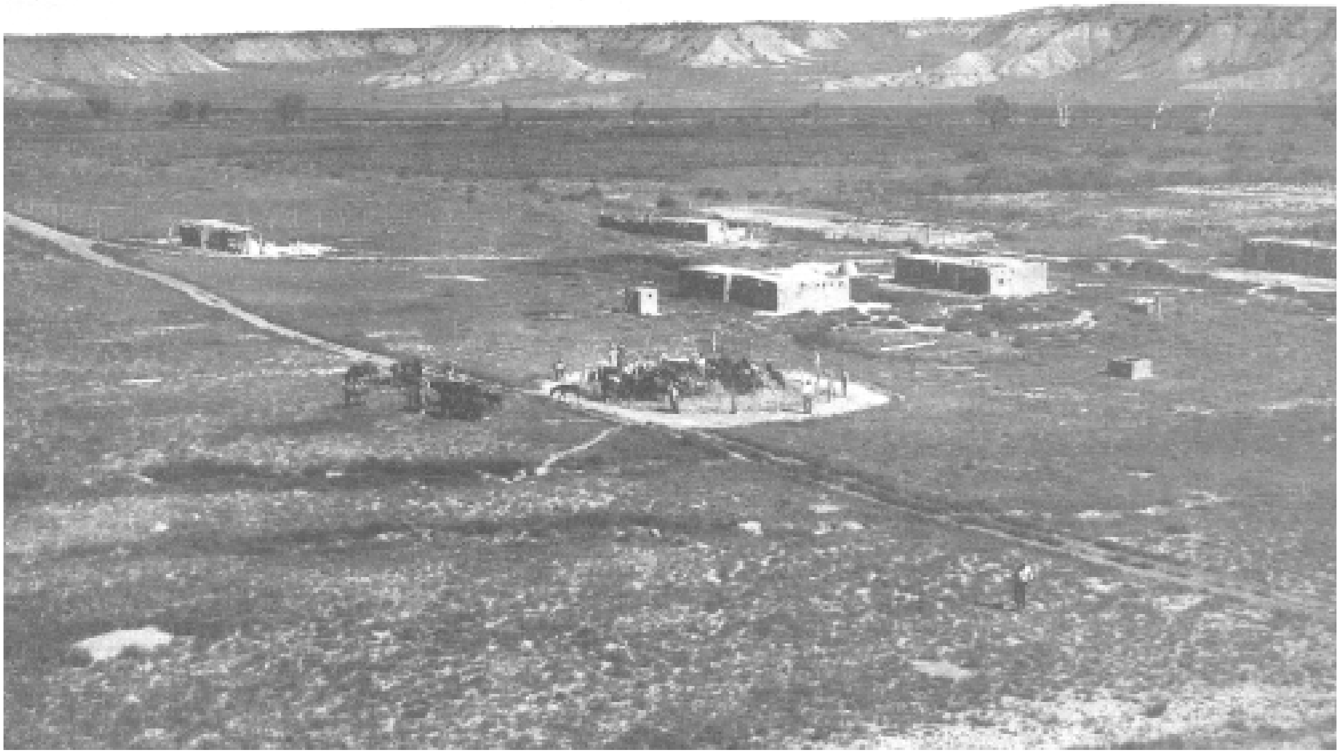

Figure 30—Hispanos threshing grain with horses, San Luis, Sandoval County. Photo by W. T. Lee, U.S. Geological Survey, 1917. USGS Photo Archives, Denver.

Mexico and, with 4,820 sheep, cattle, and goats, began livestock raising again. By the middle of the next century Spanish herds and flocks had increased to more than 100,000 animals, distributed from Taos to Belen. However, the total number declined to 69,000 in 1777 and prompted Governor Mendinueta to impose an embargo of exports of sheep and processed wool. Subsequently, under Governor Chacon from 1794 to 1805, sheep numbers increased sharply (Baxter 1987: 13, 16, 42, 51–52, 60–64; Table 37).

Pastures, rangelands, and meadows on virtually every Spanish land grant in northern and central New Mexico were grazed intensively throughout the 18th century until the mid 1900s (Fig. 31). As an example, goats and sheep from the villages of San Jose de las Huertas and Placitas at the north end of the Sandias, and from San Antonio and Tijeras on the south and east side of the mountains, were grazed in this range from about 1785 to the early part of this century. Meadows and springs were camping areas for herders and bedding grounds for their herds. Some 6,000 goats were in the Sandias prior to the establishment of the Manzano Forest Preserve, later designated part of the Cibola National Forest in 1908 (Cooper 1988: 4; Montoya 1983: 20–21; Nordhaus 1966: 17; Quintana and Kayser 1980; Scurlock 1983: 14, 16).

Table 37—Livestock numbers in New Mexico, 1598–1830. [a]

Year	Sheep	Cattle	Goats	Horses	Mules	Totals
1598	4,000	1,000	1,000	150	—	6,150
1694	2,100	—	—	—	—	3,000
1697	4,000	650	170	—	—	4,820
1757	112,182[b]	16,157	[c]	7,356	—	135,695
1777	69,000	—	—	—	—	69,000
1820s	1,000,000	5,000	—	850	2,150	1,008,000

[a] Does not include Navajo flocks.
[b] Includes Hopi flocks.
[c] Included with sheep.
Sources: Baxter 1987; Denevan 1967; Simmons 1988: 12

By the early 1700s Navajos in northwestern New Mexico adapted the Spanish sheep herding techniques learned from Pueblo refugees from the reconquest. Numbers of Navajo sheep ranged from 8,000 head in 1721 to 64,000 by 1742. In 1789, as a result of an order by Governor Concha that ewes would no longer be slaughtered or exported to Mexico, Navajo and Spanish flocks began to increase rapidly (Bailey 1980: 77, 111). This mushrooming in flock numbers was also probably due to above-average

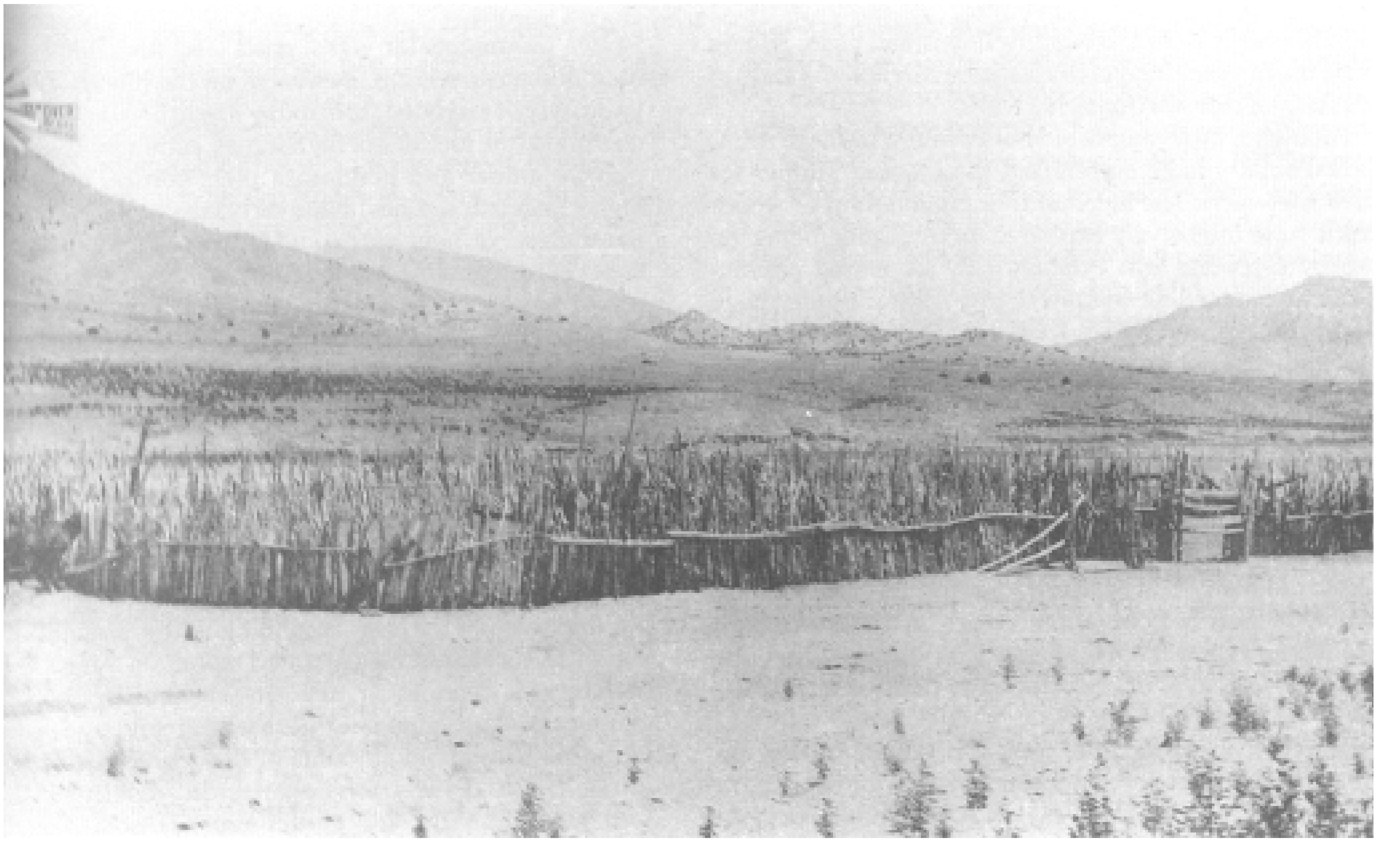

Figure 31—Hispanic brush corral with lambs on ranch near Santa Fe, 1892.

precipitation in the 1790s, which produced better grazing and browsing conditions. These larger livestock numbers, and the Navajo strategy of grazing sheep outwardly and radiantly from hogan or village sites during the day and then returning them to associated corrals at night, perhaps initiated the first major, regional overgrazing west and north of Spanish and Pueblo settlements. An average grazing area around hogan-village sites was probably about 5 square miles. When forage was depleted at a site, residences were simply moved (Scurlock 1990a: 70).

By 1820 there were at least one million Spanish sheep in New Mexico. An even higher number of sheep, up to three million, was reached between this time and the mid 1800s (Table 37). There were about 240,000 sheep and goats, 5,000 cattle, and 3,000 horses and mules in the Santa Fe-Albuquerque area alone. Apache and Navajo raids on Spanish and Pueblo sheep flocks reduced the sheep numbers to 377,000 by 1850. Losses due to droughts, blizzards, and predators also contributed to the decline. A major increase followed, with the total reaching five million sheep by 1880. This sharp rise in sheep was due to subjugation of nomadic Indian raiders, market demands from the east and west coasts, and the construction of the first railroad across the territory (Baxter 1987: 63, 90–91; Denevan 1967: 691, 696; Dortignac 1956: 56, 61).

Logging and Wood Use

Native Americans and Hispanos never logged on a large scale prior to 1846. Pinyon, juniper, ponderosa, spruce, and fir logs and poles were used for building houses, shade shelters, roofing, fences, and door-window framing by various historic Native American groups, and by Hispanos as well. Local logging and wood cutting occurred throughout the colonial and Mexican periods, and the amount of lumber produced by Spaniards in New Mexico was small due to limited technology.

Ponderosa pine was the primary wood used as building material; this included vigas, portales, corbels, and furniture. This wood was also used in making tool handles, ox yokes, cupboards, and santos. Vigas were sometimes made from Douglas fir, which was also used for plow shafts and bridge timbers. Pinyon pine was used for fuelwood and the manufacture of saddletrees, spinning-wheel legs, and plowshares. Juniper, a hard and strong wood, was used for lintels, short beams, corrals, and jacales. Juniper, too, was a preferred fuelwood (Jones 1932: 272–273; Scurlock and Johnson 1993: 277–278).

Cottonwood, found along rivers and streams in the region, was used in making dippers, ladles, spoons, mixing bowls, and wine barrels. It was also used in making carreta wheels, door and window lintels, and vigas. Frames were made from Gambel oak, as were stirrups and stays of blacksmith bellows (Jones 1932: 273).

Following the example of Southwestern Indians, Spanish colonial villagers preferred pinyon and juniper for their fuelwood. The surrounding pinyon-juniper woodlands were intensively exploited around settlements. As nearby fuelwood was exhausted by increasing populations at places like Santa Fe and Albuquerque, pack mules, burros, and horses were used to transport pinyon and juniper from up to 20 miles away (Fig. 32). Hispanic woodcutters and haulers sold or bartered their firewood in the villages and to missions located at pueblos. "Pitch pine," no doubt pinyon, was used for heating and cooking at one of New Mexico's three villa churches, Santa Cruz de la Canada, in the late 1700s. As more land grants were made on the llanos (plains) and mesas of eastern New Mexico, local residents derived some income from packing fuelwood back to population centers on the Rio Grande (Adams and Chavez 1956: 75; Cordell 1980: 45, 48; deBuys 1985: 257–258, 275; 103; Scurlock and Johnson 1993: 278–279).

Charcoal was sometimes used for cooking during the same period, and for blacksmithing, an old tradition brought from Spain. This fuel was produced not only from pine and juniper but also from oak and mesquite. Taught by the Spanish, Navajo jewelry makers used charcoal in their iron work as well. Although mining in Spanish New Mexico was limited, there was demand for charcoal for use in the smelting process at mines such as Dolores in the Ortiz Mountains and the New Placers at Tuerto in the San Pedro Mountains. A special-shaped axe was employed by the charcoal makers, or carboneros, in cutting the needed wood (Adams and Chavez 1956: 311–312; Christiansen 1974: 25–26; Simmons and Turley 1980: 7, 48).

The Spanish residents of Albuquerque, Atrisco, Alameda, Bernalillo, and the surrounding area cut trees in the nearby Sandia Mountains for vigas, posts, and firewood beginning in the early 1700s. Residents on the Elena Gallegos grant, which extended from today's North Valley of Albuquerque to the foothills of the Sandias, commonly used the pinyon-juniper and ponderosa pine, spruce, and fir in higher vegetation zones. In the early years of the Manzano Forest Reserve, later the Sandia District of the Cibola National Forest, grazing and logging permits were generally issued upon request. Grazing and timber and fuelwood cutting continued until termination in the 1950s (Nordhaus 1966: 17).

Figure 32—Burros carrying fuelwood, hay, and water (?) barrels, 1867 (from Richardson 1867).

Mining

As previously stated, potential mineral wealth was a major reason for Spanish exploration and settlement of the study region. Based on their experience in South America and central Mexico, Hispanics thought gold and silver would be easy to find and mine in New Mexico, but that was not the case. Beginning with Coronado, the region's streambeds, canyons, and mountain ranges were searched for rich mineral deposits. He and Espejo, Sosa, and Onate, who came later in search of gold and silver, found no substantial amounts of these precious metals. These men and early missionaries did determine that lead, sulphur, alum, and garnet deposits existed in the region (Northrop 1975: 8–10). After early settlement, a number of mines, primarily silver-bearing deposits, were recorded by various Spaniards during the colonial period (see chronology at end of this chapter). Most of these recorded mines were only claims to locales suspected of having mineral deposits. Some were prospected, but only a few were actually mined, and production was small (Christiansen 1975: 12–17; Schroeder 1977: 23).

Perhaps the earliest Spanish mining in the Middle Basin was for lead and turquoise in the Placitas and Cerrillos districts, long worked by the prehistoric Pueblo (Schroeder 1977: 21). From the mid 1600s to early 1800s, lead and a little silver and copper were mined by Spaniards at Tecolote in the Las Huertas drainage at the north end of the Sandia Mountains. This lead was made into musket shot for use by the Spanish military (Scurlock 1983: 12). Also in this general location, at La Mina del Tiro, gold may have been worked by the Spanish before the Pueblo Revolt; ore was definitely mined by the second decade of the 18th century. This was the only underground lode mining by Spaniards in the region documented to date. Lead was also produced from this mine; it, too, was primarily used for casting musket balls (Christiansen 1975: 17–18; Warren and Weber 1979: 8–9).

Non-precious minerals and rocks were also mined by the Spanish in the colonial period, such as mica from Petaca in Rio Arriba County. Sheets of this translucent mineral were used to cover window openings. Native copper deposits in Rio Arriba County near Abiquiu, and in Sandoval County in the San Diego Canyon of the Jemez

Mountains, were worked for the making of copper containers, utensils, and other items. Salt was procured from the lakes of the Salinas Province, a long-time source mined by the Pueblos and other Native Americans dating from the prehistoric period. Although undocumented, evidence of Spanish mining in the Rio Hondo near Taos and on Socorro Peak in the Rio Abajo was reported by later Anglo miners (Christiansen 1975: 20; Pratt and Snow 1988: chapt. 3, 58–60; Scholes 1937: 394–395).

The disruption of Pueblo mining and the usurpation of mines and ores by the Spanish were causal factors in the revolt of 1680. The Spanish took over the Tonque-Cerrillos area lead ore deposits, which had been mined by the Pueblo for use in manufacturing lead glaze for decorating pottery (Schroeder 1977: 24, 31). As a result, the Pueblo had to revert to use of mineral pigment paint (Peckham 1940: 122).

Hunting and Fishing

The first Spanish hunting in the region was that of soldiers, members of the early entradas. They, and later settlers, hunted bears, bighorn sheep, deer, elk, pronghorn, hares, rabbits, geese, ducks, and grouse for their meat, even though most had only bows and arrows or lances. Maulings of hunters, farmers, and herders by grizzly bears were not uncommon in the colonial period. More commonly, Spanish settlers relied on bartering with the Indians for wild animal meat and hides, except for the buffalo. Like the Pueblo, groups of Spanish hunters, known as ciboleros, traveled onto the plains of eastern New Mexico and western Texas in the fall to hunt these animals for their meat, marrow bones, tongues, hides, and tallow. Rarely, government personnel or the military were called upon by the highest authorities, including the King of Spain, to capture bison and elk and ship them to Mexico City, or even Madrid (Simmons 1991b: 19–22, 99–101).

Beginning in 1598, Hispanics fished in the Rio Grande and major tributaries with hook and line or throw nets (Simmons 1978: 35). Trout, catfish, "stickleback," and eels were the common species caught and eaten. Unidentified species of turtles, along with tortoises, were also taken as food (Bustamante and Simmons 1995: 12–13).

ANGLO AMERICAN PENETRATION, SETTLEMENT, POPULATION, AND RESOURCE USE, 1821–1960s

Introduction

The earliest non-Spanish people of European descent in the region were French or French-Canadian trappers and traders from the Mississippi Valley, who came to the region in the 18th and early 19th centuries. As foreigners, they were not allowed to remain in New Mexico, and when discovered, they were arrested, their equipment and furs were confiscated, and they were banned from New Mexico. Another foreigner, Zebulon Pike, an officer in the U.S. Army scouting the U.S.-Spanish boundary, and a few of his soldiers were arrested in 1807 in southern Colorado (then claimed by Spain). They were taken to Santa Fe and on to Chihuahua, where they were released. Pike kept a journal while in the region, which he used in preparing a relatively detailed report for the U.S. Government, which included references to precious minerals, furs, and other resources. His report caught the attention of Washington officials, politicians, and entrepreneurs. Subsequently, the first Anglo-Americans were attracted to New Mexico in the early 1800s, not to prospect for gold or silver, but primarily to trap or trade for furs and pelts from animals such as the beaver and river otter. Beaver pelts were bringing up to $4 apiece at this time; they were made into hats, which were popular on the East Coast and in Europe. These traders and trappers were freewheeling entrepreneurs, and their primary motivation was to make as much money in as short a period as they could. Most of these men, like the earlier French-Canadians, were arrested and sent back east because they violated a law prohibiting foreigners from trading in New Mexico (Weber 1971: 30, 31, 37, 41–48).

Fur Traders and Trappers

Trade with the United States was legalized when Mexico (including New Mexico at the time) gained independence from Spain in 1821. The Santa Fe Trail from Missouri to New Mexico was quickly "opened" over a route long used by Native Americans and Hispanos. Thus, at Santa Fe the trail linked with the old Camino Real, or Chihuahua Trail, which followed the Rio Grande into the State of Chihuahua (Figs. 33 and 34). Unlike other trails across the West, the Santa Fe Trail was not an emigrant road, but a route of commerce over which Anglos, and later Hispanic New Mexicans, introduced a variety of new trade goods and made large profits either by retailing, wholesaling, or bartering. Some items taken back to the states included furs, buffalo hides, and mules. Also, the trail was used heavily by fur trappers, who took thousands of beavers (sometimes illegally, without a Mexican permit) and many fewer river otters from the Rio Grande, Chama, Santa Fe, Pecos, and Gila drainages in New Mexico. The Anglo market also induced Native Americans to harvest furs, which they traded for metal tools, beads, alcohol, and other items (Beck 1962: 104–118).

The strong market for beaver felt spurred these Anglo trappers to roam over hundreds of miles of main stem and tributary reaches in search of fur-bearing animals. The large number of beaver methodically taken by the trappers caused a severe reduction or extirpation of local populations, as well as the river otter. Most regional streams have never recovered in terms of beaver populations reaching

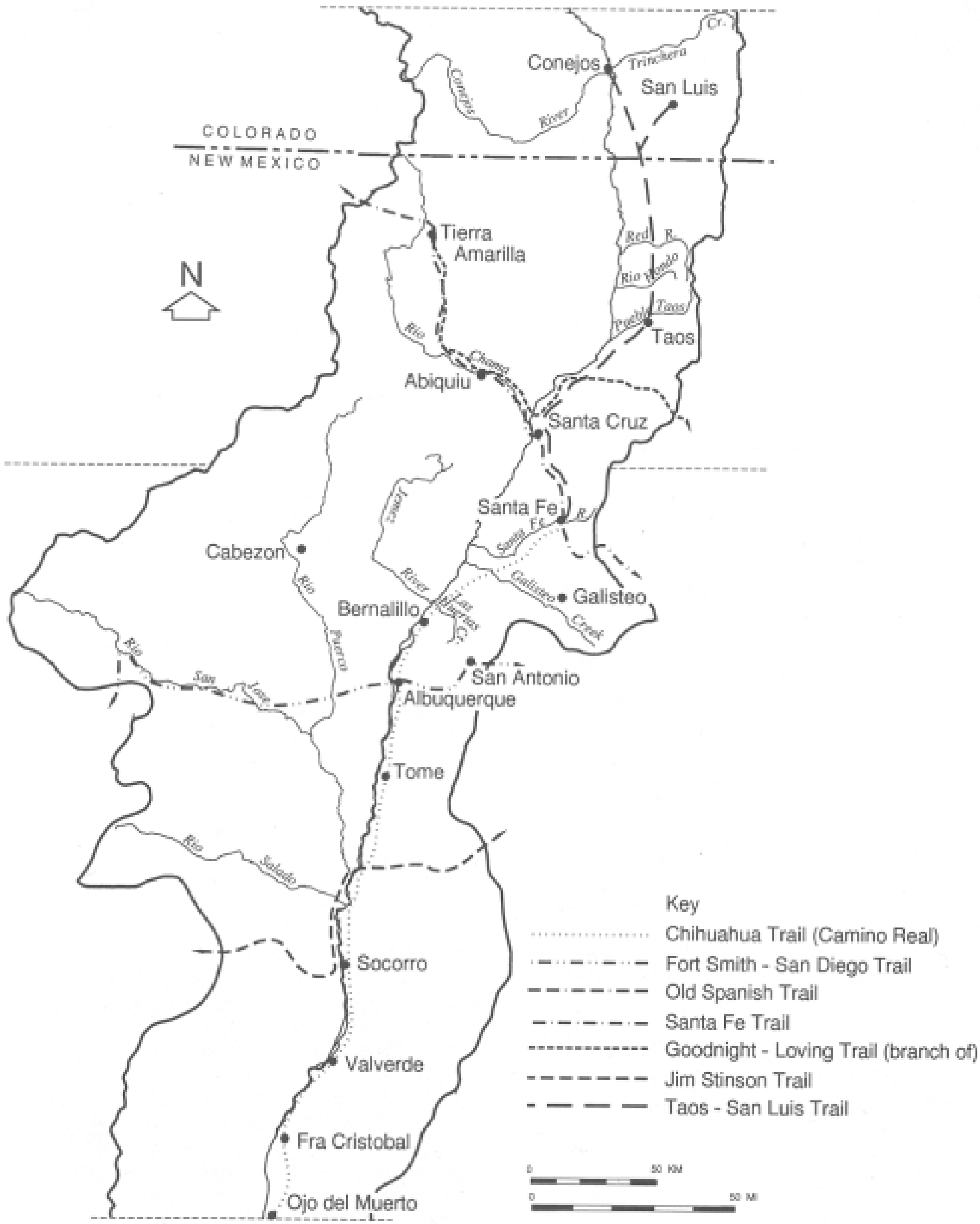

Figure 33—Major trails and roads, 1821–1880.

pre–1820 levels. Frequently, these trappers also hunted black bears, grizzly bears, elk, and deer for their hides and meat or simply for sport. The independent, free-spirited lifestyles of these men frequenting the mountainous West earned them the label of "Mountain Men." Taos became a supply center and southern Rocky Mountain rendezvous site for these individuals from the 1820s to the early 1840s. It also became the home of such colorful trappers-traders as Kit Carson, Charles Bent, and "Old Bill" Williams (Weber 1971: 51–65).

Three other old trade routes connecting Taos and Santa Fe to northwest Mexico, California, and eastern markets were used by Anglos for trading and trapping (Fig. 33). The first was the Sonora Trail, which left the Rio Grande near later Hatch and extended southwest to the Santa Rita mine near later Silver City, then followed the Gila River into southern Arizona and Sonora or southern California. Another, the Old Spanish Trail to the Great Basin and California, went northwest from Santa Fe, across southwest Colorado and central Utah, then branched in central Nevada, with one trail to San Francisco and the other to Los Angeles. New Mexicans drove sheep and mules and carried Navajo blankets over this route to trade in California. In exchange they generally received horses or gold. In 1849 both of these routes were used by Anglo Americans to reach the gold fields of California. The last trail was along the Canadian River, which had been used for hundreds of years, connecting with Pecos Pueblo and the Santa Fe-Albuquerque areas (Weber 1971: 68–69, 116–117; Fig. 33).

Anglo Settlement and Land Grant Adjudication

The Anglo settlers who followed the trader-trappers and the U.S. Army to New Mexico in the mid to late 19th century were looking for relatively cheap or free land, water, and other resources, with little or no regulatory use laws. Some dreamed of getting rich through making maximum profit aided by inexpensive local labor; some attained this goal, but most did not. As a group, they

Figure 34—Route of the Camino Real–Chihuahua Trail, Sandia Pueblo, Sandoval County. The Santa Fe rail line (right center) follows this old road in the Middle Valley. Photo by author.

brought new land use ideas and technologies for farming, ranching, mining, and transporting marketable resources.

Settlement

Some Anglos obtained land and water rights by trading with or purchasing from Hispanic owners, by marrying into Hispano families with land, by litigation and settlement of Spanish land grants, or by “squatting” on Spanish land grants or Pueblo lands. A few Anglos had received large land grants from the Mexican government prior to 1846, primarily in the Rio Arriba, or Upper Basin.

With the outbreak of the U.S.-Mexican War in 1846, American troops invaded and occupied New Mexico. The cessation of this conflict was formalized by the signing of the Treaty of Guadalupe Hidalgo in 1848. A major component of this treaty was the responsibility of the United States to protect the property and rights of Hispanic citizens in the new territory, especially land grant heirs. Subsequent court litigation as to who held legal title to the grants occurred over the remainder of the 19th century and into this century. However, congressional and judicial concerns led to “strict legalistic guidelines were drawn and equitable rights of the villagers were excluded. Legal procedures were lengthy and expensive. The most important policy which emerged was the denial of community ownership of the common pasture lands. These lands were declared public domain and thrown onto the market for homesteading . . .” (Ortiz 1980: 13, 90).

About 77 percent of the land-grant acreage, almost 9 million acres, held by Hispano and Indian subsistence farmers of northern and central New Mexico was lost to non-native interests. Of about 1,000 land grant claims in New Mexico, totalling some 10 million acres, only about 2 million acres were patented and confirmed. Most of the grant lands became public domain, state land, and railroad land. Much of the public domain in the mountains later became national forests. Location of surface water played a role in the resolution of these land claims and subsequent distribution of parcels. Attorney Thomas B. Catron, the most prominent land grant attorney of the time, controlled a substantial amount of land with significant natural resources in the region (Ortiz 1980: 92–93, 96; Westphall 1983: 143–144, 234).

To administer this public lands program and to establish the township-range grid, the Office of the U.S. Surveyor-General was created on July 22, 1854, in Santa Fe. The first duty of the Surveyor-General was to survey the public domain, primarily arable lands, but he was also responsible for making recommendations to Congress on land claims of Hispanos and Pueblos for resolution of ownership. Most of the township-range surveys in the region were not completed until 1876–84; some were not finished until much later. Although the Surveyor-General’s office could not legally survey grazing lands, this was done under the direction of Surveyor-General Henry M. Atkinson from 1876 to 1883, probably as a result of pressure from powerful cattle raisers. He had various financial interests in a number of New Mexico land and cattle corporations, himself (Westphall 1965: 1–4, 17–18, 24–28, 162–165).

The distribution of the public domain was based on a system of uniform-sized grids, imposed on the land, and effected through the use of modern surveying and map making. Unlike the Spanish custom of imprecise documenting and recording of land boundaries, ownership, and land transfers, the Anglo system entailed precise recordation and detailed transaction records (Briggs and Van Ness 1987: 193–194). The township, range, and section grid system inaugurated by the Anglos ignored regional topography and hydrology in terms of parcel boundaries. A particular square or rectangular parcel might contain no surface water or arable land, or fragmented resources. Thus, unlike the Hispanic system of land tenure based on a subsistence economy, the Anglo system encouraged the use of land and water resources as market commodities to be exploited for immediate profit (Briggs and Van Ness 1987: 194).

Anglo and Hispano settlers secured 160-acre tracts of public land through the Donation Act of 1854. However, claimants of Spanish or Mexican land grants were not allowed to file for a donation claim. Land holders under this act also could not acquire land under the Pre-emption Act, the Homestead Act of 1862, or the Mining Act of 1872. The 1862 act was amended in 1909 to allow individuals to file on and claim 320 acres (Brown 1970: 13; Westphall 1965: 1, 37, 43; Worster 1979: 87). The General Revision Act, passed by Congress in early 1891, authorized the President to set aside any part of the public domain. Many ranchers, lumbermen, and miners protested vigorously (Athearn 1985: 129).

Anglo homesteaders filed on public domain outside the land grants and otherwise claimed unoccupied land. Most of the public land available for homesteading in the study region was therefore away from the floodplains of lower, permanent streams, in upland valleys with grasslands, in canyons or on mesas with pinyon-juniper woodlands, and in the foothills or mid elevations of mountains at or near meadows and open forests. Homestead certificates in northern New Mexico increased from only three in 1879 to 263 in 1882. Homesteading in the region peaked during the following 10 years, spurred by completion of transcontinental railroads across New Mexico. Many homesteaders failed due to adverse weather, floods, inadequate water supplies, and lack of sufficient knowledge about farming or livestock raising in arid and semi-arid environments. Much of this public land was acquired by ranchers, private developers, or, later, the Forest Service (Kelly 1955: 396–397; Perrigo 1982: 107; Westphall 1965: 44–47, 168–169).

Anglo Population and Disease

As noted, the earliest and most rapid Anglo population growth over the entire period occurred in and around the existing Spanish communities along the Rio Grande, notably Santa Fe, Albuquerque, Belen, and Socorro. Following the U.S. Army occupation and the first Anglo settlers, 1846–50, there was a total of 61,547 non-Indian persons in the territory, which at that time included Arizona (Table 38). The large majority of the inhabitants counted were 54,000 Hispanics. Some 2,923 of these residents were born in other parts of the United States or in foreign countries.

By 1860 the total population, again including Arizona, had increased to 93,516. Among these were 6,647 persons born outside of New Mexico. There were 156 settlements in the region in that year; 107 of these had populations of less than 500. Ten years later, after New Mexico and Arizona were made separate territories, the total population was 91,874 (Bancroft 1889: 642; Clark 1987: 29; Harper et al. 1943: 57; Workers of the Writers' Program 1940: 329, 429, 431–432; Table 38). Over the remainder of the decade, 1871–80, population increased by 30 percent to 119,565; non-Indians numbered 109,793. This figure included 1,015 blacks, who were mainly soldiers or ex-military personnel, and Native Americans.

Following completion of the Santa Fe Railroad and subsidiary trunks, Anglo migration to the basins accelerated sharply (Fig. 35). In 1883 there were about 130,000 residents in the territory; Anglos numbered about 32,500 (Bancroft 1889: 723). The 1890 census counted 160,282, and the 1900 census, 195,310 persons (Table 38). Most of these individuals lived on farms and ranches or in settlements of less than 1,000 population. During the first decade of this century, the territorial population almost doubled when it reached 327,301. Most of this rapid growth was due to individuals homesteading, seeking cures for ailments, and ranching and farming in the southern part of the study region (Westphall 1965: 27; Workers of the Writers' Program 1940: 432–433).

Table 38—New Mexico population, 1850–1910.

Year	Hispanos/Anglos	Indians	Blacks	MRGB
1850	61,571[a]	30,000+[b]		
1860	93,516[a]			
1870	91,874			
1874		7,000[c]		
1880	119,565		1,015	
1883				130,000[d]
1890	160,282			
1900	195,310			
1910	327,301			75,036[e]

[a] *Arizona territory included.*
[b] *All Native Americans.*
[c] *Pueblo.*
[d] *Combined populations of Santa Fe, Albuquerque, Belen, Socorro.*
[e] *32,500 Anglos.*
Sources: Bancroft 1889: 459, 642, 723; Larson 1968: 116; Sayles 1986: 132; Westphall 1965: 27; Williams 1986b: 153, 156; Workers of the Writers' Program 1940: 329, 429, 431–434

Improvement of existing roads and construction of new ones also facilitated Anglo movement into the study region (Fig. 35). The first surfaced highway in New Mexico was built in 1915 from Raton to El Paso. From Santa Fe south, this route followed the old Camino Real, for which the new road was named.

Although medical practice was improving, older diseases still persisted. Smallpox, which had caused so many deaths in the colonial period, especially among the Pueblo, struck them and Hispanics again in 1852, killing hundreds (Thornton 1977: 99). In 1877 at Santo Domingo, about 20 men and 100 boys were killed by the same disease. Smallpox struck at Las Vegas that same year, where 82 people died, and also struck Arroyo Hondo, where mining was stopped due to the epidemic (Pearson 1986: 10; Perrigo 1982: 78–79). From late 1882 until 1898 outbreaks of smallpox occurred in Pueblo and Hispanic communities (Lange and Riley 1966: 383, 1970: 14; Thornton 1987: 102; White 1962: 101–102, 322). Other diseases that resulted in deaths included measles, diphtheria, whooping cough, and influenza, especially during the worldwide outbreak of 1918. Tuberculosis, introduced by Anglos, began to spread to Native Americans and Hispanics in the early 1900s (Baca 1995: 237–238; Simmons 1982: 345; Tiller 1983: 454).

Anglo Resource Use

Agriculture and Water

Many Anglo farmers brought new farm techniques, crops, and technology. Maximum commercial returns were pursued using steel plows, which penetrated the ground more deeply than Spanish plows. Other more efficient equipment and seeds of new crop varieties were also introduced. New farming techniques included crop rotation and wire fencing to protect fields from livestock. There was a marked increase in the number, size, and value of farms in the 1850s, due primarily to Anglos entering the region's agricultural industry. This technological investment and increase in farms and farm size was spurred by population growth, the increasing influx of military personnel, and the brisk traffic on the Santa Fe Trail (Bancroft 1889: 644–645; Beck 1962: 263–265; Sunseri 1979: 20–23).

In 1848 and 1850–51 the U.S. and territorial legislatures passed laws to protect existing irrigation systems, farm fields, and traditional water use rights. A number of other irrigation laws were passed in the 1880s and 1890s, primarily in response to population growth and associated pressures on agriculture (Clark 1987: 25, 31, 65; Westphall 1965: 25, 84; Wozniak 1987).

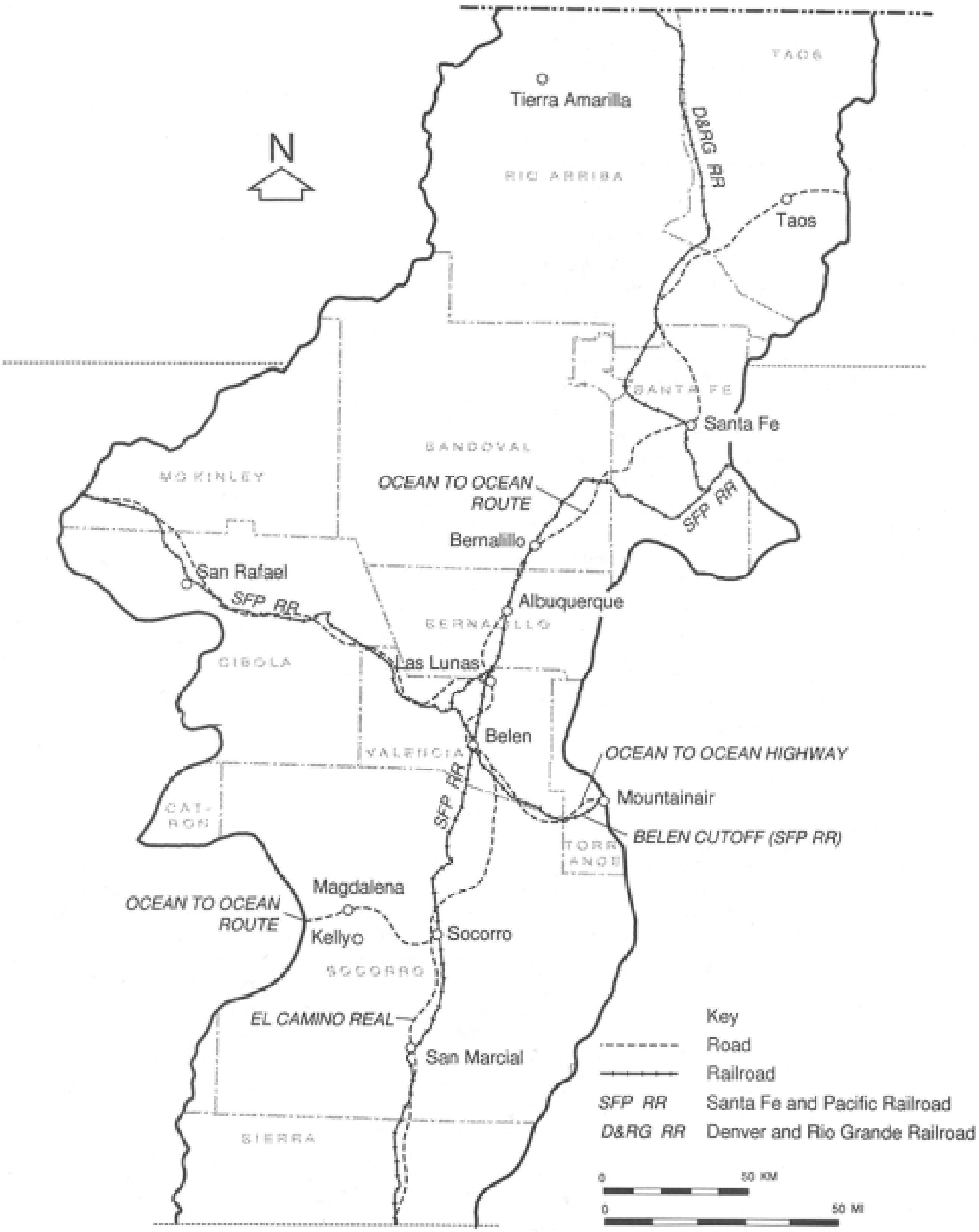

Figure 35—Major railroads, roads, and highways, 1879–1915.

The Federal Desert Land Entry Act of March 3, 1877, was intended to stimulate irrigation development through individual enterprise. A settler could buy a section of land for $1.25 an acre, up to 640 acres, if the claimant irrigated the land within 3 years (Buchanan 1988: 29). Claims could be made on unsurveyed public land. One problem with this act in New Mexico was the strict interpretation of the law by the General Land Office, which required irrigation of the entire 640 acres, something difficult to do in the region. This size tract was simply too large for most individuals to irrigate on their own. One result of the legislation was the control of substantial grazing land around surface water for the 3 years. Also, at the time of filing on the land, payment of only 25 cents per acre was required, so individuals could control sizable tracts along streams for 3 years before making proof of reclamation and completing payment. Because of these and other abuses, the law was revoked in 1892 (Westphall 1965: 77–81).

The newly created U.S. Geological Survey (1879) began a survey of the irrigation systems in the region in late 1888 (Follett 1896). This agency also established its first streamflow gauging station at Embudo in January of the following year (Beal and Gold 1988: 99; Wozniak 1987). A number of irrigation companies were organized locally, some of which failed by constructing ditch systems in environmentally unsuited areas (Westphall 1965: 82). Another important piece of legislation affecting irrigation was the Reclamation Act passed in 1902. This law authorized the Secretary of the Interior to construct irrigation projects in the western territories and states, and it established the U.S. Reclamation Service as a separate agency from the Geological Survey. Irrigation works were significantly expanded over the next 2 decades. Also, a small farmer could irrigate up to 160 acres with water from federal irrigation projects (Clark 1987: 79–82, 110, 168; Wozniak 1987).

An estimate of the land in cultivation in the Middle Rio Grande Valley when the U.S. Territory of New Mexico was created in 1850 was 87,880 acres, of which 40,185 were irrigated (Table 39). This land was planted primarily in corn, wheat, beans, and melons. The demand for Rio Grande water at this time averaged 2.75 acre-feet per acre (Hedke 1925: 15; State Engineer Office 1967: 78, 81).

In 1860 there were some 54,500 acres under irrigation, and 57,200 at the end of the decade. By 1870 there were 143,007 acres of "improved land" with 4,480 farms valued at over two million dollars. In 1870, the estimated number of acres of irrigated farmland in the territory was 57,200. About 85 percent of the farms in New Mexico during this period were less than 50 acres; in the study region, farms averaged 61 acres. By 1880 irrigated acreage had increased to 94,900 (Clark 1987: 29; Dryeson 1971: 181; Miller 1989: 81; Table 39). Corn, wheat, oats, barley, sorghum, rye, beans, peas, potatoes, hay, and tobacco were the major crops grown by Anglos, Hispanos, and Pueblos (Bancroft 1889: 768; Clark 1987: 29; Miller 1989: 132; Table 39).

Table 39—Irrigation agriculture in the Middle Rio Grande Valley, 1850-1942.

Year	Number of ditches	Irrigated acreage	Agricultural land acreage
1850	80	40,185	87,880[a]
1880	82	94,900	100,000 to 124,800[a]
1896	71	31,700	50,000
1910	79	45,220	?
1918	55	47,000	?
1925	60	40,000	?
1942	8[b]	60,000	118,000

[a] *Estimated figures*
[b] *Main canals*
Sources: Clark 1987: 29; Hedke 1924: 19–20, 1925: 15; Wozniak 1987

Ten years later there were 95,000 to near 125,000 acres in cultivation in the Middle Rio Grande Valley. Environmental problems, such as waterlogging, caused this total to drop to about 31,700 acres in 1896 (Table 39). Along the Rio Puerco Valley, from Casa Salazar to Cuba, the cultivated acreage varied from more than 18,000 in the late 1800s to 3,000 acres in the early 1940s due to incising of the river and lowered water table, erosion, increase in flood intensity and frequency, and drought (Harper et al. 1943: 51–53). The amounts of irrigated acres on this and other tributaries for 1898 are listed in Table 40. The completion of the Santa Fe Railroad and other major lines from 1879 to 1882 brought a large wave of Anglo farmers to the region. New, introduced crops included millet, sorghum grains, and kafir corn, all drought resistant. By 1900 there were more than five million acres under cultivation in the territory, and in 1910 there were 35,676 farms averaging

Table 40—Irrigation agriculture in the Middle Rio Grande Basin, 1898.

Drainage	Drainage area (square miles)	Number of ditches	Irrigated acres
Santa Fe River	480	44	5,920
Galisteo River	1,400	23	2,240
Rio Grande (White Rock Canyon to Albuquerque)	830	22	8,070
Jemez River	900	27	5,790
Rio Grande (Albuquerque to confluence with the Rio Puerco)	940	33	17,840
Rio Puerco	6,400	62	18,380
Rio Grande (Confluence of Rio Puerco to San Marcial)	800	16	5,790
Total	11,750	227	64,030

Source: Follett 1898: 81–88

316 acres (Beck 1962: 265–267). Major crops cultivated over the next 3 decades are shown in Table 41.

Livestock Raising

Anglo ranchers, like Hispano and Native American livestock raisers, faced a number of environmental problems, such as droughts, floods, windstorms, erosion, nutrient depletion of soil, accumulation of salts in soil, and insect infestations. Early in the period, a lack of adequate transportation to markets was also a problem. Anglo livestock raisers, primarily from Texas, brought the first large cattle herds to the Middle Basin since the early Spanish entradas. Sheep, however, remained the dominant livestock on pastures and rangelands in the region until the coming of the railroad in 1880. Demand for wool and mutton locally and in California gold fields after 1848 spurred Anglos, as well as Hispanos, to produce more sheep. Rio Abajo sheepmen drove thousands of sheep to the mines in California from 1849 to the late 1850s.

There were almost 400,000 sheep along the Middle Valley and on flanking uplands in 1846–50, not withstanding the loss of about 453,292 sheep to Indian raiders during this period. Jose Leandro Perea of Bernalillo alone owned 200,000 sheep. Some observers noted that "the hillsides and the plains . . . covered with sheep and cattle." In 1870 there were 435,000 sheep in the Middle and Upper Rio Grande basins (Carlson 1969: 28; Espinosa and Chavez n.d.: 75–78; Table 42; Abert 1962: 60–62, 65, 96–97).

By 1880 there were some 400,000 head of cattle in the territory. As mentioned, most of the cattle belonged to Texas ranchers, who had driven their cattle into the region to support the growing demand for beef, especially at logging camps, mining camps, railroad camps, and military posts. New breeds of cattle and sheep, better producers of meat and wool, were also introduced in the late 1800s (Athearn 1985: 130; Baydo 1970: 113, 125; Clark 1987: 54). By 1890 the total number of cattle in the Upper and Middle basins had sharply increased to 210,000 head (Bayer et al. 1994: 174; Harper et al. 1943: 49; Williams 1986: 120; Table 42).

Bernalillo County rangelands had 475,000 sheep and 41,700 cattle alone in 1883. By 1890, the total number of sheep in the Middle Valley had risen to 1,717,000 animals (Table 42). By 1900 the sheep population had increased to 1,732,000 head(Bayer et al. 1994: 174; Harper et al. 1943: 49; McCall 1851: 5; Ortiz 1980: 80; Rothman 1982: 28, 33; Simmons 1988: 8; Tiller 1992: 101–103; Fig. 36).

Most of the rangeland close to Middle Valley population centers had been overgrazed prior to 1846, and the sharp increase in livestock that occurred over the next 5 decades exacerbated the environmental decline. Three years after its organization in 1881, the Southwestern Stockmen's Association and local livestock groups attempted to control overgrazing in the region to some extent. In 1889 the Territorial Assembly passed an act to prevent overstocking, and the General Land Office began requiring ranchers to obtain permits to graze on public lands. The introduction of barbed wire, which led to the end of open range, generally prevented trespass and overgrazing of some ranges (Baydo 1970: 113, 125; Clark 1987: 54).

Most of the livestock in the region from the late 1800s to early 1900s were grazed on homesteaded or leased public lands, land grants in dispute, new forest reserve lands, or in trespass on Hispano and Indian grant lands. Texas cattlemen were especially aggressive in taking or

Table 41—Principal crops in the Middle Rio Grande Valley, 1919–1942.

Crop type	Acres
Corn	13,334
Wheat	5,900
Oats	708
Barley	354
Sorghum grain	354
Sorghum fodder	1,416
Mixed grain	236
Alfalfa	19,234
Hay (misc.)	3,540
Irrigated pastures	5,310
Truck garden	1,416
Miscellaneous	1,888
Orchard	1,652
Total	55,342

Sources: Scurlock et al. 1995: 93; Workers of the Writers' Program 1940: 82–83.

Table 42—Livestock numbers in New Mexico, 1850–1900.

Year	Sheep	Cattle	Totals
1850	377,000[a]	—	377,000
1860	830,000	—	830,000
1870	619,000	137,314	756,314
	435,000[b]	14,000[b]	449,000[b]
1880	2,000,000 to 3,000,000	400,000	2,400,000 to 3,400,000
1890	4,000,000		4,000,000
	1,517,000[b]	210,000[b]	1,717,000[b]
1900	3,500,000	843,000	4,343,000
	1,732,000[b]	211,000[b]	1,943,000[b]

[a] Does not include Navajo flocks.
[b] Middle and Upper Valley.
Sources: Baxter 1987; Carlson 1969; Denevan 1967; Miller 1989: 198; Simmons 1988

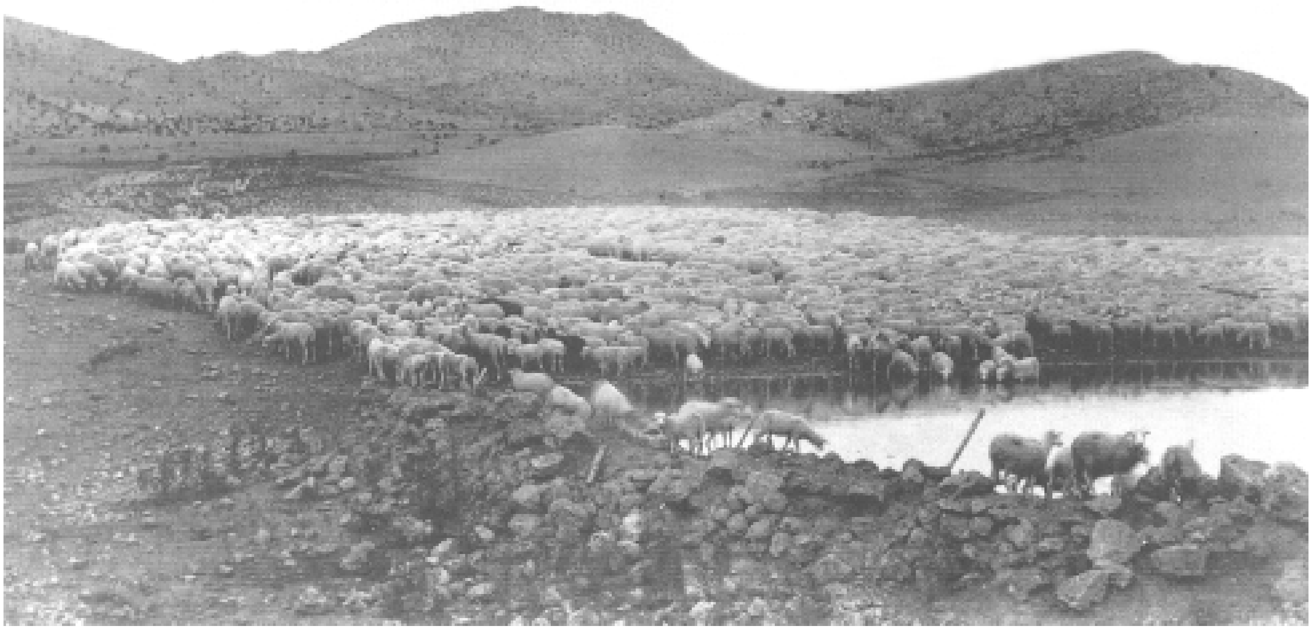

Figure 36—Sheep at the mouth (?) of Coyote Canyon, Manzano Mountains. Cobb photo, ca. 1900. Courtesy Albuquerque Museum (negative no. 1981.2.57).

trespassing on Pueblo and Jicarilla Apache lands. Hispanos also continued to trespass on Indian lands to graze their livestock. National forest reserves were created from old Spanish grant land or the public domain, much of which had been grazed for a long time. Many local residents, especially Hispanics who lost their free grazing rights on common lands, grazed their stock on the new forest reserves, for which permits were required beginning in 1912 (Bahre 1991: 116; Brown 1985: 124; Carlson 1969: 29, 33, 37, 39; deBuys 1985: 237–241; Denevan 1967: 699; Roberts 1963: 115–116).

Beginning in the 1920s, the Forest Service had to deal with permittees grazing more animals than agreed upon. Also, large livestock owners, many of whom were Anglo, were leasing or buying permits from smaller livestock raisers, who were primarily Hispano. The Forest Service stepped up enforcement to solve these two problems. Additionally, to prevent control of large areas of rangeland by a small number of wealthy individuals, the Forest Service began limiting the maximum number of animals that could be grazed on a single permit. For the Carson and Santa Fe national forests this was about 400 livestock units in the early 1980s (deBuys 1985: 242–246).

In the 1940s Hispano users of the public woodlands, forests, and meadows in New Mexico and southern Colorado began to abandon labor-intensive sheep herding and to switch to cattle, which can range over an area without human herders. The overgrazed ranges supported fewer animals; thus, there were fewer permits issued by the Forest Service. A changing economy, from a subsistence to a cash situation, also resulted in a steady decline in the number of Hispano permittees on forest lands (deBuys 1985: 247–249).

Logging and Timber

Native New Mexicans and Hispanos never logged on a large scale prior to the territorial period. However, population growth, military activities, mining, and other activities stimulated the development of the timber industry by Hispanos and Anglos. The demand for logs to saw into lumber was generated by the boom in building—military posts, houses, businesses, bridges, mine timbers, and railroad construction. Wood was especially needed on the treeless grasslands for use as building materials and fuelwood. Clear-cutting was generally practiced in mountain forested areas; only steep slopes were untouched in logging areas. A variety of logging tools and equipment, including cross-cut saws, double-bitted axes, large wagons and industrial harnesses, and draft horses, were introduced by Anglos. Portable and permanent steam-driven motors, rip saws, tables, and other equipment for sawmills were also introduced. Felling, hauling, and in some instances, floating logs in the Rio Grande were techniques new to the territory as well.

As early as the mid 1850s, Anglo American settlers were operating sawmills at Glorieta Pass and near Taos. The first planing mill was established at Las Vegas, New Mexico, in 1879, the year the Atchison, Topeka, and Santa Fe Railroad reached this community (Jones 1932: 3–4). Harvesting ponderosa and other mountain timber for use as lumber, railroad ties, or mine timbers caused relatively significant reduction in local woodlands and forests in the late 19th and early 20th centuries. Cross-ties for regular gauge rail lines were 8 to 8.5 feet in length, 6 to 7 inches in thickness, and 7 inches in width and were made from "green" timber. One railroad company constructing a line across New Mexico in 1885 used 937,240 feet of "native pine," which included pinyon as well as ponderosa pine, for ties. An estimated five million board-feet of lumber was consumed in New Mexico in 1886 (Bunting 1964: 11; Ensign 1888: 76, 80; Perry 1922: 521; Tratman 1889: 55).

The Santa Fe Railroad constructed a second set of tracks across northern New Mexico in 1914; a minimum of 16 million new ties were needed. The construction and maintenance of the first track in 1879–1907 had resulted in the exhaustion of tie timber on lands adjacent to the right-of-way. To supply the needed ties, the Santa Barbara Tie and Pole Company was started near the Santa Fe National Forest in 1909, and over the next 17 years all timber from the pinyon-juniper zone to timberline was cut on 65,750 acres of land (deBuys 1985: 227–230).

Stumpage price in 1932 was estimated to be $3 per thousand feet. About this same time, a Taos County company was selling narrow-gauge ties for 6 cents and standard gauge for 8 cents to the Denver and Rio Grande Railroad. About 4,000 ties a year from the Carson National Forest were sold by this company. In 1935 the volume of ties doubled over the earlier figure. Other ties were cut on a privately owned, old land grant along the Rio Pueblo and Santa Barbara valleys. Some 30 individuals clear-cut over 600 or 700 acres in these locations, which initiated erosion (Perry 1922: 521, 523; Weigle 1975: 209–210).

Fuelwood

An estimated 10,000 cords of fuelwood were used in the southern Rocky Mountain region in 1760–69 for cooking and heating. This figure doubled in 1770–79, remained about the same in 1780–89, then increased to 25,000 in 1790–99. With the arrival of relatively large numbers of Anglo-American settlers in New Mexico after 1846, demands for fuelwood accelerated. A burro load from the Sangre de Cristo Mountains, about half a cord, cost 25 cents in nearby Santa Fe at this time. Over the late 1800s Hispano woodcutters were the primary suppliers of fuelwood in communities, and some woodcutters were contracted by the U.S. Army at forts in the region, where wood consumption for heating and cooking was high. In 1861 fuelwood delivered to garrisons some distance from pinyon-juniper woodlands was bringing $3.75 for a cord of pinyon (Balcomb 1980: 52–53; Dobyns 1981: 96; Frazer 1983: 11, 180).

By the middle of the 19th century, following the Anglo conquest and settlement, annual fuelwood consumption had increased to 105,000 cords, and by about 1870 had increased to over five million cords. The estimate of fuelwood consumed by New Mexicans was 170,000 cords in 1879. Throughout the remaining years of the 1800s and into the 20th century, Hispano wood cutters from villages and towns in central and northern New Mexico, eastern Arizona, and southern Colorado supplied pinyon and juniper fuelwood to regional residents. Wagons, burros, or pack horses were used to transport pinyon and juniper wood from the mountains to towns such as Taos, Santa Fe, and Albuquerque until World War II. Cutters sold their fuelwood and fence posts at wood yards in these communities. Fuelwood use peaked in the region at 675,000 cords in 1918 (Reynolds and Pierson 1942: 9–10, 17–18). A decline followed due to the widespread use of natural gas for cooking and heating (Balcomb 1980: 52–53; Waters 1981: 36).

Mining in Territorial New Mexico generated extensive commercial use of pinyon, juniper, pine, and fir in the historic period. Vast stands of pinyon were consumed to make charcoal for fuel used in the smelting or roasting processes; "green" trees down to 2-inch diameter were preferred over dead wood. Sometimes horse or cattle manure was added to the fuelwood. One source stated that the pinyon, juniper, and other conifer wood was the best when at least 80 to 90 percent dry. Pinyon killed by fire was the next preferred source for smelting fuel (Christiansen 1974: 95; Ensign 1888: 77–78).

Charcoal for smelting and roasting was made by partially burning wood in virtually airtight kilns that could systematically and gradually exclude oxygen. Kilns varied in construction and design; fired brick, beehive-shaped stone kilns (Fig. 37) or simple pits covered with earth were used. Green wood was allowed to dry before it was burned in the kiln. Depending on the size of the kiln, burning varied from 3 weeks to more than a month, then the ovens were allowed to cool between a week and 10 days before removal of the charcoal. Juniper required a higher temperature for conversion to charcoal, so this wood had to be processed in a fired-brick kiln. A charcoal pit "kiln" produced from 2,800 to 3,300 bushels of charcoal from 100 cords of wood. An estimated 300 bushels of charcoal per acre of pinyon-juniper woodland were produced by charcoal makers in the late 19th century (Lanner 1981: 122, 125; Young and Budy 1979: 116–117).

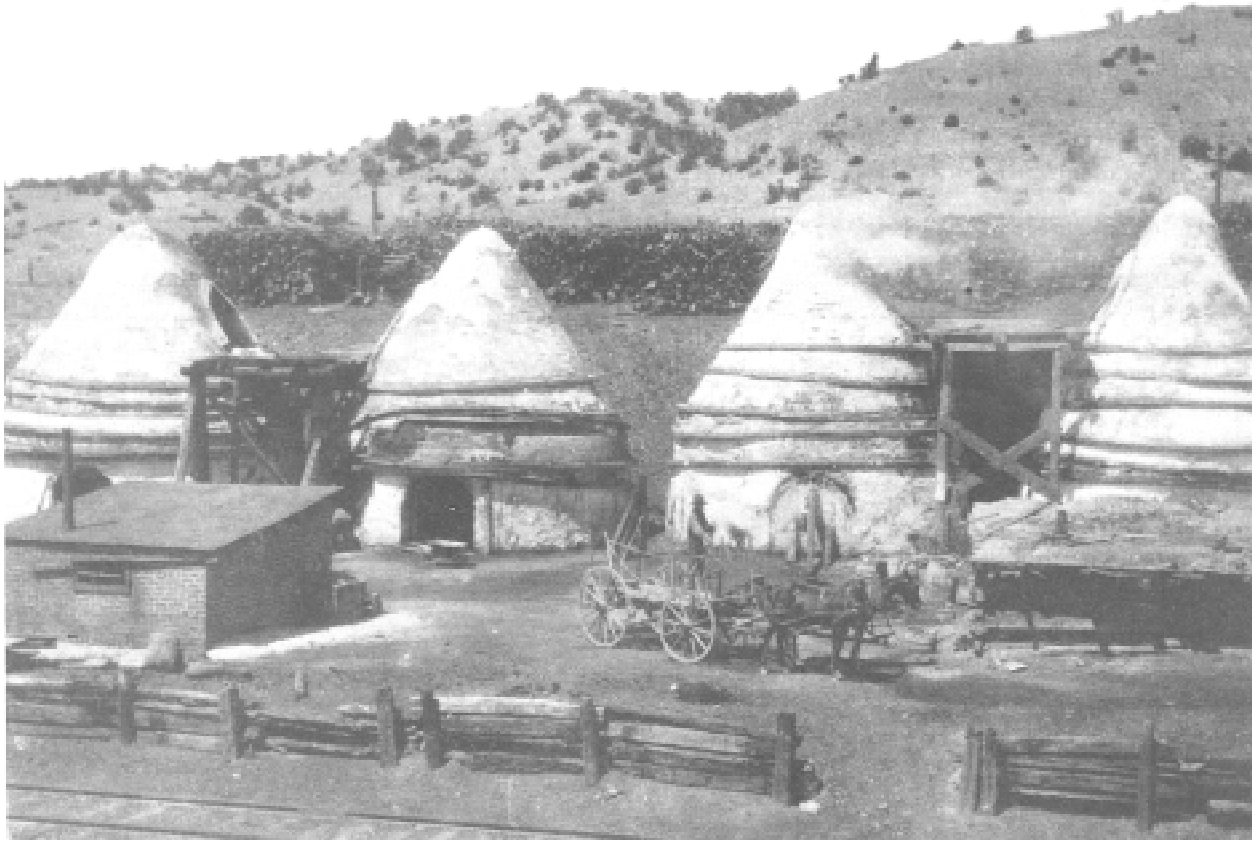

Figure 37—Charcoal kilns at Lamy, Santa Fe County. Eldred Harrington photo, 1922. Courtesy New Mexico Bureau of Mines Photo Archives, Socorro.

Pinyon and juniper, with their array of branches from near ground surface to the peak of their crowns, were difficult to fell and buck into cordwood by hand, requiring an estimated two to three times as much labor as that needed to cut and buck ponderosa. Fuelwood yields of pinyon-juniper woodlands varied from less than one cord in sparse stands to more than 25 cords per acre in the densest stands. Smelter furnaces at large mining sites working at capacity would consume from 15,000 to about 18,000 bushels of pinyon-juniper charcoal a day (Lanner 1981: 124–125; Randles 1949: 346; Young and Budy 1979: 117).

Mining

Major changes in the mining industry also resulted with the coming of the Anglos to New Mexico. New mining equipment, techniques, and markets, backed with investment money, opened many new mining areas and increased production at existing mines. New mining technology included several environmentally destructive techniques of recovering precious metals, such as hydraulic nozzling, which used a powerful stream of water to wash away soil in placer deposits, separating it from gold and silver. Shortage of water needed in processing was a general problem, however, and flooding of some mining operations was an infrequent obstacle (Beck 1962: 245, 247; Christiansen 1974: 23–26).

Almost all of the mine deposits proved to be small in extent or to have low grade ores. Prospective mining areas, located on disputed land grants, had to wait development until the courts ruled. Roads were poor, so transportation was limited until the main railroad and spur lines were constructed in 1879–90s. No significant amount of gold or silver (compared with Colorado or California) was ever mined. Owing to a general lack of safety and health concerns, illness and mortality rates among miners were high (Beck 1962: 246; Christiansen 1974: 26–27, 34–35, 95).

Some of the best producing areas were the Mexican period gold mines in the Ortiz and San Pedro mountains. New, relatively productive mines were located at Elizabethtown (gold, 1870s), Cerrillos (silver, lead, and some gold, 1870s–80s), Bland-Albemarle (silver, gold, 1889–1910),

Table 43—Major mining areas/activities, 1600 to 1945.

Mining district	County	Materials mined
Baldy (A) (Aztec, Baldy Mountain, Cimarron Copper Park, Eagle Nest, Maxwell's Mount Baldy, Old Baldy Mountains, Ute Creek, Virginia City, Willow Creek)	Colfax	Gold, silver, copper, lead
Cimarroncito (A) (Bonito, Cimarron Canyon, Urraca, Urraca Creek)	Colfax	Gold, silver, copper
Elizabethtown (A) (Cimarron, Eaglenest, E-Town, Hematite, Iron Mountain, Moreno, Moreno Valley, Moreno Creek, West Moreno)	Colfax	Gold, silver
Red River (A) (Questa)	Taos	Molybdenum
Harding (A)	Taos	Tantalum
Anchor (A) (Keystone, La Belle, Midnight, Red River)	Taos	Gold
Picuris (A) (Copper Hill, Copper Mountain, Dixon, Glenwoody, Harding Mine, Hondo Canyon, Penasco, Picuris, Rinconada, West Picuris)	Taos	Copper, gold, silver, optical calcite, sillimanite
Red River (A) (Alum Gulch, Black Copper, Black Mountain, Lower Red River, Moly, Questa, Sulphur Gulch)	Taos	Gold, silver, copper
Rio Colorado Placers (A) (Colorado Creek)	Taos	Gold
Rio Grande Valley (A) (Rio Grande placers)	Taos	Gold
Twining (S and A) (Amizette, Arroyo Hondo, Rio Hondo)	Taos	Copper
Abiquiu (S and A) (Cobre Basin, Cobre Canyon, Copper Canyon)	Rio Arriba	Copper
Abiquiu Stone (S and A) and tuff)	Rio ARriba	Building stone (sandstone
Bromide No. 2 (A) (Bromide, Headstone, Tusas Mountain)	Rio Arriba	Gold, silver, copper, lead, zinc
Chama Placers (A) (Rio Chama Placers Region)	Rio Arriba	Gold
Gallina (A) (Coyote, Gallina Prospect Region, Jarosa, Mesa Alta Mining Mountain, Youngsville)	Rio Arriba	Copper, silver, clay
Cerro Pedernal (P and S)	Rio Arriba	Chert
Hopewell (A) (Eureka, Good Hope, Headstone, Tres Piedras)	Rio Arriba	Gold, silver, lead, copper, zinc
Ojo Caliente No. 1 (A) (Ojo Caliente)	Rio Arriba	Mica

(A) = Anglo (1846–1945)

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Table 43—Major mining areas/activities, 1600 to 1945 (continued).

Mining district	County	Materials mined
Petaca (S and A) (Alamos, Cribbenville, La Madera, Las Tablas, Ojo Caliente, Paloma Canyon Prospect, Servilleta, Tres Piedras, Vallecitos)	Rio Arriba	Gold, silver, lead, copper
Mora (A)	Mora	Gold
Rociada (A) (Hadley, San Carlos, Upper Rociada)	Mora – San Miguel	Copper, gold, lead, silver, zinc
Elk Mountain (A) (Bull Creek, Cow Creek, Elk Creek, Las Vegas, Rio de la Vaca)	San Miguel	Mica
El Porvenir (A) (Hermit Mountain, Mineral Hill, Porvenir)	San Miguel	Copper
Tecolote (A) (Las Vegas, Las Vegas Mines, Mineral Hill (?), Ribera, Ribera Copper Prospects, Rivera, Salitre, San Miguel, San Pablo)	San Miguel	Copper
Willow Creek (A) (Cooper, Cowles, Hamilton, Pecos, Pecos River, Tererro, Valley Ranch)	San Miguel	Zinc, lead, copper, gold, silver
Aspen Mountain (A) (Aspen Ranch)	Santa Fe	Gold, silver, copper, lead, zinc
Cerrillos (P, S, and A) (Bonanza City, Carbonateville, Cerrillos, Galisteo Creek, Hungry Gulch, Los Cerrillos, Los Cerrillos, Mountain Chalchuihuitl, Turquesa, Turquois(e), Turquoise City, Turquoise Hill)	Santa Fe	Turquoise, zinc, lead, silver, copper, gold, clay
Cerrillos Coal Field (A)	Santa Fe	Coal—anthracite and bituminous
Glorieta (P and A) (Glorieta, Glorieta Mesa, Mailleuchet Mesa)	Santa Fe	Copper, mineral paint (ocher)
Nambe (A) (Chimayo, Cordova, Santa Fe Mountains, Truchas)	Santa Fe	Mica
New Placers (S and A) (Alamillo, Carnahan Golden, Golden Placers, Lazarus Gulch, Nero Placers (?), Placer Mountains, San Isidro (?), San Lazaro, San Lazarus Placers, San Pedro, San Pedro Mountain(s), Santa Fe, San Ysidro Mountains, San Zaro, Silver Butte(s), Tuerto Mountain(s), Tuertos Range)	Santa Fe	Copper, silver, gold
Old Placers (S and A) (Cunningham Gulch, Dolores, El Real de Dolores, Lone Mountain, Ortiz, Ortiz Mountains, Rio Galisteo, San Lazaro (?), San Zaro (?), Sierra del Oro, Silver Butte(s))	Santa Fe	Gold, copper
Santa Fe (S and A) (Dalton-Maho, Mailleuchet (?), Mikado, Montezuma, Penacho Peak Prospects, Santa Fe Mountains, Tencaho)	Santa Fe	Copper, silver, gold, clay, limestone
Cochiti (A) (Albemarle, Bland, Peralta Canyon)	Sandoval	Gold, silver, lead, copper
Hagan Coal (A) (Hagan, Una del Gato)	Sandoval	Coal
Jemez Springs (S and A) (Jemas, Jemes, Jemez Mountain, Jemez Plateau, Jemez Pueblo, Spanish Queen)	Sandoval	Copper

(S) Spanish (1699–1846); (P) Pueblo (1450–1945)

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Table 43—Major mining areas/activities, 1600 to 1945 (continued).

Mining district	County	Materials mined
Nacimiento Mountains (A) (Copper City, Cuba, Eureka Mine, Nacimiento, San Francesca, San Miguel, San Miguel Mine, Senorita, Senorito, Sierra Nacimiento)	Sandoval	Copper, silver
Placitas (P, S, and A) (Algodones, Bernalillo, Capulin Peak, Juan Tabo, La Luz, La Luz Mine, La Madera, Las Placitas, Montezuma, New Placers (?), Placitas–Montezuma, Sandia, Sandia Mountains, Sandia–North Manzano Prospect Region, Sandia No. 1)	Sandoval	Lead, copper
Tijeras (S? and A)	Bernalillo	Gold, silver, copper, iron
Laguna (A)	Cibola	Uranium, fluorspar, pumice, scoria
Grants (A)	Cibola	Uranium, fluorspar, pumice, scoria
Zuni Mountains (A)	Cibola	Uranium, fluorspar, pumice, scoria
Scholle (A)	Torrance	Copper, uranium
Cat Mountain (A)	Socorro	Gold
Chupadera (A)	Socorro	Copper, lead
Council Rock (A)	Socorro	Silver, lead
Hansonburg (A) (Carthage)	Socorro	Copper, lead
Hop Canyon (A)	Socorro	Gold
Iron Mountain (A)	Socorro	Iron, tungsten, beryllium
Jones Camp (A)	Socorro	Iron
Joyita Hills (A) (Canoncito)	Socorro	Lead
Ladron Mountains (A)	Socorro	Lead, zinc, manganese, uranium
Lemitar Mountains (A)	Socorro	Lead, zinc, uranium
Luis Lopez (A)	Socorro	Manganese
Magdalena (A)	Socorro	Gold, silver, zinc, lead, copper, manganese, vanadium
Magdalena Mountains (A)	Socorro	Gold, silver, copper, manganese, zinc
Mill Canyon (A)	Socorro	Gold, copper
North Magdalena (A)	Socorro	Copper
Ojo Caliente (A)	Socorro	Copper, lead
Rayo (A)	Socorro	Copper

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Figure 38—Mining operation, Kelly, Socorro County, 1905. Courtesy Mary Louise (Brown) Dillard and New Mexico Bureau of Mines Photo Archives, Socorro.

Table 43—Major mining areas/activities, 1600 to 1945 (continued).

Mining district	County	Materials mined
Rosedale (A)	Socorro	Gold
Mockingbird Gap (A)	Socorro	Copper, lead, zinc
San Jose (A) (Nogal, San Mateo)	Socorro	Gold, silver
San Lorenzo (A) (San Acacia)	Socorro	Copper, uranium
Scholle (A)	Socorro	Silver, copper, uranium
Socorro Peak (A)	Socorro	Silver, lead
Water Canyon (A) (Silver Mountain	Socorro	Gold, silver, copper,

Sources: Christiansen 1974; Cordell 1979: 125–128; Jones 1904: 191–192; Northrop 1959: 571–596; Tainter and Levine 1987: 130–131

Figure 39—Major mining districts and towns, 1600–1945.

Socorro-Magdalena (silver, lead, 1881–90s) (Fig. 38), and Carthage (coal, 1880s–90s) (Christiansen 1974: 35–70). The locations of these and other mining sites, and rocks or minerals mined, are shown in Figure 39 and Table 43.

Military Resources

The establishment and garrisoning of military posts throughout the region with several thousand troops and many more draft animals from 1861 to the late 1800s created a new demand for other local resources such as horses, mules, oxen, beef, mutton, agricultural products (mainly wheat and corn), salt, native "hay," and lumber (Frazer 1983; Miller 1989). With rapid growth of livestock generated not only by the demands of the army, but also by a rapidly increasing emigrant and settler population, lowland grasslands were quickly depleted, and demand for native hay (gramas, galleta, tobosa, bluestems, etc.) increased accordingly. Army horses usually received a daily ration of 14 pounds of hay; 4,950 tons of hay were consumed in 1870. These hay grasses had to be hand cut, usually with sickles and scythes, in mountain meadows such as the Valle Grande, or in valleys such as those of the Rio Puerco and Santa Fe River. By 1885 most hay for regional posts was freighted from Kansas, even though local farmers were raising substantial amounts of alfalfa by this time. Horses, as well as mules and oxen, also required a large amount of corn, grains, and fodder. Horses received 12 pounds of grain daily (Frazer 1983: 50; Keleher 1982: 43; McNitt 1972: 184–185; Meketa 1986: 205–206; Miller 1989: 92–95, 99, 104).

One contractor promised 200,000 pounds of corn for livestock and military men in 1870. For that year, some 77,854 bushels of corn were contracted from local growers by the army. Flour was also procured by the military for soldiers to consume. Flour from grist millers totalled 1.5 million pounds in 1861. About 161,000 pounds of beans were provided by 10 local farmers to regional posts in 1866 (Frazer 1983: 50, 179; Miller 1989: 57–58, 92, 145, 151; Perrigo 1982: 15).

Healing and Hot Springs

Throughout the historic period, Native Americans and Hispanics utilized hot springs in the region for treating various ailments. Ojo Caliente, San Antonio, Jemez Springs, Montezuma, and Coyote Canyon were favorites of later Anglo residents. Some of these springs became sites of health resorts and remain so today (Cahill 1988: 39–45, 55–57, 77).

With the arrival of the first railroad in 1879–80, New Mexico's reputation as a place to recuperate from certain illnesses and to live a long life began to grow. This belief was based primarily on the sunny, dry climate, relatively mild temperatures, scenic landscape, clean air, and hot and cold mineral springs. All of these were important elements of the territory's image as a curative environment, and along with Arizona, it became known as the "well country." Persons suffering from consumption, or tuberculosis, were especially attracted to the region. Tour boosters and railroad officials began to promote the region, and sanitoria resorts were established at Las Vegas, Ojo Caliente, Santa Fe, Jemez Springs, Albuquerque, Coyote Springs, and Socorro. At the end of the century the military built large hospitals and sanatoria at several posts in the region (Williams and Fox 1986).

SUMMARY

Native Americans in the region viewed the landscape, including the Rio Grande, as "sacred." Their relationship with the environment was meant to be based on harmony with physical and biological elements maintained through ritual and ceremony. This world view, combined with low-level technology, produced impacts on the environment that were considerably less than those of later Euro-American populations.

Major Pueblo villages were generally on or near the edge of floodplains. Seasonal hunting, gathering, or farming camps were usually near the target resource, close to water, as well as to the indigenous human populations of the basin. Prior to Spanish arrival, abandonment of villages due to drought or other factors was relatively common. The outer limits of Pueblo settlement within the region was shrinking in the late prehistoric period, with populations concentrating in large villages at or close to dependable water sources, such as the Rio Grande.

When the Spanish arrived, they settled at or near Pueblo villages and forced the residents to assist them in farming, livestock raising, and maintaining households and mission churches. New field configurations, irrigation systems (including diversion dams and gates), and crops were introduced. Sheep, goats, cattle, horses, wheeled vehicles, metal tools, firearms, and metal-tipped plows were introduced. These innovations, along with new infectious diseases, brought dramatic changes in Native American populations, lifeways, and landscape. Spanish policies and disease forced even more abandonments and consolidation, with each extant pueblo eventually receiving a grant of four square leagues as its exclusive use area. This represented a much smaller resource area than previously used, but this was offset to some degree by significant declines in population due to European diseases, warfare, famines, and severe droughts.

With acquisition of the horse from the Spanish, nomadic Indian groups extended their range of resource exploitation, including raiding for livestock and agricultural produce. Sheep and cattle provided a more dependable supply of meat than game animals for these groups. Spanish sheep and their husbandry were adopted by the Pueblos, who in turn passed this resource and associated management skills to the Navajo. Sheep not only provided meat but also wool for weaving. Navajo flocks increased over time, while Pueblo sheep raising generally declined, especially over the last 100 years, except at Laguna and Acoma. Grazing around settlements and camps was intensive.

The Pueblos practiced floodwater farming and limited irrigation at the time of early Spanish contact. Through association with these Europeans, the first technique was virtually abandoned for a more intensive and effective diversion structure-ditch based agricultural system. As production of introduced wheat and traditional corn, beans, squash, and so forth increased, there was less dependence on gathering of wild plant foods.

Although hunting and gathering were no longer as important to the Pueblos as they were in the prehistoric period, these activities remained significant to the Navajo, Apache, and Southern Ute in the region. A variety of mammals and birds provided food, hides, sinew, tool material, skins, and feathers. Wild plants provided food, medicine, shelter, fuel, and arts-crafts materials. Several hundred indigenous species were used by these Indian groups as well as the Pueblos in the study region.

The region also provided an array of rocks and minerals used by Native Americans in the manufacture of tools, weapons, jewelry, pottery, and so forth. Chalcedony, obsidian, jet, galena, malachite, hematite, and turquoise were some of the more important minerals collected and used. Clays from a number of locations were used in making pottery, the most important art-craft endeavor of the Pueblo. Sandstones and limestones were used by groups as tool and building materials.

If one or more of the above resources were not available within a group's area, they were obtained through trade with another group. Some of the more common materials or goods traded were buffalo and other animal hides, agricultural produce, livestock, pinyon nuts, shell, turquoise, woven items, and minerals.

The Spanish brought an array of new settlement and resource use strategies and technologies, and new attitudes toward the environment. Unlike Native Americans, Spaniards saw themselves as having dominion over nature and superior to the indigenous peoples.

Redistribution of Pueblo lands and distribution of other lands to Spanish settlers were accomplished through land grants. Some of these grants were made to private individuals as encomiendas (17th century) and grazing use (18th–19th centuries). After 1694, most were communal grants made to families who were subsistence farmers and livestock raisers. Water, arable soils, grass, and woodland or forest resources were environmental determinants in selecting and making these grants. Encroachment by Spaniards on Pueblo lands was a continuing problem.

By the mid 1700s most of the best farmlands along the Rio Grande and major tributaries were under irrigation. Adjacent grasslands were supporting more than 135,000 head of sheep, goats, cattle, and horses, not counting those animals herded by the Navajo and Apache. Some one million sheep were being exported annually to Mexican states to the south. By the mid 1800s there were probably three million sheep in New Mexico.

Indigenous woody plants were used locally by the Spanish for house construction, furniture, tools, carts, and fuelwood, to name just a few examples. Wild plants were used as food, medicine, and arts and crafts; these uses were primarily learned from the Pueblos and other Native American groups. Bosque and upland woodlands and forests were sometimes burned to create pastures or meadows. Owing to the limitations of available weapons, hunting was not a major subsistence activity among Hispanics, except for the fall buffalo hunts to the east of the study region. Hides and meat of various other mammals, as well as bison, were commonly obtained through trade with Native Americans.

Although the Spanish made intensive forays in search of mineral wealth, there were few mining operations in the colonial period. Deposits mined by the Pueblo for a considerable time, such as the lead and turquoise, were exploited by Hispanics in the Cerrillos-Las Huertas area. Limited amounts of gold and silver were extracted from lodes in various mountain ranges, the best known being in the Ortiz Mountains. Mica, for window coverings, and copper, made into containers and utensils, were mined on a limited scale. Salt was commonly collected in the Salinas Province and at the confluence of the Chama River and Rio Grande.

Furs and trade over the Santa Fe Trail attracted the first wave of Anglos to the basins beginning in the early 1820s. This marked the beginning of intensive exploitation of beaver and otter, populations of which were decimated or extirpated. The second wave of Anglos began in 1846 with occupation of New Mexico by U.S. troops. Subsequent settlement was generally concentrated in and around existing communities. These soldiers and settlers, like the trappers-traders, brought an environmental view and technology quite different from those of Native Americans and Hispanics; resources were to be exploited for monetary gain. Besides more efficient weapons and steel traps, Anglos introduced steel plows, machine-made fabrics, new cultigens, large numbers of cattle, and new modes of transportation. By 1880, the first railroad had been constructed along the Middle Rio Grande, and intensive settlement on newly surveyed public domain and mining of an array of minerals followed. Several other railroads were completed over the next 3 decades, and extensive forest areas were logged on old grant lands and national forests for construction materials. New mining technologies made extraction more economically efficient but more environmentally destructive. A new judicial system and some unscrupulous lawyers took hundreds of thousands of acres of grant land claimed by Hispanos, much of which ended up under U.S. Government control as public lands in national forest preserves.

A rapidly growing population placed added pressures on resources such as water, grass, timber, fauna, and farmland. When major environmental problems began to appear at the turn of the century, a conservation movement at the federal and territorial (later state) levels began. Depletion of in-stream flows, soil erosion due to overgrazing and clear-cutting, and extirpation of a number of wild animals continued into the early part of this century. During this time the Pueblos and their supporters were engaged in several legislative and judicial "battles" to keep their land base.

Grazing permits and restrictions on logging of public lands followed in the early 1900s and marked the beginning of some environmental recovery. Subsequently, more resource management agencies and regulations were established, especially during and following the 1930s–50s droughts and the environmental movement of the mid 1960s-early 1970s. Major concerns since then have focused on establishing wilderness, endangered species, grazing on public lands, logging, water quantity and quality, and mitigation or preservation of eco-cultural resources (see chapters 4 and 5).

CHRONOLOGY

1490–1525 Tonque Pueblo produced virtually all of the lead-glazed pottery used in the Pueblo region (Snow 1981: 363).

1400s–1500s Pueblos mined and collected turquoise and lead for paint from the Cerrillos area, fibrolite for axes from the southern Sangre de Cristo Mountains, obsidian for tools and weapons from the Jemez Mountains, malachite and azurite for jewelry from various northern mountain ranges, travertine for jewelry (?) from the Los Lunas area, salt for food seasoning and preservation from the Estancia Basin, and Pedernal chert for tools and weapons from the Chama Valley (Snow 1981: 364).

1400s–1680 San Marcos Pueblo, called "Turquoise Pueblo Ruin" by later Tewas, was so-named due to its proximity to Mount Chalchihuitl, or "Place of Turquoise." Turquoise, as well as lead, and probably copper were mined here by the Pueblos (Schroeder 1977: 21–23).

1400s–1600s Based on archeological evidence, 54 species of birds were used at Las Humanas and Pueblo del Encierro for meat, feathers, and personal adornment (Snow 1981: 364).

1500–50 A group of mines and quarries along the Cuchillo de San Francisco in the Placitas mining district were worked by Pueblos. Various tools and Rio Grande glaze-paint sherds are associated (Warren and Weber 1979: 10).

1539–40 At first European contact, the Pueblos were growing corn, squash, beans, amaranth, pumpkins, and sunflowers. Corn varieties included flint, dent, flour, sweet, and popcorn (Sando 1992: 43).

1540 (pre) Some Pueblos, who were inhabiting mesa tops, maintained catchment reservoirs. In some instances these were filled by rolling large snowballs into them during winter (DuMars et al. 1984: 7).

1540 (pre) European diseases may have spread north from Mexico to New Mexico via trade routes. By the end of the 16th century these maladies had severely impacted Pueblo and other Native American populations and had caused a decline in trade (Riley 1987: 325).

1540 (pre) The Pueblo Indians used an ancient trail along the Rio Grande, between Taos and El Paso, for travel and trade. This later became the upper Camino Real (Riley 1993: 13–14).

1540 (late October) The main body of the Coronado expedition found a "horn — six feet long and thick at the base as a man's thigh. It seemed to be more like the horn of a goat than of any other animal" on a river in east-central Arizona (Hodge 1946: 305–306).

1540 fall Coronado's livestock caused serious damage to Tiguex Pueblo fields and crops (Flint and Flint 1992: 135).

1540 (fall to 1541) Castaneda reported a large number of cranes (probably sandhill), wild geese, crows, and "starlings" (probably a species of blackbird) in the Tiguex Province. He also noted that there were "a great many native fowl in these provinces, and cocks with great hanging chins" (wild turkey) (Hodge 1946: 353–354).

1540 (December-January 1541) Under siege by Coronado's troops for 50 days, residents of a Tiguex pueblo dug a well, or cistern, in the village, but the walls collapsed before they found water. Some 30 Pueblos were killed in the cave-in (Hodge 1946: 322).

1540 Castaneda, one of the chroniclers of the Coronado expedition, reported an abundance of turquoise near Pecos. This location was probably the long-exploited deposits at Cerrillos (Northrop 1975: 8).

1540 Alvarado, another one of Coronado's chroniclers, wrote this description of the Tiguex Province (Isleta to near San Felipe): "This river of Nuestra Senora flows through a broad valley planted with fields of maize and dotted with cottonwood groves. There are twelve pueblos, whose houses are built of mud and are two stories high. They have a food supply of maize, beans, melons and turkeys in great abundance" (Bolton 1964: 184; Hammond and Rey 1940: 183, 255–256). Cotton was being grown by the Tiguex Pueblo (Riley 1987: 234).

1540 The Pueblos gathered "large quantities of herbs . . ." (Hammond and Rey 1940: 256).

1540 From first European contact and throughout the historic period, the main items traded by the Pueblos to other Native American groups were corn flour, pollen, and husks; pinyon nuts; turquoise; salt; feathers of eagles, hawks, turkeys, and a number of small birds; and woven baskets and pottery (Sando 1992: 37, 44).

1540–83 Regional pueblos were involved in the manufacture, procurement, and trade of turquoise, cotton blankets, feather blankets, various animal hides, fibrolite axes, lead-glazed ceramics, copper, obsidian, malachite, azurite, and iron ores. The Pueblos were receiving considerable amounts of buffalo meat and hides from the Southern Plains Indians in trade (Riley 1987: 237–243).

1540–94 Spanish explorers noted the abundance, utility, and trade value of furs and skins (Weber 1971: 14).

1540 (ca.) Some 20,000–25,000 acres of land in the Middle Rio Grande Valley were in cultivation by Pueblo villagers (Hedke 1925: 9).

1540–1700 Pueblos were mining lead in the Cerrillos area for use as lead-glaze paint decoration on pottery (Schroeder 1977: 21).

1541 (February 20-March 31) Coronado laid siege to Moho Pueblo in the Tiguex Province. After the snow stopped falling, the Pueblo inhabitants suffered from little or no water. They eventually abandoned their village, and some fought their way through the Spanish lines (Bolton 1964: 219–230).

1541 July Part of the Coronado expedition found a "great deal of food" and "many bowls full of a carefully selected shining metal with which they glazed the earthenware" in two Jemez villages (Hodge 1946: 340).

1541 (summer) One of Coronado's contingents traveled up the Rio Grande to Taos on a food collecting trip. At this pueblo they found a wooden bridge of large, heavy, square pine timbers spanning the Taos River (Riley 1987: 225–226).

1549 The Spanish Crown deleted the "labor grant" from the encomienda but retained the right of the encomendero to demand tribute of goods or foodstuffs. Spaniards also had the right of repartimiento, that is, to use Indians for limited work time in fields, on ranches, and in mines (Jenkins 1987: 65).

1550–90 The Pueblo population of the Rio Grande Basin declined, perhaps due to European diseases introduced by Spanish explorers (Patterson-Rudolph 1990: 6).

1573 The Spanish Laws of Settlement called for the naming of geographic features and becoming familiar with the foods of an area. Early settlers learned the latter from the Pueblos (Schroeder and Matson 1965: 5). A royal ordinance specified that municipal governments of new settlements were responsible for protecting water supplies, keeping streets clean, and maintaining cemeteries (Simmons 1992: 223). Another ordinance set forth requirements for siting Spanish towns such as "healthful environment, clear atmosphere, pure air, and weather without extremes." Also, the "land had to be suitable for farming and ranching; there had to be mountains and hills with an abundant supply of stone and wood for building materials and an adequate source of water for drinking and irrigation. Waters inside the town were to be held for the common benefit of the inhabitants, but the source of supply was to be common to all persons" (Engstrand 1978: 323). New laws promulgated by the Council of the Indies declared missionization as an important goal, and priests joined soldiers, miners, and settlers in expeditions to exploit human and natural resources (Riley 1987: 23). Guidelines as to how and to whom water and cropland were to be distributed were specified. A subsequent law specified that prior to allocating water for individual residents, the settlement itself should secure its own water needs (Meyer 1984: 29). To protect Indian agricultural fields and villages, Spanish law required that cattle and horse herds were to be no closer than a league and a half (about 4 miles) and farms for sheep and goats at a distance of half a league (1.3 miles) (Engstrand 1978: 323). Another ordinance gave nomadic Indians certain rights or reducciones (reservations) to arable land, water, and wood, and common land for livestock, separating them from Spanish herds (Jenkins 1987: 65).

1573 (December 1-October 1618) The Spanish government defined the areas and rights of the Pueblos (DuMars et al. 1984: 19).

1574 The Mesta, established earlier, was reorganized and passed laws regulating the branding of horses and cattle, the disposing of unbranded livestock, the regulating of slaughter houses, and other related activities. The Spanish government claimed ownership of wild horses and cattle (Dobie 1952: 95–96).

1576–79 The European-introduced plague decimated the Indian population in Mexico, causing a shortage of labor in agriculture and industry (Ringrose 1970: 47).

1581 (July) The Chamuscado-Rodriguez expedition explored the eight leagues of marshes and swamps along the west bank of the Rio Grande below El Paso. When they crossed the river at the ford above the pass, they became the first Europeans to do so. In reaching the ford, they had to leave the river north of El Paso and swing westward around the pass because it was too narrow for the men and pack trains to get through. They then moved back northeastward to the river and the crossing (Sonnichsen 1968: 4).

1581 (August 21–22) Moving upriver, Chamuscado-Rodriguez reached an abandoned Piro Pueblo village ruin, perhaps in the San Marcial area. The next day they reached another pueblo which had been abandoned the night before. Here the Spaniards found turkeys, cotton, and corn in the houses, and beans, calabashes, and cotton in the nearby fields (Hammond and Rey 1966: 141).

1581 (August 23) Members of the Chamuscado-Rodriguez expedition were given corn, beans, squash, cotton blankets, and tanned buffalo skins by Piro Pueblos near historic San Marcial. In return, the Spaniards gave the Indians "iron, sleigh bells, playing cards, and various trinkets . . ." (Hammond and Rey 1966: 142).

1581 (early September) At the south end of the southern Tiwa villages along the Rio Grande, the Chamuscado-Rodriguez expedition noted the crops of corn, beans, and squash; they also related that the Pueblos had extensive cotton fields. Also, every man had a pen of 100 turkeys and "small, shaggy dogs," which they housed in "underground huts" (Hammond and Rey 1966: 83).

1581 (mid September) At the Galisteo pueblos Chamuscado and Rodriguez were told of Plains Apaches to the east who subsisted on buffalo meat in winter and harvested prickly pear and yucca fruit in summer. They lived in buffalo hide tipis and also traded hides, meat, and deerskins for corn and blankets at the Pueblo villages. The buffalo, they said, were "as numerous as the grains of sand in their hands, and there were many rivers, water holes, and marshes where the buffalo ranged." The Pueblos also said that the buffalo seasonally came within 20–25 miles of their villages (Hammond and Rey 1966: 86–87).

1581 (late September) The Chamuscado-Rodriguez expedition reached the salt lakes east of the Manzano Mountains and visited five pueblos in the area to the west and southwest of the lakes (Hammond and Rey 1966: 106–107).

1581 Hernan Gallegos wrote this about the pueblos along the Rio Grande: "These pueblos were located on excellent sites with good level land..." (Hammond and Rey 1966: 142).

1582 (early) Moving down the Rio Grande on their return to Mexico, the Chamuscado-Rodriguez expedition found "very good veins," a reference to potential mining locales (Northrop 1975: 8).

1583 (January) Espejo reported "many cottonwood groves and some patches of white poplars four leagues wide" and "quantities of grapevines and Castilian walnut trees" as he traveled up the Rio Grande from the San Marcial area to the Keres pueblos (Hammond and Rey 1966: 219).

1583 (February 1) At the Piro village of San Felipe the Antonio de Espejo expedition recorded its inhabitants as wearing cotton cloth and tanned deerskin clothing, buffalo hide moccasins, cotton blankets, and turkey feather robes. Espejo's expedition found corn stubble in Piro fields, which he said "was the salvation of our horses" (Hammond and Rey 1966: 172).

1583 (February 10–12) The Salinas Pueblos had "abundant corn, turkeys, and other supplies" and wore clothes made from buffalo hides, cotton blankets, and "chamois skins." Their villages were located on the west edge of the buffalo range (Hammond and Rey 1966: 222).

1583 (February) In the Isleta Pueblo area, Espejo found two villages stocked with abundant corn, beans, "green and sun-dried calabashes," and other "dried vegetables" (Hammond and Rey 1966: 176, 178).

1583 (late February) Near Cochiti Pueblo the Espejo expedition gave inhabitants of the area sleigh (hawk?) bells and "iron articles" for tortillas, turkeys, pinoles, and buffalo hides (Hammond and Rey 1966: 179, 238).

1583 (late February) Espejo noted a magpie in a cage at a Keres pueblo (Hammond and Rey 1966: 223).

1583 (March 5–6) At Acoma, Espejo was given "blankets, tanned deerskins, turkeys, and a quantity of corn" (Hammond and Rey 1966: 182).

1583 (March 7) Luxan, with the Espejo expedition, described Acoma's irrigated fields at the Rio San Jose: "We found many irrigated cornfields with canals and dams, built as if by Spaniards." Espejo wrote "These people have their fields two leagues distant from the pueblo, near a medium-sized river, and irrigate their farms by little streams of water diverted from a marsh near the river" (Hammond and Rey 1966: 182, 224).

1583 (March 15-April 7) Espejo noted that the Zunis from Hawikuh were planting their fields. Showers, mainly in the form of snow, fell frequently. The expedition was provided with "plenty of hares and rabbits" (Hammond and Rey 1966: 184–185).

1583 (June) Cottonwoods were growing near Kuaua Pueblo (Riley 1987: 228).

1583 The Espejo expedition reported "antimony" (probably galena) along the Rio Grande Valley, possibly in the Manzano, Caballo, and Organ mountains. At Zia, Espejo was given copper ore from the Jemez Mountains (Northrop 1975: 8).

1591 (January 10–11) Explorer Castano de Sosa recorded that six northern pueblos, including Pecos, Pojoaque, and Nambe, had irrigation ditches. He also found an extensive irrigation system and wood-burning "ovens" at San Ildefonso Pueblo (Riley 1987: 235; Schroeder and Matson 1965: 116–117, 120).

1591 (March 7–16) Members of the Sosa expedition spent 17 days prospecting around San Marcos Pueblo, where they found evidence of silver. Pueblo Indians were mining turquoise and lead in the same area (Schroeder 1977: 22–23).

1591 (March 11) As Sosa approached, the Tiwa Pueblos abandoned their villages on the west side of the Rio Grande, but some could not cross the flooding river (Hammond and Rey 1966: 292).

1598 (pre) The Tewa Pueblo of San Juan had engaged in ditch irrigation of fields over the last 300 years (Ellis 1987: 17).

1598 (late May) North of the Jornada del Muerto, corn was procured from the Piro Pueblo of Qualacu, which helped alleviate the food shortage for the Juan de Onate expedition. Travel continued to be arduous due to the soft, deep sand. The wheels of the supply carts sank to their hubs. As the expedition moved northward, a rainstorm provided needed water, as well as substantially decreasing the air and ground temperature (Simmons 1991a: 105–106).

1598 (June 14) As the Onate expedition continued northward through Piro country, they found the pueblos deserted and the grain storerooms cleaned out by their residents. As the food shortage became more critical, the expedition found an occupied pueblo known as Pilabo on the west side of the river. After the expedition crossed the river, the Pueblos welcomed the Spaniards and gave them a large supply of corn. For this act, Onate named the Pueblo Socorro (aid, help) (Fugate and Fugate 1989: 66; Simmons 1991a: 106).

1598 (June) Onate, leading his army and colonists, marched north from Sevilleta Pueblo and passed many pueblos, mostly abandoned, and fields on both banks of the Rio Grande before reaching Isleta (Hammond and Rey 1953, I: 318–319).

1598 (July) Onate and some of his soldiers learned of Pueblo turquoise and lead mines near the San Marcos Pueblo (Simmons 1991a: 113).

1598 (August 11) Onate initiated the construction of an irrigation system at San Juan using 1,500 Pueblo Indians as laborers (Clark 1987: 13).

1598 (September) Onate learned of a promising cluster of mines close to the El Tuerto Pueblo, located east of the Sandia Mountains (Simmons 1991a: 150).

1598 (early October) Onate led some of his soldiers southeastward from San Juan along the east side of the Sandia and Manzano mountains to the saline lakes in the Estancia Valley. Besides salt, Onate was also searching for precious minerals in these mountains (Simmons 1991a: 125).

1598 Onate recorded deposits of sulfur and alum, perhaps calcareous tufa, in the Jemez Hot Springs area. One of his commanders, Marcos Farfunn, was sent to explore the Zuni Salt Lake, which he described as having extensive deposits of superior quality (Northrop 1975: 9).

1598 The rotation of crops, common in medieval Europe, was not practiced by the Spanish in New Mexico (Beck 1962: 263).

1598–99 Onate and the Spanish colonists brought churro sheep to northern New Mexico. This breed was small with limited, coarse, long-staple wool, but they were selected over Merino because the churro's meat was better, its fleece more suited to hand processing, and it could survive drought better than cattle (Baxter 1987: 20). A grass native to Eurasia, sheep fescue (*Festuca ovina*), may have been introduced to New Mexico via the fleece and droppings of these sheep (deBuys 1985: 225).

1598–99 Onate's colonists complained about living in Pueblo rooms which they found poorly ventilated and infested with bedbugs and other biting insects (Ellis 1987: 19).

1598–99 Chile, tomato, and cultivated tobacco were introduced from Mexico (Simmons 1991a: 66–67).

1598–1608 Reports of silver lode and limited silver mining by various Spaniards were recorded for the Cerrillos-San Pedro Mountains area (Schroeder 1977: 23).

1598–1610 Loss of arable land and food reserves to the Spanish resulted in accelerated development of irrigation agriculture by the Pueblos. Movement of villages to new, more productive sites was almost precluded by the Spanish presence. Some residents of Taos, Picuris, and Santa Clara did temporarily move onto the plains of eastern New Mexico (Snow 1981: 366).

1598–1630 With the construction of more irrigation systems and the introduction of livestock by the Spanish, the demand for surface water increased significantly (Meyer 1984: 50).

1598–1630 By growing winter wheat brought by the Spanish, the Pueblos extended the farming season, and by adopting livestock, they had to hunt less for meat and hides. The use of cow dung for firing pottery and heating homes may have begun during this period (Schroeder 1975: 53).

1599 (early) Onate moved his headquarters and capital from San Juan to the west side of the Rio Grande to San Gabriel Pueblo. Most of the Pueblo inhabitants left, but some remained to haul water and fuelwood for the Spaniards (Simmons 1991a: 148–149).

1599 (late October) Juan de Onate described the Rio Puerco-of-the-West in the Cabezon Peak area as having many cottonwoods and fairly deep water where he crossed the stream. He named the river "La Torriente de los Alamos" and described the valley as "lush, rich, and fertile" (Lopez 1980: 71, 77).

1599–1600 (late) Onate and his men continued their search for gold and silver. Low-grade silver was found near San Marcos Pueblo and at several locales near the El Tuerto Pueblo close to the east side of the Sandia Mountains (Simmons 1991a: 150).

1599–1680 New Mexico's governors dominated the export trade in furs and skins, such as buffalo, antelope, elk, and deer (Weber 1971: 18–19).

1600 (post) The area along the east side of the Rio Grande between Alameda Pueblo lands and the Mexia "swamps" was called "Bosque Grande" (Adams and Chavez 1956: 145).

1600–1634 Spanish livestock herds nearly doubled every 15 months (Gutierrez 1991: 57).

1600–1650 The Spanish conquistadores and military officers brought mastiffs and large greyhounds to New Mexico. These "war dogs" were used in combat, which terrorized Native Americans. They were also used in hunting, especially the greyhound (Simmons 1991b: 36).

1600–80 Disputes over land and water rights between the church and state were common during this period (Scholes 1935: 109).

1600–80 The Spanish mined lead for making rifle ball ammunition in the Cerrillos area (Warren and Weber 1979: 8–9).

1600–80 The granting of lands around Pueblo villages and the encroachment of ranches on their land precluded migration as a traditional option in mitigating environmental stress (Snow 1981: 366).

1600–80 About 48,000 acres of irrigated land were brought into production by the Spanish in the Middle Rio Grande Valley (Hedke 1925: 23).

1601 (September) Food shortages continued to cause suffering among the colonists at San Gabriel. Some of the soldiers and settlers began to protest their plight. The priests also spoke out about the maltreatment of the Pueblos (Simmons 1991a: 165–167).

1601 The Pueblos in the Rio Abajo and Rio Arriba were reduced to "poverty" due to the corn, blankets, and other tribute taken by the encomenderos and other Spaniards (Oppenheimer 1962: 11).

1601 By this year the Spanish colonists in the San Gabriel area had consumed all of the food reserves that nearby pueblos had stored prior to the Spanish arrival in 1598. Both cultural groups were forced to venture greater distances to procure food (Hammond and Rey 1953: 680–688, 693).

1602 The Council of the Indies set encomienda as either a manta or a hide and a fanega (1- bushels) of corn per year for each household (Jenkins 1987: 67).

1604 Spanish carpenters trained Pecos Pueblo men in woodworking skills. The accessibility and diversity of woodlands and forests in the area provided the basis for a vigorous craft over the next 150 years. Carved corbels and vigas, doors, window frames, and furniture were crafted to meet local and regional demands (Kessell 1979: 132–133).

1610 Each resident of Santa Fe received "two lots for a house and garden, two suertes (field lots) for a vegetable garden, and four caballerias (each 100 to 125 acres) for grazing" (Jones 1979: 147).

1610 The supply service caravans, known as conductas, began operating over the Rio Grande route opened by Chamuscado-Rodriguez, Espejo, and Onate expeditions. Known as the Camino Real, this road connected the central and northern Mexico settlements with Santa Fe. Much-needed supplies were brought up this road every 3–7 seven years, usually in 32 wagons escorted by 12–14 soldiers and a herd of livestock and spare draft animals (Moorhead 1958: 28–33).

1600s (early) Under the encomienda system, Spaniards took Pueblo lands for grazing of livestock. Overgrazing and soil erosion resulted. Water was also directed to Spanish fields, causing a shortage for Pueblo crops (Sando 1992: 60).

1600s (early) By this time the Spanish had so disrupted Pueblo agriculture and trade with other Native American groups that they were starving. One Franciscan priest claimed that Pueblos were surviving by eating tree bark and leaves or by mixing dirt and ashes with a little corn (Kenner 1969: 12).

1600s (early–1680) Pueblo residents were forced to collect firewood, salt, and pinyon nuts in large quantities, to prepare hides, and to manufacture cotton blankets, causing stress among the villagers (Snow 1981: 368).

1600s (early–1680) Life expectancy, disease rate, and decrease in stature were all experienced by Pueblo people in the Salinas Province due, in part, to drought and European diseases (Tainter and Levine 1987: 56, 72).

1600s (early–1680) Items exported south from New Mexico included sheep, raw wool, hides (buffalo, deer, and antelope), pinyon nuts, salt, Indian blankets, and El Paso brandy (Moorhead 1958: 49).

1620–80 "Each mission friar had one to two thousand sheep ..." (Hackett 1937: 69; Scholes 1935: 107–108). In 1621 encomenderos were grazing livestock near the pueblos and their agricultural lands. Stock roamed onto these fields, causing damage to the crops and stubble (Bloom 1928: 368).

1621 Fray Benavides wrote "the abundance of game appears infinite." He noted that wolves, mountain lions, wildcats, jackrabbits, and cottontail rabbits were numerous. Bighorn sheep were common in the uplands (Ayer 1965: 37).

1625 By this year encomenderos were levying tributes on their Indian charges, usually corn, cotton cloth, or animal hides (Westphall 1983: 4).

1626 (pre) Benavides recorded the destruction of crops by rabbits. The Tewa Pueblos were experiencing famine due to insufficient irrigation water (Hodge, Hammond, and Rey 1945: 39, 69).

1628 The mission supply caravan had four dozen chickens for New Mexico missionaries among its cargo (Schroeder 1972: 55).

1629–30 Fathers Salmeron and Benavides reported various mineral deposits in north and central New Mexico, including silver, copper, lead, alum, sulfur, turquoise, garnet, and salt (Northrop 1975: 10).

1620s Missionaries successfully cultivated vineyards in the Socorro district. Wines produced included red and white; brandy was also manufactured (Simmons 1991b: 72).

1620s (to early 1700s) An extensive stand of cottonwoods was found along the Rio Grande in the Albuquerque area. It was known as the Bosque

Grande de San Francisco Xavier. South of this woodland were the open wetlands called Esteros de Mejia (Simmons 1982: 40).

1630 Fray Benavides listed the following fish found in the Rio Grande Basin: bagre (blue catfish, *Ictalurus furcatus*), trucha (trout, *Salmo* spp.), yellow bullhead, *Ictalurus natalis*), anguila (eel, *Anguilla rostrata*), boqeinete (sucker, *Moxostoma* sp.), sardina (chub, *Notropis* sp.), aguja (gar shovel-nose sturgeon, *Scaphirhynchus playtyrhynchus*), cazon (longnose gar, *Lepisosteus osseus*), and matalote (Gila chub, *Gila intermedia*) (Ayer 1965: 37, 261–262).

1631 A conducta from Mexico to New Mexico carried 48 domesticated hens for food for those who became ill on the trip (Schroeder 1968: 106).

1630s (early) Grasshoppers and rabbits destroyed crops at various Rio Grande pueblos (Schroeder 1972: 5).

1633 Spanish settlers were establishing farms in Pueblo fields, impacting arable lands by constructing houses, outbuildings, and corrals and introducing livestock (Hackett 1937: 127–131).

1635–37 Governor Francisco Martinez de Baeza forced converted Indians to collect and pack large quantities of pinyon nuts for shipment down the Camino Real (Kessell 1979: 155–156).

1638 A widespread outbreak of European diseases struck Native Americans (Palkovich 1985: 417).

1639 Governor Rosas shipped 122 painted buffalo hides and 198 "chamois" skins south on the mission supply caravan (Weber 1971: 20).

1639–40 Raiding Apaches attacked Rio Grande settlements and burned some 52,000 bushels of Pueblo corn (Gutierrez 1991: 112; Vivian 1964: 25).

1641 Thousands of Native Americans died from smallpox (Horgan 1954, I: 261).

1650–60 Spaniards began mining silver, copper, and lead in the Tecolote area at the north end of the Sandia Mountains (Scurlock 1983: 12).

1600s (mid) Prairie chickens were found in the Salinas Province (Schroeder 1968: 102).

1659 Several Tewa Pueblos complained to the Spanish governor about damage to their crops caused by an encomendero's livestock (Anderson 1985: 363).

1659 Some priests traded with various Indian groups for pronghorn skins (Weber 1971: 19).

1660 The annual trade caravan, which passed by Tome Hill, included 10 new carts, at least 160 oxen, and more than 60 pack mules. Among the cargo were 1,350 deerskins, buffalo hides, 600 pairs woolen stockings, 300 fanegas of pinyon nuts, salt, and quantities of clothing (Minge 1979: 11).

1660 Governor Mendizabel received a shipment of 23 fanegas of pinyon nuts from Pecos Pueblo (Kessell 1979: 156).

1660 Governor Lopez de Mendizabel shipped 1,350 deer skins and hides to Parral to market. He sent two other large shipments of skins during his term. Some 1,200 pronghorn skins and four bundles of elk skins were found at his property in Santa Fe (Weber 1971: 20–21).

1661 Some 60 Pueblo laborers from Quarai were conscripted by the Spanish to harvest and transport loads of pinyon nuts. Some 40 Indians of Jemez Pueblo were forced by the Spanish to transport pinyon nuts to "depots" at Santa Fe, Cochiti, and San Felipe. Nineteen Indians from Abo worked for 6 days carrying maize from Tabira and Las Humanas pueblos to the house of Captain Nicolas de Aguilar in the Rio Abajo (Scholes 1937: 394–395).

1661 Pueblos from Tabira harvested salt from a nearby "salt marsh" and transported it to the estancia of Sargento Mayor Francisco Gomez in the Middle Rio Grande. Sixty-three Pueblos carried salt from the east bank of the Rio Grande to Socorro Pueblo (Scholes 1937: 394–395).

1661 An organ for the church at Abo was purchased with money made by selling pinyon nuts (Toulouse 1949: 4).

1662 Encomienda system payments made by Indians at Pecos included 66 pronghorn skins, 21 white buckskins, 16 buckskins, and 18 buffalo hides (Weber 1971: 18).

1663–66 There were 14 estancias in the Isleta-Sandia Pueblo area (Oppenheimer 1962: 12).

1664 Governor Penalosa decreed that "enemy" Indians, even though at peace, would no longer be allowed to enter into the pueblos to trade. This exacerbated significantly Apache food shortages, which led to accelerated hostilities between them and the Pueblos and Spanish (Forbes 1960: 158–159).

1667 Locusts devastated crops, especially at Santo Domingo Pueblo (Kessell 1979: 218).

1660s Lead ores continued to be mined by the Spanish at the north end of the Sandia Mountains in the Tecolote-Las Huertas valley areas (Scurlock 1983: 12).

1671 An unidentified epidemic disease virtually struck every Indian group in the province (Forbes 1960: 166).

1672–79 Tajique, Chilili, Abo, Quarai, and Las Humanas pueblos were abandoned due to drought, which caused loss of crops and interrelated Apache raids (Tainter and Levine 1987: 86–87).

1675–1710 The pueblo and later land grant of Alameda was located on the west side of the Rio Grande. Sometime after this, and before 1769, the river shifted westward, leaving the village of Alameda on the west side of the Rio Grande (Sargeant 1987: 38–40).

1680 (pre) On the east side of the Rio Grande, now part of Albuquerque's Barelas-South Valley area, there was an area of cienegas and charcos known as the Esteros de Mejia (Simmons 1982: 40).

1680 (pre) The father of Roque Madrid reportedly worked a lead mine near Santa Fe (Schroeder 1977: 24).

1680 A collapse in the Chalchihuitl turquoise mine killed a number of Indian slaves. This may have been a factor causing the Pueblo Revolt later in the year (Tyler 1964: 184).

1680 (August 10) The Pueblo Revolt, caused partly by food shortages due to drought and interrelated raiding by nomadic groups, began (Sando 1979: 195).

1680 (post August 10) Reportedly, Pueblo Indians in the area sealed the gold mine known as the Montezuma Mine during the revolt (Batchen 1972: 36).

1680 (September 13) The Pueblos, who had attacked and skirmished with Otermin's troops trying to hold the provincial capital, diverted the Santa Fe River away from the Spaniards for 2 days and a night. This loss of water supply was a factor in Otermin's decision to retreat southward (Hackett and Shelby 1942, I: lxiii-lxiv).

1681 (pre-December) Owing to lack of rain, the northern Pueblos experienced famine and abandoned their villages (Hackett and Shelby 1942, I: cxxxvii).

1681 Governor Otermin discovered that the Pueblos had kept part of the sheep flocks and cattle herds following the revolt of the previous year. This suggested that they had acquired a taste for mutton and beef and that wool had replaced cotton as the preferred material used in weaving (Baxter 1987: 13).

1681 There were domesticated chickens at Puaray and Alameda pueblos (Schroeder 1968a: 106).

1687 (June 4) The Spanish royal cedula defined the areas of land granted to the Indians (DuMars et al. 1984: 19).

1692 (September 4) The Spanish army of the reconquest, led by Diego deVargas, rested at the abandoned rancho of Felipe Romero near the abandoned Sevilletta Pueblo. This site was selected for its excellent grasses and adequate water (Espinosa and Chavez n.d.: 22).

1692 (late October) Diego de Vargas, who crossed the Rio Puerco west of later Albuquerque, with his reconquest command, noted that the water was so deep that the soldiers had to carry provisions and equipment on their shoulders (Lopez 1980: 71; Twitchell 1963, I: 381).

1692–93 The Esteros de Mejia, which extended along the east side of the Rio Grande from the present Central Bridge to the Barelas Bridge, was the site of a hacienda on the Camino Real. Made up of charcos (small lakes) and cienegas (marshes), which supported lush grasses, sedges, and other forage plants, the esteros was utilized by legal and trespass livestock ranchers. This led to a near fatal altercation among several individuals (Simmons 1982: 10, 40, 87, 112).

1692 (to early 1700) The Pueblo population declined as much as 50 percent due to war and disease (Thornton 1987: 77).

1692 (post) The Pueblo Indians had chickens (Schroeder 1968a: 102).

1693 There was no late summer-fall harvest because of worms and grasshoppers at Santa Ana, San Felipe, and Zia pueblos (Bailey 1940: 95–98).

1693 (late) Governor Diego de Vargas led his reconquest army and more than 800 settlers up the Rio Grande from El Paso to the Middle and Upper Rio Grande settlements (Kessell et al. 1995: 383–387).

1694 (May) Plains Apaches visited Governor Vargas at Pecos Pueblo and presented him three buffalo hides and an elk-hide camp tent as gifts. They promised to bring buffalo, elk, and deer hides to trade in the fall (Weber 1971: 22).

1694 (June) Sixty-four more families from Mexico arrived in northern New Mexico, and their presence exacerbated the troublesome food shortage. Vargas deemed it necessary to raid the pueblos for food, which caused more bitter battles and sieges (Sonnichsen 1968: 71).

1694 (summer) Vargas destroyed the Jemez villages of Astiolakwa and Pebulikwa and collected more than 500 bushels of stored corn. Most of the corn was given to the Keresans who had helped the Spanish campaign (Sando 1992: 72).

1694–1700 During the reconquest, or in the first few years following, the Spanish commandeered the lead-ore mines in the Cerrillos Hills for use in making musket balls and perhaps other items. Without lead for making their glaze-decorated pottery, the Pueblos were forced to revert to their old tradition of making mineral pigment paint for decoration (Peckham 1990: 122).

1695 (July 12) The Spanish royal cedula amended the 1687 act by reducing areas granted the Indians (DuMars et al. 1984: 19).

1695 (summer) An infestation of worms ate most of the crops, which contributed to a famine in the following year (Twitchell 1963, 1: 409).

1695 Crops failed at San Juan Pueblo (Whitman 1940: 392).

1695 Two years after resettlement, Spanish families had been reduced to 328 due to an epidemic, hostilities with Native Americans, and desertions (Reeve 1961, I: 302).

1695 A grant of one fanega of planting land and pasture for 200 sheep and 20 cattle at La Cieneguilla was made to Joachim Anaya de Almayor (Wozniak 1987).

1695 (post) A Spanish cart-wagon road, which extended southeast from the Bernalillo area along the west base of the Manzanos, linking springs along a fault line, crossed Abo Pass to the Salinas villages (Simmons 1973a: 148).

1695–1748 Spanish colonists settled on abandoned Sandia Pueblo lands along the Rio Grande, which were fertile and well watered. Most of these settlers were on the west side of the river across from the old pueblo. Following resettlement by the Sandia Indians in 1748 on the east side of the river, the Spanish on the opposite side retained their lands (Clark 1987: 22).

1696 The famine impacted Pueblo and Hispanic settlements. Various wild animals and plants from the valleys and the mountains were eaten (Twitchell 1963, 1: 409).

1696 Under the direction of Vargas, a silver mining camp was established at the former Los Cerrillos settlement, and it was named Cerro de San Marcos. Three mines were worked at this location, located near the deserted pueblo of San Marcos (Schroeder 1977: 24).

1690s Owing to concerns that there were not adequate unclaimed lands and waters to meet the needs of new Hispanic settlements, farms, and ranches, new regulations on the granting and use of these resources were put in place (Bayer et al. 1994: 75–76).

1600s The Spanish mined turquoise on Mount Chalchiuitl, site of prehistoric Pueblo mines (Christiansen 1974: 17).

1600s The Camino Real caravans carried 500 pounds of tallow to lubricate wheels and axles of carts and wagons (Moorhead 1958: 33).

1600s The Jicarilla Apache believed that the bighorn sheep of northern New Mexico were driven from their valley habitat into the mountains by the guns of the Spaniards (Tiller 1992: 22).

1600s Bones of the smallmouth buffalo (fish) were found in archeological sites dating to this period along the northern Rio Grande drainage (Sublette et al. 1990: 222).

1600s (late) Four smelters were operated in the New Placers district by area Pueblos to produce lead glaze for ceramics. Spanish materials for mining and smelting of this ore occurred in the nearby San Pedro Mountains (Warren and Weber 1979).

1600s (late) Obregon wrote that the Rio Grande was "swift and beautiful, surrounded by numerous meadows and farms..." (Hammond and Rey 1927: 291).

1600s (late) Rafts were used to cross the Rio Grande to reach the pueblo of San Felipe located on the west bank of the Rio Grande (Strong 1979a: 392).

1600s (late) The market for buffalo hides in Mexico sharply increased demand. Spanish traders by-passed the Pueblo middlemen and dealt directly with Plains Indians for the hides. Colonists and government agents exerted pressure on the Pueblos to procure even more hides, causing more stress among the villages (Snow 1981: 367–368).

1700 (May 24) Jose Trujillo took possession of a grazing grant on the uplands between Santa Cruz de la Canada and San Ildefonso. Some farmland along the lower Arroyo Seco was also included in the grant (Wozniak 1987).

1700 By this year the Rio Grande-Galisteo Pueblos ceased mining, smelting, and using lead to decorate their pottery. This may have been a result of the Spanish requiring so much lead for ammunition during the reconquest and conflicts with various Native American groups in the 18th century (Schroeder 1977: 24, 31).

1700–1800 About 27,000 new acres were put into cultivation by the Spanish in the Middle Rio Grande Valley (Hedke 1925: 23).

1700–1800 By 1700, there were an estimated 62 acequia madres, and some 102 more were constructed by the end of the period (Clark 1987: 16).

1700 (post) Pueblo agriculture flourished, especially the cultivation of wheat, corn, and other vegetables. Santo Domingo and Cochiti regularly supplied chile, lettuce, and garlic to Spanish villages. Acoma, Laguna, and Zuni had large flocks of sheep (Simmons 1979a: 190).

1703 A grant of arable and grazing lands in the Rio Grande Valley above San Juan Pueblo was taken by Sebastian and Antonio Martin. An acequia madre from the river to their floodplain fields was constructed (Wozniak 1987).

1704–76 The acequia madre at San Ildefonso was constructed of terrones, with the grassy side facing the water. This ditch fed a pool from which the Pueblos irrigated their kitchen gardens (Adams and Chavez 1956: 59).

1706 April The area settled by the new residents of Albuquerque was known as the Bosque Grande de San Francisco Xavier, which extended along the valley from Old Town to Alameda. The Esteros de Mexico, located just south of Old Town, was avoided by the Mejia settlers (Oppenheimer 1962: 15). The site of Albuquerque was chosen for the availability of good water, tillable land, good grazing grasses, and fuelwood. This location was also selected owing to its being on slightly elevated ground and on the Camino Real and having a good, close ford over the Rio Grande (Simmons 1982: 81–82).

1706 The east bank of the Rio Grande was heavily wooded from modern Ranchos de Albuquerque to below Central Avenue (Simmons 1980: 202).

1709–39 The channel of the Rio Grande between Algodones and Bernalillo shifted westward. The church and several homes at colonial Bernalillo (near present Llanito) were washed away in 1735 or 1736 (Snow 1976: 172–175).

1709–63 Santa Ana Pueblo purchased lands from Spanish settlers at Ranchitos, located on the east side of the Rio Grande, along the north boundary of the Bernalillo Grant. Some of the land was used for irrigation farming, and the remainder was used for livestock grazing. The latter area was covered with cottonwood trees (White 1942: 27).

1710 (January 27) Montes Vigil was given possession of a land grant on the west side of the Rio Grande opposite Sandia Pueblo. Following his failure to settle the grant, Vigil conveyed the land to Captain Juan Gonzalez on July 18, 1712. Vigil began to raise cattle (Adams and Chavez 1956: 152; Eisenstadt 1980: 2–3).

1710 The earliest mine registered in the region was the San Miguel, located about 38 miles south of Santa Fe (Warren and Weber 1979: 9).

1710 (post) The Rio Grande, then located east of Alameda, began shifting westward. By 1768 the channel had moved to its present location, placing the village of Alameda on the west side of the river (Sargeant 1987: 38–39).

1700s (early) Because of to continuing flood damage to their agricultural fields, Santa Ana Pueblos began buying land along the Rio Grande where they established ranchos. They moved to these new settlements from spring planting to fall harvest and then returned to the old pueblo for the winter. Later, in the next century, these Keresans established permanent residence at the Ranchos de Santa Ana and returned to their Jemez River pueblos only for ceremonies (Kessell 1980: 168).

1700s (early) The Rio Grande shifted its channel and at times ran east of Bernalillo, Alameda, and Albuquerque. After 1720 the Bernalillo church was washed away by a flood (Chavez 1957: 3).

1700s (early) Overgrazing had become a problem around the older plazas such as Atrisco, Albuquerque, and Corrales (Baxter 1987: 24).

1700s (early) Grasses and other wetland vegetation were abundant in the cienega located in the eastern part of Santa Fe. This was a special use property, where these plants were "mowed" and fed to the horses of the presidial troops, who escorted town residents to the mountains, where they collected fuelwood or timber (Ebright 1994: 90).

1700s (early) A decree by the governor declared that every Santa Fe area farmer had to allow livestock from the community to graze on crop stubble from just after harvest until spring planting (Ebright 1994: 90).

1700s (early) The recently arrived Comanches raided Jicarilla, Lipan, and Mescalero Apache villages at or just after the fall harvest (Dobyns 1973: 17–18).

1700s (early) The Pueblos, who became allies with the Spanish against the Apache, Navajo, and Comanche, performed as scouts, interpreters, and informants, as well as soldiers. They made reports to the Spanish commanders on weather, field food sources, water, and topography (Sando 1992: 80).

1700s	(early to mid) The dispersed Spanish settlement in the Chama Valley was due in part to the topography, vegetative communities, and lack of adequate tools. Benchlands of pinyon-juniper above the river could not be cleared easily, so cultivated lands were located on the narrow disjunct, floodplain plots (Swadesh 1974: 133–134).
1700s	(early to mid) To catch dirt falling from the ceiling in churches, decorated animal hides were stretched and nailed across the vigas. Priests chased away swallows that were nesting in some churches (Kessell 1980: 12).
1712–14	Spanish settlers took possession of agricultural land on the lower Chama River, which was planted in corn. The town of Chameta (Chamita) was founded here (Wozniak 1987).
1712–76	Albuquerque was a string of farms along the east side of the Rio Grande, from Alameda to south of the village plaza (Simmons 1980: 203–204).
1713	A mine in the Sierra de San Lazora in present Rio Arriba County was registered with the governor (Northrop 1975: 13).
1714	The Neustra Senora de los Reyes Linares mine was registered to Miguel de Coca. It was located on the San Lazaro Mountain at El Tuerto (Warren and Weber 1979: 9).
1716	Spanish resettlement of the Valencia area began. Antonia Sandoval y Manzanares received a grant of land that had been the encomienda of Juan de Valencia before the Pueblo Revolt. Apparently, Valencia had transferred the title to his estancia-encomienda to Sandoval's husband before the revolt. This grant included the Pueblo of San Clemente, later the site of Los Lunas (Espinosa and Chavez n.d.: 30, 53; Wiseman 1988: 17).
1716	A grant of grazing and agricultural lands was made near the abandoned pueblo of San Clemente, south of Isleta Pueblo. Another grant in the area, located on the west side of the Rio Grande, was made to Antonio Gutierrez, who farmed and ran livestock on the lands (Wozniak 1987).
1717	A grant was made for a lead mine located five leagues from Santa Fe between Cienega and La Cieneguilla. This mine may have been located at the late 19th century mining camp of Bonanza (Schroeder 1977: 24–25).
1718	(May) Diego de Padilla received a land grant located east of the Rio Grande and south of Isleta lands. Padilla grazed sheep here until 1751. This was the later site of Peralta and the Juan Antonio Otero home (Espinosa and Chavez n.d.: 64; Taylor 1989: 4–5).
1718	Spanish livestock encroached on fields belonging to San Juan Pueblo. The governor ordered ranchers to remove their stock from the Indian land. The *Leyes Reales* specifically forbade such trespass (Baxter 1987: 23–24).
1719	Localized smallpox epidemics occurred (Thornton 1987: 79).
1720	(ca.) Santa Ana Pueblo potters began to use fine river sand as a substitute temper for crushed basaltic rock used at nearby Zia (Frank and Harlow 1990: 101–102).
1720–30s	Settlement of grazing and farming lands along the Rio Chama, upstream from Chamita, occurred (Wozniak 1987).
1722	Captain Antonio Cobian Busto reported "From the city of San Felipe el Real [Chihuahua] to Santa Fe in New Mexico...there are innumerable valleys, streams, and plains, very rich and suitable for breeding cattle and sheep, and sowing wheat, corn, and other foodstuffs..." (Baxter 1987: 19).
1722	Gold was mined at La Mina del Tiro in the Cerrillos Mountains (Christiansen 1974: 17; Northrop 1959: 46).
1726	Pedro de Rivera visited the Valencia area noting spacious, fertile valley land with extensive cottonwood bosques. He passed several ruined ranches in the Valencia area that were still uninhabited following the Pueblo Revolt (Rivera 1946: 51).
1727	A measle epidemic struck Zia, Jemez, and Santa Ana pueblos. This may have been a factor in the rebellion of residents, who fled to nearby mesa tops (Swadesh 1978: 42).
1727	The Tafoya family received a grazing lands grant along the Canada de Santa Clara, above the Pueblo of Santa Clara. Over much of the rest of the century there were disputes between the settlers and the Pueblos over water rights to the Rio Santa Clara (Wozniak 1987).
1728	(December) Measles killed 109 Jemez Pueblo Indians (Stockel 1993: 34).
1728–29	An epidemic of measles struck Zia Pueblo. Residents and those of Jemez, Santa Ana, and Cochiti rebelled against the Spaniards and sought refuge in the mountains (White 1962: 25).
1720s	Comanches "discovered" a better route over the Sangre de Cristo Mountains from the Arkansas River Valley to Taos. This trail followed a branch of the Huerfano River to the Sangre de Cristo Pass, down Sangre de Cristo

to the San Luis Valley, and south to Taos (Lecompte 1978: 57).

1731 (January) Bernardino de Sena and Luis Lopez took possession of grazing land at the abandoned pueblo of Cuyamungue (Wozniak 1987).

1731 Taos leaders lodged a complaint against Spanish settlers, who had encroached on Pueblo lands and were using their brands on Indian livestock (Gunnerson 1974: 216).

1731–35 Settlers in the lower Chama River Valley and the Santa Cruz area, facing shortages of farm and grazing lands, as well as water, petitioned for and received grants higher up the Chama (MacCameron 1994: 29).

1730s (early) Jose de Riano obtained rights to grazing lands in the Piedra Lumbre Valley (Wozniak 1987).

1733 Localized smallpox epidemics occurred (Thornton 1987: 79).

1734 (May 30) Ten settlers took possession of a grant of agricultural lands along the Rio Chama at Abiquiu (Wozniak 1987).

1735 Various settlers received land grants for farming and grazing in the Abiquiu-Piedra Lumbre area (Wozniak 1987).

1735 The Galvan ranch, located near Zia Pueblo, had 700 sheep, 18 cattle, and an unknown number of horses (Swadesh 1978: 43).

1736 (early) Five Albuquerque farmers requested that the alcalde allow them to move their livestock back to the Isleta area, where better grazing conditions existed (Baxter 1987: 24).

1738 Smallpox killed 26 young children in 18 weeks at Pecos Pueblo (Kessell 1979: 378).

1739 (July 30) A grant of about 122,000 acres was made to petitioners from Albuquerque, who said they had a scarcity of wood, water, and pasture and could not extend their farmlands or livestock range "on account of the many footpaths encroaching upon us" (Ellis 1955: 9; Espinosa and Chavez n.d.: 29, 92; Twitchell 1914: 285). The boundaries of the Tome grant were the Rio Grande on the west, Los Tres Alamos on the south, the "main ridge" of the Manzano Mountains on the east, and a cienega on the north side of Cerro de Tome (Ellis 1955: 92).

1739 Vicente Duran y Armijo claimed he suffered crop failure along the Santa Fe River due to a scarcity of water (Wozniak 1987).

1739 Nicolas Duran y Chavez received a grant of grazing land between the Rio Grande and the Rio Puerco, south of the Gutierrez grant (Wozniak 1987).

1739 (post) Along a fault line at the west base of the Manzano Mountains were three communal springs—Los Ojuelos, Ojo de Alamita, and Ojo de los Barrendos. Livestock owned by Tome residents watered here, and a small acequia carried water from these springs to watering tanks constructed some distance to the west on the bajada (Ellis 1955: 103).

1730s (to early 1742) Pedro Sanchez claimed that wolves attacked and bit his sheepherders on the Ramon Vigil grant and caused him to remove his sheep (Ebright 1994: 229).

1740 (November 15) The governor granted land to settlers who founded Belen, Jarales, and other area communities. Ditches from the Rio Grande to fields were dug with palas de palo (wooden shovels). The uplands along the Rio Puerco-of-the-East and the Manzano Mountains were common lands for grazing livestock, collecting fuelwood, and hunting (Espinosa and Chavez n.d.: 33–36, 75–78).

1742 Due at least in part to the drought of the previous decade, all of the Rio Grande Pueblo refugees (except residents of Hano) fled the Hopi area and returned to their former villages on the river (Adams 1981: 326).

1742 Nicolas Ortiz received the Caja del Rio grant of grazing lands on the east side of the Rio Grande and along the lower reaches of the Santa Fe River (Wozniak 1987).

1742–43 Several grants of agricultural lands along the middle Santa Fe River were made (Wozniak 1987).

1743 (September) Four residents of Chimayo received grants of arable and grazing lands near Cundiyo (Wozniak 1987).

1743 Land grant settlements of farm and grazing lands were made along the lower Rito de Ojo Caliente (Wozniak 1987).

1744 A grant of agricultural and grazing lands, north of Cochiti Pueblo, on the west side of the Rio Grande was made to Juan Jose Moreno (Wozniak 1987).

1744 Albuquerque experienced an infestation of moths, which were eating large stores of raw wool. Fortunately, a buyer from Mexico City arrived and purchased the wool before the insects destroyed very much (Simmons 1982: 114–115).

1744 Valley cottonwoods extended more than 10 miles along the Rio Grande around Alameda (Galvin 1972: 58).

1744 Several mines near Picuris Pueblo were registered with the governor (Northrop 1975: 15).

1745–60 Abundant irrigation water produced good harvests at Nambe Pueblo (Adams 1954: 55; Hackett 1937: 466).

1747 (August) All settlements west of the Rio Grande were attacked by nomadic Indians (Swadesh 1974: 35).

1747 Localized smallpox epidemics occurred (Thornton 1987: 79).

1748 (April 5) A grant was made to Sandia Pueblo by the Spanish governor. The grant was bounded on the west by the Rio Grande and on the east by the "ridge of the Sandia Mountains" (Brayer 1938: 68–69).

1748–71 Almost 4,000 Spaniards and Pueblos were killed by Apaches, Navajos, and Comanches in New Mexico (Thomas 1932: 6).

1748–1846 Sandia Pueblo lost a significant portion of its lands to Hispanics owing to its fertility and available water (Clark 1987: 22).

1749–54 Gold was mined in the Cerrillos area southwest of Santa Fe (Workers of the Writers' Program 1940: 71).

1740s Comanches, Apaches, and Utes frequently raided villages, fields, and livestock herds in the study region. The eastern frontier north of Albuquerque was depopulated (Sonnichsen 1968: 77).

1750 (pre) Santa Ana Pueblos began acquiring better farmlands along the Rio Grande because their fields near the pueblo were periodically destroyed by Jemez River floods (Kessell 1980: 168).

1750 By this year Albuquerque and nearby communities were experiencing some pressures of overpopulation. Suitable agricultural land was taken, and livestock overgrazed some pastures and outlying rangelands. Outmigration to "new" lands, such as the Rio Puerco-of-the-East, began (Simmons 1982: 106–107). The bajada between Albuquerque and the Sandia-Manzano mountains was virtually denuded of grass by livestock (Simmons 1988: 7).

1750–1820 Problems due to overgrazing in the Upper and Middle Rio Grande basins were exacerbated by "hostile," nomadic Indians and denial of land grant petitions by government officials (MacCameron 1994: 22–23).

1700s (mid) Intensive livestock grazing and fuelwood cutting led to decimation of vegetative cover and soil erosion along Abiquiu Creek. Water from the stream tasted and smelled like cattle manure (McDonald 1985: 120).

1700s (mid) The Jicarilla Apache were confined to the northern mountains by the Comanches and other Plains Indians. As a result, the Apache were unable to hunt buffalo and large game on the plains to the east. Game in the mountains became increasingly scarce due to Indian and Spanish hunting pressure. At the same time, arable land in mountain valleys was increasingly occupied by Spanish settlers (Gunnerson 1974: 237).

1751 Governor Velez Cachupin noted that because of overpopulation of Santa Fe, some town farmers had no agricultural land or water for irrigation. To help remedy this problem, he approved the Las Trampas grant to the north of Santa Fe (Ebright 1994: 146).

1752 Juan de Gabaldon received a grant of arable land on the Rio Tesuque. He had been unable to find farmland near Santa Fe because of a scarcity of irrigation water (Wozniak 1987).

1753 (October 21) Several Albuquerque families, seeking adequate grazing for their livestock, petitioned the governor for a grazing grant on the Rio Puerco (Simmons 1982: 106–107).

1753 A ranch near Zia Pueblo had 330 goats and sheep, 42 cows and calves, 38 heifers and steers, 3 bulls, 6 oxen, 31 mares and stallions, a jenny, and a jack mule (Swadesh 1978: 43).

1753 Governor Cachupin ordered Spanish settlers near Taos to fence their farms to keep their stock off of traditional Pueblo grazing lands (Baxter 1987: 24).

1754 Faraon Apaches raided the Albuquerque area from the Sandia Mountains and via the Bocas de Abo at the south end of the Manzano Mountains (Thomas 1940: 143).

1754 A priest reported that there were "fine melon patches" and fields that produce several "fanegas of wheat and one cuartilla of corn" at Cochiti Pueblo (Lange 1959: 86).

1757 Pueblos and Hispanos had 112,182 sheep, 16,157 cattle, and 7,356 horses (Weber 1992: 310).

1757 There were 112,182 sheep and goats, 16,157 cattle, and 7,356 horses in Spanish New Mexico (Baxter 1987: 42).

1758 A Spanish government decree required landholders to provide proof of title to retain land and water rights to their property (Clark 1987: 12).

1750s As the Navajos were forced south by Utes, conflict over resource competition in the Rio Puerco basin with Hispanos accelerated (Lopez 1980: 72).

1750s (to 1760) Major Spanish settlement of lands along the middle and upper Rio Puerco and on the south and west sides of the San Mateo Mountains occurred (Wozniak 1987).

1750s (to 1760s) Clemente Gutierrez, a wealthy trader and rancher, suffered heavy sheep losses on lands along the Rio Puerco-of-the-East. These losses were due to a parasitic skin disease of sheep known as scab (lepe), as well as Navajo raids, which intensified into the 1770s (Baxter 1987: 48).

1760 Bishop Tamaron, with all of the people in his entourage, and the livestock, were ferried across the Rio Grande at El Paso on a raft pulled by Indian swimmers (Jones 1979: 144).

1760–61 Residents of the Belen grant claimed to "have suffered many hardships in order to drive the enemy away from this frontier [such as] eating rats, badgers, and wild herbs" (Ebright 1994: 7–8).

1761 (May 4) The Los Quelites, or San Francisco del Valle, grant was made. This land bordered the Tome grant (Pearce 1965: 92).

1763 (July) Santa Ana Pueblo paid "more than 67 cows and calves, 8 bulls, 29 oxen, 50 sheep, 74 goats, 8 horses, 3 mules, 1 mare, 1 colt, 2 new bridles, 4 blankets, and 1 pot" to Bernalillo residents for a tract of land lying between the river and the base of the Sandia Mountains (Bayer et al. 1994: 80).

1763–64 Two grants for silver mines in the Cerrillos area were made; one was known as Nuestra Senora de los Dolores (Schroeder 1977: 25).

1764 (October) The town council of El Paso and the Suma Indians of San Lorenzo had a dispute over the latter's common woodlands south of the villa of El Paso. Hispanics had used the land in gathering building materials (latias and vigas), fuelwood, and willows used to construct diversion dams. Additionally, Spanish sheepherders were grazing their flocks on Suma land and were setting fire to trees and shrubs to produce better grazing ranges. The governor ordered the El Pasoans to stop their use of the land and to plant trees and willows, graze their livestock, and gather firewood on their own common lands (Ebright 1994: 5).

1765 Eight residents of the Los Quelites grant on the Puerco and San Jose rivers requested Governor Capuchin's permission to withdraw from the grant, claiming that there was insufficient and salty water in the two streams. Water from springs and a cistern were used for watering their corn, chile, and cotton (Ebright 1994: 10).

1766 (August 14) Opposite the ruins of Sevilleta Pueblo on the Rio Grande, Nicolas Lafora wrote about the mouth of the Rio Puerco "whose waters always flow muddy and turgid" (Kinnaird 1967: 89).

1766 (August 15–16) Lafora continued to travel north up the east bank of the Rio Grande. His expedition reached Las Nutrias, then Tome, passing over a "good level road." The population of Tome was given as 70 Spanish residents. Lafora noted that "all kinds of grain abound, as well as sheep, and there is plenty of good pasture everywhere in the vicinity." On the next day he traveled 10 leagues north over "a plain extensively forested with poplar trees along the river's edge" (Kinnaird 1967: 89–90).

1766–1873 Zia, Jemez, and Santa Ana pueblos grazed sheep on the 382,849-acre Espiritu Santo land grant (Bayer et al. 1994: 157).

1767–70 Governor Pedro Fermin de Mendinueta issued 15 land grants during his administration. He instructed the appropriate alcalde to survey the grant and place "permanent" markers on the boundaries, usually mounds of stone and mud. On the Paulin Montoya grant each family head was given 70 square varas of land for a house and corral and 300 square varas for planting. At the request of Santo Domingo and San Felipe pueblos, Mendinueta allotted each of them a league of land for cultivation between the grant lands of the two pueblos. He reserved the remaining land and water for use by both pueblos (Patrick 1976: 10–11, 13).

1768 (April) Residents of Atrisco received a grant of grazing lands to the west, along the Ceja de Puerco (Wozniak 1987).

1768 The Marques de Rabi recommended that new presidios be located at sites with adequate water and grazing land for the horses (Meyer 1984: 96).

1768 Six families were granted land on Vallecitos Creek in the Jemez Mountains. In 1776 the settlement was known as San Toribio del Vallecito, inhabited by 11 families (Adams and Chavez 1956: 181–182).

1771–72 Some 170 inhabitants were killed, and 7,000 horses and mules stolen, by raiding Indians in New Mexico (Thomas 1932: 5–6).

1773 Governor Meninueta reported that the Pueblos produced abundant crops, especially grains, which Spanish settlers and government officials could purchase when needed. The Pueblos were raising maize, wheat, and vegetables; Santo Domingo and Cochiti were also growing lettuce, chili, and garlic. They were supplying Spanish residents in the area with these and other garden crops. Also, the western Pueblos were successful sheep raisers and wove fine woolen blankets. The governor repeatedly warned Spanish residents to keep cattle and horses at least 3 leagues (about 8 miles) from Pueblo fields, but the rule was commonly violated, and their farmland was constantly damaged by untended livestock (Simmons 1979a: 190).

1775 (June 23) A major Comanche raid on Sandia Pueblo destroyed all of the crops and livestock and resulted in the death of 32 residents (Chavez 1957: 3). These Comanches also raided Alameda, then fled eastward to the Galisteo area. They took refuge in a narrow canyon with a trench filled with trees and rocks. Behind this fortification were more smaller trenches, concentrically arranged with a dug well in the center. Here the Comanches held off a Spanish-led contingent, which withdrew from the conflict (Thomas 1940: 181–182).

1775 Comanches attacked Belen and other settlements (Espinosa and Chavez n.d.: 93).

1775 So many mares were stolen by nomadic Indians that the Spanish could not breed more horses (Loomis and Nasatir 1967: 17).

1775 Bernardo Miera y Pacheco, an officer of the Royal Garrison at Santa Fe, made the first detailed map of New Mexico (Espinosa and Chavez n.d.: 37).

1776 (pre) There were "good orchards of fruits such as pears, grapes, peaches, and others that had resisted the cold..." at Santa Cruz. Beans and chile were not being raised at Picuris Pueblo owing to the short growing season; also, corn was sometimes killed by the cold. There were three agricultural fields in which wheat, green vegetables, and corn at Nambe Pueblo were planted. San Juan Pueblo maintained "fertile" agricultural fields on both banks of the Rio Grande for a league above and a league below the village. The pueblo usually harvested 60 fanegas of wheat, about 30 of maize, and some legumes. Five small fields at Santa Clara Pueblo yielded a fanega of wheat in each, or an almund of corn. Three other small plots produced "legumes." At San Ildefonso Pueblo there were five fields, which usually yielded 30 fanegas each of wheat, maize, and legumes. Water was carried in a ditch from "a little swamp" to a "great pool," water from which was used to water a garden and a small field. Wheat, corn, legumes, green vegetables, melon, watermelons, and apricots were cultivated at Santa Fe. Agricultural fields at Cochiti Pueblo were productive, especially those along the east side of the Rio Grande, downstream from the village (Adams and Chavez 1956: 41, 55–56, 69, 83, 88, 90, 98, 103, 117, 142, 157, 159, 163, 165).

1776 (pre) The mission at San Felipe Pueblo had fields on both sides of the river, a league upstream and a league downstream from the church, and a large "kitchen garden" across the Rio Grande. They had yielded "many good crops" (Adams and Chavez 1956: 163, 165). The apricots, peaches, and grapes at Sandia Pueblo were killed by frosts in most years.

1776 The altar screen at San Geronimo de Taos church was "painted with earth as iridescent as cinnabar and flowered with mica" (Adams and Chavez 1956: 103).

1776 The Galisteo Pueblo and mission had about a square league of farmlands, and almost all was dry farmed. One plot of land to the west of the village was irrigated by water from the Nieto spring. The drought and Comanche raids had caused many of the residents to flee. Those who remained were eating the "hides of cows, oxen, horses, etc., in a sort of fried cracklings, and when they do not find this quickly they strip the vellum from the saddle trees or toast old shoes. They do not have one cow; there is not a single horse." Jemez Pueblo grew wheat and corn, raised hogs, and fed their livestock corn stubble and husks. Their harvests were normally 60 fanegas of wheat and 40 of maize. Bernalillo, located about 2 leagues north of Sandia Pueblo, consisted of scattered ranchos and "not very good lands" irrigated by water from the Rio Grande. Across the river, to the west, was upper Corrales, and it too was made up of scattered ranchos and relatively poor lands. Agricultural fields of Sandia Pueblo extended along the east side of the river, a league above and a league below the village. The upper fields, which were sandy, were not as productive as the lower fields. Crops were watered by irrigation ditches from the Rio Grande. The mission at Albuquerque had fields that yielded 100 fanegas of maize, 50 of wheat, 16 of beans, 16 of other legumes, 30 strings of chile, and a cartload of onions. Good crops were harvested from the fields of the village and from the orchards of apricot, peach, apple, and pear and from the vineyards. The village was located "about two musket shots" from the Rio del Norte. Owing to the sandy soil, the fields at Atrisco were not productive, although they yielded "reasonable crops" because of the intensive efforts of resident farmers. Farmlands and crops at Isleta were similar to those at Atrisco and Albuquerque. The Isleta Pueblo were farming the entire floodplain a league upstream and a league downstream from the village. These fields produced "very copious crops." There were also "many orchards of fruit trees as well as vinestocks, and they usually make a little wine." Peaches, wheat, corn, and cotton were also raised. Father Dominguez noted that Valencia was the place of the 17th century hacienda of Francisco de Valencia. A settlement of ranchos totalling 17 families, some 90 persons in all, was situated on a "meadow." Belen had good, irrigated farmlands that yielded "copious crops." According to Dominguez, the farmlands at Sabinal were better than those at Belen (Adams and Chavez 1956: 103, 142–144, 151, 153, 154, 179, 205, 207–208, 217, 312–313).

1776 Comanches raided Tome, killing 23 people and nearly destroying the town (Espinosa and Chavez n.d.: 38–39).

1777 (summer) A Comanche raid on Sandia Pueblo killed 32 residents and destroyed all of their crops and livestock (Chavez 1957).

1777 Twenty-three persons were killed in an Indian raid on Valencia (Taylor 1989: 3).

1778 An Apache raid on Tome killed 30 people. Isleta Pueblos came to their rescue and prevented destruction of the town. Surviving residents took refuge in the church (Espinosa and Chavez n.d.: 17; Taylor 1989: 3).

1778 The lands at El Sabinal were so fertile that the citizens of Belen requested permission from Governor Mendinueta to begin farming there (Simmons 1977a: 35).

1778 Genizaros commonly hunted deer for their subsistence meat (Simmons 1977a: 34).

1779 There were 69,366 sheep, 7,676 cattle, and 1,773 oxen in the province (Simmons 1988: 7).

1770s Spanish livestock, left untended, caused constant damage to Pueblo fields (Simmons 1979a: 190).

1770s Domesticated chickens were well established in New Mexico (Schroeder 1968: 107).

1780–81 A smallpox epidemic struck New Mexico following the drought of the previous 3 years. This disease and the resulting famine resulted in the death of 5,025 Pueblo Indians, which constituted more than a quarter of New Mexico's population (Kessell 1979: 348; Simmons 1966: 79; Workers of the Writers' Program 1940: 69). As a result of the smallpox epidemic, eight Spanish missions were reduced to visitas (Bloom 1913b: 135). Some 500 Indians died in a 2-month epidemic of smallpox at Santa Clara and San Juan (Arnon and Hill 1979: 296). About one-third of the residents of San Juan Pueblo died during the smallpox epidemic (Ortiz 1979: 281). Smallpox killed 142 residents of Santa Fe (Stockel 1993: 34). A smallpox epidemic struck Galisteo, causing abandonment of the pueblo. Most survivors emigrated to Santo Domingo; some appeared at Pecos Pueblo in the 1790s (Kessell 1979: 543). More than 250 residents of Santo Domingo died of smallpox (Stockel 1993: 34). There were 130 deaths recorded at San Felipe Pueblo; almost all of these were smallpox related (Simmons 1966: 322). Following the decimation of Santa Ana's population during the severe outbreak, the pueblo was reduced to a visita of the Zia mission (White 1942: 28). A severe smallpox epidemic killed a number of Spanish settlers at Bernalillo (Chavez 1957). Albuquerque lost 31 citizens to the disease, and San Felipe recorded 130 deaths (Simmons 1966: 322). The epidemic swept across Navajo country, causing a noticeable decrease in the Navajo population. This disease was perhaps a factor in the abandonment of portions of the Navajo region (Brugge 1968, 1986: 142).

1781 (February 23) The Spanish government issued a decree expressly prohibiting the unlicensed sales of real property by Indians (DuMars et al. 1984: 19).

1782 Residents of Santa Fe received a grant of grazing lands along the Galisteo River (Wozniak 1987).

1782 Fray Morfi reported that Santo Domingo Pueblos cultivated cotton (Thomas 1932: 99).

1782 Albuquerque was described as a rancheria-style settlement extending along the Rio Grande Valley for about 2.5 miles. Agricultural fields extended for almost 20 miles along the banks of the Rio Grande. Much of the farmland was fallow because of Indian raids. Scarcity of wood forced residents to use horse manure for fuel (Thomas 1932: 101).

1782 Fray Morfi reported that "a long time ago large haciendas" existed at the spring of El Espiritu Santo but were subsequently deserted (Thomas 1932: 100).

1782 A Spanish trader brought a parrot into New Mexico for the Indian trade (Thomas 1932: 113).

1782 Santa Fe had plenty of farm and range lands, but the river was "poor and can only fertilize some fields" (Thomas 1932: 92).

1782–94 Galisteo Pueblo, resettled by Tanos after the Pueblo revolt, was abandoned for the final time due to disease and raids by Comanches and Plains Apaches (Dozier 1983: 64).

1785 Eight residents of the Los Quelites grant on the Puerco and San Jose rivers requested Governor Capuchin's permission to withdraw from the grant, claiming that there was insufficient and salty water in the two streams. Water from springs and a cistern were used for watering their corn, chile, and cotton (Ebright 1994: 10).

1788 A grant of agricultural lands at the confluence of the Rio Jemez and Rio Guadalupe was made (Wozniak 1987).

1788–89 A smallpox epidemic caused Pueblo population losses up to 50 percent (Thornton 1987: 7).

1789 Governor Concha believed that the range in northern New Mexico would support more sheep, so he prohibited the slaughter or exportation of ewes to increase flocks. A rapid increase in the number of sheep between that year and the early 1800s occurred as a result (Bailey 1980: 111).

1780s New land grants were made in the Santa Fe area and along the Rio Jemez (Wozniak 1987).

1790 There were some 927 farmers, 113 persons associated with livestock raising, and a few hunters in the province (Jones 1979: 133–134).

1790 There were 120 households in Tome. Occupations listed in the census included, in order of importance, farmers, livestock raisers, carpenters, and sheepherders. Seven weavers, two tailors, two carders, and a silversmith were also listed. Some woven goods were shipped south over the Chihuahua Trail for trade (Espinosa and Chavez n.d.: 95; Minge 1979: 21).

1790 Two residents of Santa Fe were listed as lumbermen (Olmstead 1975: 68, 75).

1791 Twenty-four adults and 21 children died from smallpox at Nambe Pueblo (Stockel 1993: 54).

1791 (post) A bridge was constructed at Belen using sacks filled with heavy rocks and sunk in the Rio Grande. Vigas, hauled to the site by oxen, were laid on the sacks to form the superstructure (Jones 1979: 144).

1793–1846 Periodic epidemics of infectious diseases accounted for 30 percent of all Catholic deaths recorded in the Tome parish. All of the deaths were children under the age of 13 (Baca and Baca 1994: 5).

1794 The San Miguel del Vado land grant was approved by Governor Chacon; he also distributed irrigated tracts to 48 Spanish heads of families (Hall 1984: 4–5).

1795 (February) Twenty Spanish families took possession of agricultural lands at Cieneguilla on the Rio Grande above Embudo (Wozniak 1987).

1796 Grants of land were made to settlers at Santa Barbara, La Canada, and San Fernando de Taos (Wozniak 1987).

1798 Spanish settlers living in the San Diego and Guadalupe canyons received a grant north of Jemez Pueblo. Later, 110,000 acres were confirmed by the Surveyor-General of New Mexico (Leonard 1970: 110).

1799 (November to March 1800) Smallpox epidemics struck north and central New Mexico (Stockel 1993: 35).

1799 (post) Mestizos and genizaros from the Belen area moved to San Miguel del Vado in search of good farmland (Jones 1979: 116–117).

1700s (late) Settlers on community land grants employed more intensive use of land near streams for agriculture and homes. Less intensive exploitation of resources, such as livestock grazing, was practiced away from these water courses onto the common lands. Encroachment of livestock onto crop fields was a fairly common problem (Ebright 1994: 26).

1700s (late) Animal hides and tallow were frequently shipped down the Camino Real to Chihuahua and Durango (Weber 1971: 21).

1700s (late) Santa Ana residents were using "boats made of logs from the Jemez Mountains tied with rawhide and sealed with a mixture of pinyon pitch and crushed bark" to cross the Rio Grande between their village and agricultural fields east of the river. These craft were tied to "huge cottonwood trees on the east bank of the Rio Grande." Near these fields the "farmers built small huts of cottonwood, in which they stored their tools and supplies" (Bayer et al. 1994: 81).

1700s Ranchers and farmers traditionally raised sheep rather than cattle because nomadic raiders could more easily and quickly drive the latter away in their escape. Also, when attacked, herders would scatter the sheep to reduce losses. Goats were raised in areas where the grazing terrain was rougher, such as those in the Sandia Mountains (Montoya 1983; Simmons 1982: 114).

1700s Owing to poor soils, the pueblos of Santa Ana, Zia, and Jemez experienced little land encroachment by Spaniards (Clark 1987: 22).

1800 By this year, an estimated 164 acequias madres were in use (Clark 1987: 16).

1800 By this year Bernalillo farmers were known for their abundant produce, especially grapes (Chavez 1957).

1800 A grant at a mine location known as San Pedro in the San Pedro Mountains was made (Schroeder 1977: 25).

1800-07 New Mexico sheep raisers annually drove about 30,000 sheep south for sale in Nueva Vizcaya, Sonora, and Sinaloa (Coues 1987, 2: 739).

1800–50 About 25,000 new acres were placed in cultivation in the Middle Rio Grande Valley (Hedke 1925: 23).

1801 The first Merino sheep were brought into New Mexico (Baxter 1987: 91).

1803 Cultivated tobacco was smoked or dipped as snuff. Dipping was practiced by most of the clergy (Simmons 1991b: 165).

1803 Mica and gypsum were being used for window coverings. The latter was used in making a whitewash for walls (Simmons 1991b: 167).

1804 The new smallpox vaccine was brought from Chihuahua City to New Mexico. Because refrigeration was unavailable it at the time, the vaccine was transported to New Mexico via small children who had been inoculated (Kessell 1979: 456; McDonald 1992: 9–10).

1805 An estimated 3,610 Spanish and Pueblo children were inoculated against smallpox (Jones 1979: 140).

1805 An epidemic of measles struck Cochiti Pueblo (Stockel 1993: 35).

1805-08 Unrest among Spanish citizens, to the point of near rebellion, was due to the government's limiting what goods could be taken on the annual caravan to Chihuahua, prohibiting the selling of sheep to the Navajo, and collecting of grain from the poor citizens of the Rio Arriba to feed the Santa Fe garrison (Kessell 1979: 435).

1807 (early) Eight residents of Abiquiu, which lacked sufficient arable land, cleared 2,000 varas of land in the Canon de los Pedernales. They received a grant of this land about a year later (Wozniak 1987).

1807 Abiquiu residents complained about livestock from Vallecito de San Antonio damaging their crops. The alcalde ordered residents of both settlements to fence their fields and to keep their livestock from wandering (Swadesh 1974: 49).

1807 Zebulon Pike noted that there were "numerous heads of goats, sheep, and asses" in the valley around Santo Domingo Pueblo (Coues 1987, II: 616).

1808 (March) A grant of agricultural lands at the Canon del Rio Chama was made to 26 spanish settlers (Wozniak 1987).

1811 (January 5) The Spanish government issued a decree protecting the Indians in "their person and real property" (DuMars et al. 1984: 19).

1811 (February 9) The Spanish government issued a decree guaranteeing full political equality for the Indians of New Mexico (DuMars et al. 1984: 19).

1811 The following items were woven in New Mexico: "heavy baize, serge, blankets (bed covers), serapes (panchos), regular baize, sack cloth, coarse carpeting, cotton stockings, and table coverings" (Bustamante and Simmons 1995: 16).

1813–35 Several grants of arable lands were made to settlers of Arroyo Hondo and the San Cristobal drainage (Wozniak 1987).

1815 (December) Eighteen adults died from smallpox at Pecos (Kessell 1979: 457).

1815 A group of Spaniards occupied lands at Arroyo Seco and began irrigating with water from the arroyo and Rio Lucero. Taos Pueblos protested, as they depended on the same water for farming. Eight years later the ayuntamiento upheld the prior right of the Indians (Clark 1987: 21).

1816 (spring) A smallpox epidemic struck San Juan Pueblo (Stockel 1993: 35).

1816 (September) The Zia Pueblo governor complained about a Spanish rancher's cattle trespassing on the pueblo's corn fields, causing extensive damage (Swadesh 1978: 45).

1818 (pre) A Taos resident mined copper near the town and manufactured the metal into kitchen utensils (Moquin and Van Doren 1972: 170).

1818 With the passing of the Apache threat east of the settlement, a group of Albuquerque citizens applied for a land grant to resettle Carnue, just inside the mouth of Tijeras Pass (Simmons 1982: 111).

1818 Government officials ordered that lead should be extracted from deposits near Las Huertas, north of Placitas, for the making of musket balls (Schroeder 1977: 24).

1818 Governor Melgares appealed for the donation of woven goods to the military posts. Residents of Belen, Tome, and probably Valencia contributed serapes and sheep (Minge 1979: 20).

1819 (January-February) Twenty settlers from Albuquerque reoccupied and received possession of the Carnue grant at the mouth of Tijeras Canyon (Wozniak 1987).

1819 (February 25–26) The village of San Antonio de Padua was founded on the new Carnue land grant close to Tijeras Canyon. Some 24 families built their homes, a church, and irrigation ditches and cleared fields for 3 miles along the valley (Quintana and Kayser 1980a: 46).

1819 Don Bartolome Baca was granted 1,282,000 acres of land in the Estancia Valley (Towne and Wentworth 1945: 63).

1819 Pedro Armendaris took possession of a large grazing grant on the east side of the Rio Grande, at the north end of the Jornada del Muerto. The governor made the grant to facilitate travel and livestock drives across the Jornada (Wozniak 1987).

1820–30 Ranchers in the Belen-Tome area owned an average of 1,000 sheep (Minge 1979: 23).

1820–46 New Mexican Hispanic traders carried the hides of elk, pronghorn, bear, mountain lion, and beaver to Mexico for trade. Native Americans collected many of these hides (Minge 1979: 25).

1820–30s A number of grants of grazing and farm lands located on the east sides of the Sangre de Cristo, Sandia, and Manzano mountains were made (Wozniak 1987).

1800s (early) Settlers at San Jose de las Huertas were running goats in the area. Nomadic Indians sometimes raided the herds and drove the animals away (Batchen 1972: 83).

1800s (early) As the Pueblo population decreased in northern Rio Grande villages, irrigated lands were abandoned. Spanish residents in the area began to acquire these fields from the Pueblo largely through exchanges of livestock, agricultural products, and goods (Carlson 1979: 30).

1800s (early) Hispanics of the northern frontier began to herd sheep eastward toward St. Louis for trade (Swadesh 1974: 63).

1800s (early) (to 1825) Bartolome Baca established a ranch in the Belen area. He acquired huge land holdings in the Estancia Valley, where he pastured large herds of sheep, cattle, and horses. Baca became alcalde of Tome and Belen, captain of the Rio Abajo militia, and governor (Espinosa y Chavez n.d.: 95).

1800s (early to mid) H.S. "Harry" Buckman opened a sawmill and began timbering operations on the Petaca grant, near Tierra Amarilla. In 1886 he established a sawmill below Espanola and began cutting on the Pajarito Plateau (Rothman 1989: 203).

1800s (early to mid) There was a smelter at Cienega for processing metal ores (Boyd 1974: 268, 270–271).

1821 (August 24) The new, independent Mexican Congress adopted the Plan of Iguala, which in part made it legal for non-Indians to buy, lease, or use Indian lands as collateral. Unscrupulous bureaucrats and politicians produced phony titles to Indian land and overlooked Mexican encroachment (Sando 1989: 71).

1821 (November 16) The first Anglo-American traders from Missouri reached Santa Fe with their goods, opening the Santa Fe Trail and linking with the Chihuahua Trail. New American markets became available for New Mexico merchants, and residents had access to a whole new range of U.S. manufactured goods (Minge 1979: 24–27; Moorhead 1958: 7–8).

1821 The Comanches made widespread raids across New Mexico, probably due in part to the drought (Bancroft 1889: 302; Denevan 1967: 701).

1821–46 Sometime during this period the Mexican government gave four metal axes to Santa Clara Pueblo. These were used in turn by families as needed (Hill 1982: 42).

1821–46 The Mexican administration in Santa Fe provided less protection for Pueblo land and water rights, and the expanding Hispanic population put more pressure on available farmland and trespassed more on Indian lands (Simmons 1979b: 207).

1821–46 Sheep and efectos del pais were shipped down the Chihuahua Trail to various points in Chihuahua, Sonora, Durango, and Zacatecas. The latter items, locally produced or manufactured, included woven goods such as serapes, mantas, jerga, sabanilla, frazadas, and colchas (Minge 1979b: 8–9).

1821–50 Most Pueblo populations continued to decline, due mainly to diseases (Minge 1976: 44).

1821 (post) Hispanic authorities of the now independent Mexico retained control of trapping, hunting, and trading through licensing (Weber 1971: 29).

1821 (post) The opening of trade with the United States was a major cause of the increasing stratification of New Mexico society (Swadesh 1974: 59).

1821 (post) A dispute over certain islands in the

Rio Grande claimed by Tome and Belen broke out between the two communities (de la Vega 1976: 28).

1822 (January-June) A party of some 22 Anglo trappers took fur-bearing animals around Taos (Connor and Skaggs 1977: 32–33).

1822 James Baird came back to New Mexico and within 3 years was operating a distillery near Taos. In 1826 he moved to El Paso and began to trap beaver. Subsequently, he complained about Anglo trappers wiping out the beaver populations, taking pelts worth $100,000 over a year-and-a-half period of trapping (Sonnichsen 1968: 102).

1822 Arroyo Hondo villagers protested the construction of a ditch by Arroyo Seco residents, claiming that it usurped irrigation water needed for their fields (Wozniak 1987).

1822 The area around Albuquerque, a 38-mile-long and 8-mile-wide tract, was under the administration of the town's ayuntamiento. This land was used primarily for livestock grazing and fuelwood collecting (Simmons 1982: 129).

1822–24 The first area within the study region to be intensively trapped was the southern Sangre de Cristo Mountains between Santa Fe and Taos (deBuys 1985: 93).

1823 (September) Some 43 residents of Manzano received a grant of farm and grazing lands between Tome and the abandoned settlement of Las Nutrias (Wozniak 1987).

1823 The governor ordered the settlers of San Jose de las Huertas to abandon their village "to save them from Navajo raids" (Batchen 1972: 31).

1824 (June 26) An official in Mexico City directed the governor of New Mexico to prohibit foreigners from trapping in the territory. This regulation was virtually ignored, and trapping by Americans continued (Weber 1971: 66–67).

1824 Several Anglo Americans began operations distilling "Taos Lightning" for trade with Hispanics and Native Americans (Muldoon 1987: 69–70).

1824 Santa Fe Trail traders began to carry their goods south to Chihuahua (Walker 1966: 140).

1824 Some 2,000 pelts and furs that went back east over the Santa Fe Trail were valued at about $15,000 (deBuys 1985: 97).

1824 Grants of farmlands were made in the Chama Valley at Vallecito de Lovato, near Rito Colorado, at Las Casas del Riano, above Canones, and at Vallecito (Wozniak 1987).

1824 A provincial law decreed that cattle owners would pay two reales per head of livestock that wandered onto agricultural fields and any damages they inflicted on farmland (Simmons 1988: 7).

1824–46 Numerous small grants of Sandia Pueblo land were made to non-Indians, including settlers of present Bernalillo (Brayer 1938: 71).

1825 Native cotton was still being grown at Valencia and Belen, but this crop soon went out of production (Minge 1979: 24).

1826 Some Hispanic families settled on a grant in the Manzano area on the east side of the Manzano Mountains. This grant and settlement were under the jurisdiction of Tome (Ellis 1955: 97).

1826 By this year, Taos trappers virtually took all of the beaver in the Sangre de Cristo and Jemez mountains (Flores 1992: 8). Although the official policy of the Mexican government was to prohibit trapping by foreigners, Governor Narbona allowed Americans to continue trapping in New Mexico (Weber 1971: 111–115).

1827 Over 1,100 beaver skins taken by Ewing Young and associated trappers were confiscated by government officials in Santa Fe. The pelts were threatened with deterioration when "a great rain" saturated them. To save their value, the pelts were sold (Cleland 1950: 217, 220, 224).

1827 Anglo trappers harvested beaver on float trips down the Rio Grande from Cochiti Pueblo to El Paso. At El Paso, they dismantled their rafts and sold the "lumber" and logs to local residents. The trappers then turned eastward to the Anglo frontier, thus avoiding payment of export fees (Weber 1971: 157).

1827 Anglo and Franco-American trappers had harvested virtually all of the beaver in the Sangre de Cristo Range by this date (Ungnade 1972: 48).

1827 Antonio Sandoval constructed an acequia along the foothills on a land grant near Las Lagunitas and south of Las Barelas (Wozniak 1987).

1827 Some 293,000 head of Mexican livestock were in northern New Mexico (Oppenheimer 1962: 20).

1827 There were about 240,000 sheep and goats, 5,000 cattle, and 3,000 horses and mules in the Santa Fe-Albuquerque area. Locally, ranges were being overgrazed, and an erosion cycle was started. Overall, the rangelands in New Mexico remained in relatively good condition

(Baydo 1970: 34; Dortignac 1956: 56, 61; Towne and Wentworth 1946: 56).

1827–46 Taos was the most important market for the fur trade in the southern Rocky Mountains (Weber 1971: 192, 204, 225–227).

1828 Placer gold was reportedly discovered by a sheepherder at the Old Placers site in the Ortiz Mountains. Mule trains loaded with gold reportedly made trips south down the Chihuahua Trail to Ciudad Chihuahua (Northrop 1975: 16, 32).

1828 (December to 1832) Grants of arable and grazing lands were made to Spanish settlers at Canada de las Mestanas near Rito San Cristobal and on the upper Rio del Pueblo south of Taos (Wozniak 1987).

1829 Farmers at Sabinal, with a population of 207, raised some 700 bundles of tobacco, 18 bushels of cotton, corn, beans, chile, wheat, and onions. Residents owned 309 sheep and some cattle (Minge 1979: 27).

1820s (to early 1830s) Some foreign trappers told government authorities that they had purchased furs from Native Americans or Hispanic residents, when in fact they had trapped the animals. Then they would sell them to Santa Fe Trail traders, who would transport them back to Missouri (Weber 1971: 159).

1820s–30s Fur trappers and early freighters came to rely on the mule rather than the horse for transportation. The latter "could not keep up its strength over a long period of time on a diet of nothing but buffalo grass, and grain was not readily available." Horses were also subject to a number of diseases, and they were not as resistant to the "rigors of prairie heat, cold, and dust" as were mules. Mules had a working life of about 18 years and required one-third less food than oxen (Walker 1966: 102–103).

1820s–30s Santa Fe Trail caravans would usually stock up with beef, in case the buffalo were scarce or absent on the Southern Plains (Gregg 1966, I: 97).

1820s–46 Goods produced locally for export included sheep, wool, and woven goods and buffalo, pronghorn, antelope, bear, and elk hides. Pinyon nuts and salt were also collected for trade (Minge 1979: 25).

1830 (pre) At the Los Ojitos de Zia, or Los Ojitos Hervidores as they were also known, Pueblo and Hispano residents and travelers in the area drank the water from these springs for medicinal purposes. These coldwater springs were also a popular bathing site (Swadesh 1978: 19–20).

1830s (early to late) Fewer beaver were taken as a result of population reduction due to trapping and falling pelt prices. The taking of buffalo robes increased due to demand and rising prices (Weber 1971: 208–210, 215).

1830s (early) (to 1840) Three grants of farmlands in the Chama Valley were made to Spanish settlers (Wozniak 1987).

1830 Abiquiu residents were mining copper in the area and "fashioned certain kitchen utensils by hammer [from it]" (Potash 1949: 339).

1830 There were 250,000 cattle in New Mexico (Williams 1986a: 120).

1830–31 Simeon Turley started a distillery 12 miles north of Taos on the Rio Hondo. He grew and milled wheat and corn (McTighe 1984: 6–7).

1830–45 Francisco Sandoval of San Ysidro owned the Spanish Queen Copper Mine in San Diego Canyon. A smelting furnace was located near the mine, and up to 250 pounds of copper ore were extracted by one miner. Some gold was associated with the copper-bearing veins (Swadesh 1978: 47).

1831 (February) Nerio Antonio Montoya of Valencia petitioned the ayuntamiento of Tome for one-half league of land in a canyon near Manzano. He took possession of the land in December and built a three-room wood house, constructed an acequia system, and planted a vineyard and orchard of peach and apple trees over the next few years (Tainter and Levine 1987: 103).

1831 (summer) William Sublette, a Santa Fe Trail trader, exchanged his merchandise for 55 packs (1,705) of beaver pelts and 800 buffalo robes, which he took back to Missouri (Weber 1971: 147).

1831 Cotton was being cultivated in El Paso, Tome, and Bernalillo (Potash 1949: 336).

1831–33 Trading and trapping by Anglos and Hispanos resulted in the shipment of a substantial amount of beaver pelts east over the Santa Fe Trail (Weber 1971: 206).

1832 About 90 packs (2,790) of beaver pelts went east over the Santa Fe Trail (Weber 1971: 206).

1832 Pablo Salazar, from Tome, drove two flocks of wethers to northern New Mexico (Baxter 1987: 103).

1832–44 Father Martinez complained to the provincial government that the liquor being illegally traded to Southern Plains tribes was resulting in "these Indian nations [becoming] extremely demoralized and were prompted to greater destruction of buffaloes in order to satisfy their appetites for strong drink, which

	they obtained in exchange. They also made raids in New Mexico, in order to steal cattle which were bought off them by the proprietors of these forts" (Lavender 1954: 229–230).
1832	(post) Stock raisers from Abiquiu periodically grazed their flocks of sheep in the Tierra Amarilla area (Wozniak 1987).
1833	The governor authorized local residents to use the water from Ojo del Oso for machinery at the Ortiz mine (Tyler 1991: 299).
1834	Each caravan from Santa Fe took $15,000 worth of beaver pelts and 50 packs of buffalo robes back to Missouri (Weber 1971: 218).
1835	A short distance north of the Ortiz Mountains near lake Madrid, coal mining developed in response to the need for smelting ores at Old and New Placers. The coal was used to fuel the adobe smelting furnaces (Christiansen 1974: 26).
1830s	(mid) The popularity of buffalo hides as sleigh lap robes and floor rugs was growing in the eastern United States. As a result, the price of robes increased (Barsness 1985: 93).
1836	A Santa Fe trader took 1,000 beaver pelts and 1,000 buffalo robes to Missouri (Weber 1971: 219).
1837	Another Santa Fe trader carried 200 buffalo robes and two packs of beaver pelts to Missouri (Weber 1971: 219).
1837	Over 40,000 sheep were driven down the Chihuahua Trail to northern and central Mexico. Most of these came from the Rio Abajo, especially the Valencia-Belen area (Baxter 1987: 105).
1837	Rumors circulated among New Mexico residents that new Governor Perez would tax them by taking half of a family's property and the water, wood, and pasture of the common lands (Lecompte 1985: 18).
1837	Smallpox killed about 10 percent of New Mexico's population (Bayer et al. 1994: 115).
1837–40	An epidemic of typhoid, followed by an outbreak of smallpox, resulted in the death of 10 percent of the province's residents (Gregg 1966, I: 147).
1838	(July 5) The U.S. Corps of Topographical Engineers was created by congressional act (Goetzmann 1991: 6).
1838	A band of French trappers went into the Sangre de Cristo Mountains above Mora, but due to prior trapping along area streams, they caught no beaver (deBuys 1985: 159).
1839	Another gold rush began in the San Pedro Mountains, located southwest of the Ortiz grant. The site of this new discovery became known as the New Placers to differentiate it from the Old Placers near Dolores, and a mining camp, known as Tuerto, was founded (Northrop 1975: 17; Schroeder 1977: 25). Lack of water was a problem that limited production. Most of the mining occurred in the winter, when snow melt water was used. At other times of the year, water was transported in at exorbitant prices (Meketa 1986: 70).
1839–46	Spades and shovels made from the wood of white fir, pinyon, and ponderosa pine were used by Hispanic miners at the El Tuerto and Dolores mines. Sometimes, when available, iron blades were attached to replace wooden ones that had broken off. A kind of crowbar or pry rod was fashioned from oak wood. The mines also manufactured spoons of wood and deer antler (Meketa 1986: 71).
1830s	A new medical belief, that a change of climate could result in miraculous recoveries of one's health, began to evolve. Josiah Gregg began his Santa Fe Trail adventures as a successful cure for his poor health (O'Connor and Skaggs 1977: 89–90).
1830s	In dry grasslands, shepherds drove their flocks to water once every 2 or 3 days, or they loaded gourds filled with water and transported them on burros to the flocks for drinking. Gregg noted that goats were "found in great abundance" in New Mexico, and their milk was commonly consumed. Domestic turkeys and pigeons were few in number (Gregg 1966, I: 188, 191). Gregg recorded the following cultivated crops: corn, beans, chile, wheat, apples, peaches, apricots, and grapes. Wild plants gathered and eaten included pinyon nuts and prickly pear tuna (fruit) (Gregg 1966, I: 157–158).
1830s	Gregg wrote that the only successful mine in New Mexico was El Real de Dolores or El Placer. He reported that gold was discovered at this location by a mule herder in 1828 (Gregg 1966, I: 166–167).
1830s	The lakes, Las Salinas, near Abo and Gran Quivira, were important sources of salt, according to Gregg. He described their significance as "an inexhaustible supply of this indispensable commodity, not only for the consumption of this province, but for portions of the adjoining departments." He also described a causeway that had been constructed across the middle of the "principal lake," which afforded access to the salt deposits. Gregg stated that the dry season, when the lakes were low, was the best collecting time (Gregg 1966, I: 175–176).

1830s Most of the buffalo robes collected by Hispanos went down the Chihuahua Trail to interior Mexican states, where they were exchanged for manufactured goods. Smaller numbers of elk, deer, and bear skins were also shipped south (Weber 1971: 217–218).

1830s The various ojos calientes were popular bathing sites for Hispanos suffering from "rheumatisms and other chronic diseases." Those with sulphur content were especially known for their efficacy (Gregg 1966, I: 176–177).

1830s Gregg observed that the Santa Fe wagon trains were especially welcomed in the capital during droughts because they brought relief to area residents. Some Hispanics thought the Americans brought rain, but Gregg remarked that this was a "superstition" as the traders arrived in the rainy season of July and August (Gregg 1966, I: 148).

1830s Gregg (Gregg 1966, I: 140) noted that the Rio Puerco was dry at its mouth part of the year.

1830s (late) Almost all felt for hats was made from furs like raccoon, which were much cheaper than beaver. With a decreased price in the beaver market, large trapping companies went out of business (Murray 1979: 32).

1830s–40s New Mexicans were forbidden to sell punche, a locally grown tobacco, to Santa Fe traders (Walker 1966: 138).

1830s–70s Hispanic residents from the Las Huertas Valley were running goats in the Sandia Mountains (Batchen 1972: 42–46).

1840s (early) Fur and hide traders competed intensively for the Indian trade, commonly using alcohol in the exchange. The consumption of liquor was a detrimental factor for the Southern Cheyenne and other Indian groups in the region (Berthrong 1963: 90).

1840 (spring) An epidemic of "fever" struck adults, and smallpox struck children at San Juan Pueblo (Stockel 1993: 35).

1840 (November 17) The Tejon grant, located east of the site of Tonque Pueblo, was granted for livestock grazing (Wozniak 1987). A plaza was founded on a "flat, fertile, well-watered tract not far from the place where Tejon Canon sudden emerges from the mountains [Sandias]." The plaza also was named Tejon. This area had abundant grass for goats, and an "old watering place" known as Una de Gato (Batchen 1972: 11–12).

1840 There were an estimated 1.5 million sheep in the territory (Gonzalez 1969: 48).

1840 (ca.) San Felipe Pueblo constructed a footbridge over the Rio Grande. The bridge consisted of huge willow baskets filled with rocks and spaced about 12 feet apart. These caissons were spanned by 2-by–12 planks, which were removed when threatened by flood. The bridge, reportedly, never washed out, but was replaced by a steel truss bridge built by the U.S. Indian Service. It was severely damaged by floodwater the next year, however (Balcomb 1980: 42–45).

1840–41 A fatal typhoid epidemic, followed by a smallpox epidemic, may have killed 10 percent of New Mexico's population (Meketa 1986: 77, 366–367).

1841 (January 8) The Maxwell land grant included sacred mountains, streams, and forests of Taos Pueblo (Wood 1989: 61).

1841 (March 20) Santiago Padilla and 26 other heads of households received a tract of 41,481 acres known as the Chilili grant (Eastman and Gray 1987: 78).

1841 (July-September) Botanist William Gambel came over the Santa Fe Trail and collected plants in the Sangre de Cristo Mountains and the nearby Rio Grande Valley. His specimen of *Quercus gambelli* was later named in his honor (Dickerman 1985: 163–164).

1841 Julian and Antonio Donaldson obtained a grant of land with hot springs just north of Las Vegas, and some 5 years later they constructed a bathhouse, which could be used by the public for a fee (Perrigo 1982: 22).

1841–43 A number of American traders and trappers were using "Taos lightning," a whiskey made locally in northern New Mexico, in trade with Native Americans for hides. Its sale or exchange was illegal in Indian territory, but the traffic of liquor for furs continued in the region (Weber 1971: 225–226). The consumption of liquor was a detrimental factor for the Southern Cheyenne (Berthrong 1963: 90). Simon Turley, who operated a distillery at Taos, exchanged liquor for furs with traders who then used the whiskey to obtain more furs. He was killed by Taos Pueblos during their January 1847 uprising (Weber 1971: 218, 227–228).

1843 Taos Pueblo lost some of its sacred land when Governor Armijo, ignoring protests of the Indian villagers, granted a huge tract of sacred mountain land to two Mexican citizens (Simmons 1979b: 207).

1843 (ca.) Sixteen families from the Algodones area, seeking adequate farmland and water, had settled Placitas near the Ojo del Oso (Batchen 1972: 2).

1843–45 Gold production at the Old and New Placers remained high (Northrop 1975: 18).

1844 Publication of *Commerce of the Prairies* by Josiah Gregg boosted travel on the Santa Fe Trail as a means in regaining one's health (Barbour 1990: 47).

1845 Governor Manuel Armijo made a grant of almost one-half million acres in the middle of the 1819 grant to Don Bartolome Baca (Towne and Wentworth 1945: 63).

1845 Don Juan Otero petitioned the Mexican government for a land grant including the Ojo de la Cabra, located northeast of Isleta and claimed by its residents. The grant was authorized, but later this decision was reversed by the U.S. Court of private Land Claims. Otero used this land for grazing livestock (Brayer 1938: 59–60; Reeve 1961, II: 430).

1840s (mid) (to 1900) Bernalillo was a major wine-making center in the territory (Olson 1976: 43).

1846 (early) U.S. Senator Thomas Hart Benton used the term "manifest destiny" to justify westward expansion into traditional Native American and Hispano American lands. He said, "It would seem that the white race alone received the divine command, to subdue and replenish the earth for it is the only race that has obeyed it—the only race that hunts out new and distant lands and even a New World to subdue and replenish" (Grinde and Johansen 1995: 9–10).

1846 (March 7) A grant of land, the Bosque del Apache, was made to a sheep raiser and farmer (Wozniak 1987).

1846 (May) Captain Donaciano Vigil noted that Anglo trappers were shipping $200,000 worth of beaver skins annually from Abiquiu and Taos (Cleland 1963: 153).

1846 (July 10) Water had to be hauled into the New Placer mine, south of Santa Fe, for the "gold washing" (Wislizenus 1969: 31).

1846 (July 11) There was a small Indian pueblo 10 miles north of San Antonio on the east side of the Sandia Mountains. The residents were practicing irrigation farming (Wislizenus 1969: 33).

1846 (July 15) Part of the north-south main road (Chihuahua Trail) in the valley near Albuquerque was nearly impassable due to rain. Wislizenus (1969: 34) took the "upper eastern road, which was sandy, and difficult to traverse. Artemisia and similar shrubbery, but without grass," was the dominant vegetation along his route.

1846 (July 18-August 8) Frederick Adolphus Wislizenus, a physician from St. Louis, accompanied Santa Fe trader Albert Speyer on a trip to New Mexico and northern Mexico. A keen observer and botanist, Wislizenus and his party passed through Peralta, Valencia, and Tome recording observations on the natural environment, towns, and residents of the area (Wislizenus 1969: 5, 14–40).

1846 (July 26) Wislizenus (1969: 36) noted the occurrence of mesquite and narrow-leaf yucca, or amole, south of La Joya de Sevilleta.

1846 (August-September) Lt. William Emory collected plants along the Rio Grande Valley from Santa Fe to present Elephant Butte dam and west to the Gila River. An oak species and a mesquite species were subsequently named for him by John Torrey. Emory also found a new genus of sunflower (*Baileya*) and nine new species of wildflowers (Dickerman 1985: 167–168).

1846 (September 4–5) Corn was the major crop at San Felipe Pueblo and Algodones. Grapes and wine were found at Bernalillo. At Alameda there were "grapes, melons, and eggs"; nearby were "swarms of wild geese and sand cranes" (Calvin 1968: 67–69).

1846 (September 28) Several kinds of meat, eggs, cheese, pinyon nuts, chile, onions, watermelons, corn husks, tobacco, peaches, and grapes were for sale at the Santa Fe plaza (Abert 1962: 46).

1846 (September 30) Residents of Tuerto were running "large flocks of sheep" in the upper Pecos River valley (Abert 1962: 51).

1846 (October 1) Emory (Calvin 1968: 82) observed that below Tome, to Belen, the width of the valley increased, and the crops were better than those upriver.

1846 (October 1) Abert (1962: 51) visited copper, lead, and gold mines in the San Pedro Mountains.

1846 (October 2) Abert (1962: 54) found the water at Cienega "delicious."

1846 (October 7) Abert (1962: 60–62), traveling from Taos to Santa Fe, noted that there was "no grass." At Embudo, a village of 300 or 400 ranchers, there were herds of sheep and goats, but only a small number of horses and cattle owing to the shortage of grass. At San Juan Pueblo he saw "very fine fields of corn" and "orchards of peach and plum trees."

1846 (October 9) In the Santa Fe River valley Lt. Abert (1962: 65) observed numerous flocks of sheep and goats. Also seen were "some large grullas [sandhill cranes], blue cranes [great blue herons?], in the low grounds, and several flocks of wild geese."

1846 (October 14) Abert (1962: 73) saw a herd of 4,000 sheep and goats at Atrisco.

1846 (October 21) Abert's (1962: 82, 87) contingent traveled south to Acoma Pueblo. Along the road they met a Hispanic pack train carrying "peaches, water melons, and dried fruit," which they had purchased at Acoma. A new species of yucca (*baccata*) was observed, as was juniper mistletoe. "Many flocks of sheep grazing" were also passed, as were Pueblos with burros laden with peaches. Abert (1962: 88) camped below Acoma and beside some wells dug into a drainage. There were "large flocks of sheep, herds of cattle, and droves of horses" on the surrounding plain.

1846 (October 25) Navajos ran off 5,000 to 6,000 sheep owned by Don Antonio Jose Otero, who lived at Valencia and had a ranch nearby. Two sheepherders were killed in the raid (McNitt 1972: 101).

1846 (October 26) Abert (1962: 96–97) learned that Navajos had taken 50,000 sheep only a few miles south of Atrisco. Trying to cross Tijeras Arroyo on the east side of the river, some of his animals were nearly mired in "treacherous quicksand."

1846 (October 29) Moving down the west bank of the Rio Grande, Abert (1962: 99–100) reached Isleta Pueblo. He noted "extensive vineyards" and some Pueblos making wine. Crossing the river here, and moving south, the contingent reached Peralta, located at the "south skirt of a large round grove of cottonwood trees." There were several flour mills in the area. Abert returned to Isleta, where buffalo robes were offered as trade goods. Grapes and melons were common produce among the residents.

1846 (November 2–3) At Tajique there were several Hispanics digging in an Indian ruin for earth to make adobe bricks. Moving south, Abert (1962: 105–107) reached Torreon and made camp on a large stream "that bursts forth at once from a grand spring in the side of a ravine above town." Teal and mallard ducks were flushed from the water. Corn was purchased in Tajique, before continuing southward to Manzano. As they traveled along the road, several small lakes were seen in the Estancia Basin to the east. At Manzano Abert camped on an acequia that powered the town's mill and near a "large grove of apple trees."

1846 (November 3) Lt. Abert described a grist mill and a dam-reservoir to create water power for the molino at Manzano. The dam was constructed of logs, stones, and earth; the small reservoir was drying up, and there was not enough water power to turn the stone (Abert 1962: 107–108).

1846 (November 3–4) Abert (1962: 108–110) met Don Pedro Baca, "who was in charge of the silver mines." He said there were mines "of silver, copper and iron" in the Manzano Mountains. An employee of Baca brought Abert "numerous specimens of silver ore." Abert led his men to Quarai to visit the church and pueblo ruins. Later in the afternoon they reached the ruins of Abo, where camp was made.

1846 (November 11–14) Abert (1962: 121–125) turned east to the Rio Grande Valley and crossed the river to Socorro, where he learned that gold, silver, copper, and lead were found in the nearby mountains. Continuing down the east bank of the river, more sand hills were encountered. The first night's camp was made in "some large cottonwood trees, overgrown with bunches of mistletoe," a half-mile south of Bosquecito. Navajos had been raiding sheep herds; one flock of 3,000 was taken. Abert continued south to San Pedro, then farther on reached the Bosque del Apache, where he and his men camped. Near there, he killed "two large swans."

1846 (November 19–20) Ruxton was told that drinking water from the Rio del Norte prevented kidney diseases and stones. He also noted that various "medicinal herbs of great value," found in the Organ Mountains, were sometimes brought to El Paso by Apaches to sell or trade (Hafen 1950: 166).

1846 (November 28–30) There were 2 days of drizzling rain, which hampered construction of temporary quarters for Abert's (1962: 128–129) men at Valverde. Two unarmed soldiers were killed by Navajos with "reed arrows" [*Phragmites*?] nearby.

1846 (December 16–19) Abert (1962: 135–137) and his command continued north through Socorro and on to Lemitar, where some residents had mules for sale. He bought two of the animals.

1846 (fall) The army at Santa Fe procured firewood from local Hispanics, who cut and transported the fuel from the foothills and higher slopes of the Sangre de Cristo Mountains above the town (Frazer 1983: 11).

1846 (fall) (to 1849) Mules as mounts and draft animals were purchased from local owners by the U.S. military (Frazer 1983: 249).

1846 (fall-winter) Owing to the large amount of local food crops consumed by Kearny's Army of the West, there was a near famine in the Middle Valley over the winter (Sunseri 1979: 22).

1846 A grant of agricultural lands along the Rito Lama, between the Rito San Cristobal and Rio Colorado, was made (Wozniak 1987).

1846 A Hispanic couple opened a small bathhouse at the Montezuma Hot Springs, but within 10 years poor management ended their business. Reopened by an Anglo in 1864, the waters were proclaimed as a cure of "syphilitic and kindred diseases, Scrofula, Cutaneous diseases, Rheumatism, etc." (Perrigo 1982: 22).

1846 Santa Ana farmers, using walking plows, hand sickles, and hand-threshing, spent 50 to 60 hours producing only 20 bushels of wheat (Bayer et al. 1994: 229).

1846 There were about 54,000 Hispanics in the Middle Rio Grande Valley. The Pueblo population was 7,000 to 8,000 (Harper et al. 1943: 57).

1846 Jose Leandro Perea of Bernalillo owned 200,000 sheep, which were divided into 2,500 flocks, or 80 in each flock (Ortiz 1980: 80).

1846 Large caravans from Santa Fe annually travelled in the "dry season" to the salt lakes east of the Manzano Mountains (Wislizenus 1969: 25).

1846–50 Whiskey for the men and "wild marsh grass" for the livestock were delivered by local Hispanics to the U.S. military in Santa Fe (Dickey 1970: 15).

1846–50 Some 453,292 sheep and 31,581 cattle were taken by various Indian raiders (Simmons 1988: 8).

1847 (September-December) The soldiers stationed at Santa Fe were struck by an epidemic of typhoid fever, ten men died (Stockel 1993: 44).

1847 (December) The first sawmill in New Mexico was erected at Santa Fe, on the river of the same name (Workers of the Writers' Program 1940: 429).

1847–61 The army set up a number of sawmills across the region. Some lumber was contracted from private sources, but soldiers cut and sawed most of the lumber used in construction (Frazer 1983: 187).

1847–67 The army contracted with local sheep raisers for mutton. Flocks of sheep often accompanied troops on campaigns into Indian country as a moving commissary (Frazer 1983: 9, 51; Miller 1989: 187).

1848–51 The placement of a detachment of cavalry in Las Vegas and the establishment of Fort Union east of Mora bolstered local economies. The army needed flour, corn, and beef, and ranchers and farmers increased their production of these resources and also built several gristmills in the area. Freighting on the Santa Fe Trail and feeder roads boomed as well (Perrigo 1982: 15).

1848–65 James L. Hubbell of Pajarito was freighting cut grama grass in 48 oxen-drawn wagons to regional military and civilians (Moyer 1979: 65).

1849 Manuel Otero and Antonio and Jesus Luna from the Rio Abajo drove 25,000 sheep to California (Carlson 1969: 28).

1849 Hay was scarce in Santa Fe; it cost $60 a ton (Keleher 1982: 43).

1849 (August 20) Lt. Simpson visited the abandoned Spanish Queen copper mine, located just below Jemez Springs. He was told that the springs would cure "cutaneous or rheumatic" illnesses (McNitt 1964: 15–17).

1849 Emigrants to the California gold fields made demands for food at the Pueblo villages. One party of forty-niners kidnapped the governor of Laguna Pueblo when he refused their demand for sheep. He was tied and taken to Zuni before his kidnappers released him (Simmons 1979b: 209).

1849–54 Salt from the Salinas lakes in the Estancia Basin was delivered by contractors to military posts in the region. Some 600 bushels sold for $4.50 per unit (Frazer 1983: 109, 156).

1849–50s It was recommended that wagons pulled by mules depending on native grasses for feed should not exceed a 2,000-pound load. If the mules were fed transported grain, the load could exceed this weight (Marcy 1988: 27).

1840s Some 30,000 to 40,000 sheep were driven south annually from New Mexico to Mexico (Weber 1982: 139).

1840s After the crop harvests, many farmers in the area of the Placer or Real de Dolores set up "cafes" to feed the large number of miners and others who came to the mine in the late fall and winter (Meketa 1986: 70).

1840s–70s Each year the men from Placitas traveled to the Salinas area to collect salt (Batchen 1972: 19).

1850 Based on an estimated 100,000 acres in cultivation in the Middle Rio Grande Valley, the net area demand for river water was 2.75 acre-feet per acre (Hedke 1924: 15).

1850 Brevet Lieutenant Colonel George A. McCall reported that "the hillsides and the plains that were in days past covered with sheep and cattle are now bare in many parts of the state, yet the work of the plunder still goes on" (McCall 1851: 5).

1850 There were 185,000 sheep in Bernalillo County (Dortignac 1960: 47)

1850 The number of sheep in the territory declined to an estimated 377,000 (Gonzalez 1969: 48).

1850 The U.S. Census Bureau recorded 61,547 persons in the New Mexico Territory, which included present Arizona and a small portion of Colorado's San Luis Valley (Workers of the Writers' Program 1940: 429). There were more than 30,000 Indians in the territory (Bancroft 1889: 459).

1850 (post) Hispanos cut poles and timber in the less accessible parts of Pino Canyon on the west side of the Sandia Mountains (Baisan 1994: 2).

1800s (mid) Family sheep flocks at Laguna Pueblo commonly numbered 50 to 100 head. A few families managed herds of 500 to more than 1,000 head (Eastman and Gray 1987: 95).

1800s (mid) The Oteros of the Los Lunas area were grazing their livestock in the Estancia Basin and New Plains areas (Espinosa and Chavez n.d.: 75–78).

1800s (mid) A priest in northern New Mexico reported that other priests were prospecting and mining gold in the Pecos District of the Santa Fe National Forest. A "Father Tafoya" supposedly recovered enough gold to buy land in the Picacho area (Barker 1953: 158).

1800s (mid) Hispanic women of the village of Tejon carried water in tinajas from a spring 2.5 miles away (Batchen 1972: 12).

1800s (mid to late) A Hispanic Taos trader, who also raised sheep, grew grain and collected hides, would periodically transport these products to the Rio Abajo. There he traded for chile, fruit, and other agricultural produce (Brown 1978: 72).

1851 (summer) The Territorial Legislature passed legislation empowering owners of tillable lands to take water from the most convenient source and move it across the properties of others, assessing damages on owners of livestock that trespassed onto another's fields, making the creation of a footpath across a field punishable by reprimand or fine, forbidding the building of any structures, such as mills, that would interfere with irrigating crops, and providing that "the course of ditches or acequias already established shall not be disturbed" (Clark 1987: 25).

1851 The army contracted with Domingo Baca of Santa Ana County to deliver 20,000 arrobas (507,200 pounds) of grass and fodder to four locations along the old road between Albuquerque and Santa Fe (Frazer 1983: 50).

1851 The U.S. Army had a "hay camp" on the East Fork of the Jemez River in the Valle Grande (McNitt 1972: 184–185).

1851 The Territorial Assembly passed a memorial requesting the U.S. Congress to reserve all salt lakes, mines, and springs and to prevent them from passing into private ownership. Also, all fuelwood and timber in the mountain should be reserved for the common use of the people (Clark 1987: 32).

1851 Residents of the territory were raising wheat, oats, corn, melons, onions, grapes, and several other fruits (Dillon 1970: 62).

1851 A territorial statute regulating the property procured in war against Plains Indians was passed. Encouraging Hispanics to participate in the hostilities, the law stipulated that all captured property, including captives, would be divided equally among the members of any war party (Sunseri 1979: 62).

1852 (January 7) The territorial assembly enacted legislation that detailed the administration of community acequias (Clark 1987: 25).

1852 (May or June) Suffering from rheumatism, Franz Huning went to the hot springs north of Las Vegas. At the springs he described a two-story log cabin with a "bathing tub in each of the two rooms below...." In front of the cabin "was a swamp place full of warm springs and always green." He tied his mule on the edge of this cienega to feed on the grasses, but the animal "ventured too far and sank down to his belly" (Browne 1973: 53).

1852 A smallpox epidemic killed hundreds of Pueblo Indians (Thornton 1977: 99).

1853 (October) Lt. A.W. Whipple commented on the valley between Bernalillo and Albuquerque: "... but between Bernardillo [sic] and this place are the finest ranchos and vineyards to be found in the Territory" (Foreman 1941: 111).

1853 Lt. A.W. Whipple (Foreman 1941: 119) crossed the Puerco near present Interstate 40W and described the river as "quite wide" and "contained pools of water." He observed that the streambed was 18 feet below the valley floor (Rittenhouse 1965: 27–28).

1854 (spring) Much of the valley above and below Bernalillo was in cultivation; vineyards were common, and two varieties of grape vines were thriving (Davis 1982: 349–350).

1854 (July 22) Congress passed the Donation Act, providing for the appointment of a State Surveyor-General and gave every citizen over the age of 21 and residing in New Mexico before 1853, or settling in the territory prior to 1858, a donation of 160 acres. These donations were made to promote the military strength of settlements exposed to attacks by Indians. William Pelham was appointed the first Surveyor-General (Westphall 1965: 1, 37).

1854 (December) The first U.S. Surveyor-General arrived in the territory to begin the public land surveys. The policy of his office was to only survey arable or agricultural land (Westphall 1965: 1, 17).

1854 W.H.H. Davis visited a warm spring in the foothills above Socorro. He described the pool at the spring as "some twenty feet long by fifteen wide, and eighteen inches deep. The temperature of the water is about that of new milk, and it is said to possess some medicinal qualities that render bathing in it conducive to health" (Davis 1982: 369–370).

1854–59 Sorghum crop varieties from China and African countries were introduced into the Southwest (Ryerson 1976: 251).

1855 (mid) By this time most baled hay for New Mexico military posts was imported from Kansas, even though local farmers were growing substantial amounts of alfalfa for hay (Miller 1989: 104).

1855 (July) The U.S. military was operating a ferry at or near the Barelas ford 3 miles south of Albuquerque. A "rickety old scow that could accommodate but one wagon at a time" constituted the ferry. This dugout was made from a cottonwood log (Davis 1982: 361, 390).

1855 (July) Davis (1982: 390) purchased eggs, three chickens, and a log for use as fuel at one of the Atrisco plazas on the west side of the Rio Grande.

1855 During a dry period, survey of the principal meridian south of the base line near Socorro was discontinued due to the high price of water (75 cents/gallon) for the survey crew and their mules. Work did not resume "until the rains came" (Westphall 1965: 10).

1855–70 (winters) Jose Leandro Perea of La Ventana ran 50,000 to 150,000 sheep on the Espiritu Santo land grant (Bayer et al. 1994: 158).

1856 A smallpox epidemic resulted in the death of 110 individuals, nearly half of them infants, in Mora Parish (deBuys 1985: 139–140).

1856 The Donaldsons built a six-room, log bathhouse at Montezuma hot springs (Perrigo 1982: 22).

1858 (December 22) The U.S. Congress confirmed the land grants made to the Pueblos by Governor Cruzate in 1689, and 8 years later the General Land Office issued patents (Brayer 1938: 21; Sando 1992: 110, 112). The San Ildefonso Pueblo grant of 15,413 acres was confirmed by Congress (Aberle 1948: 78).

1858–59 The U.S. Topographical Engineers constructed a road along the route of the old Camino Real from Santa Fe to Dona Ana (Jackson 1952: 109–111, 116–117).

1858–1913 Fr. John Baptist Ralliere was priest at Tome and a leader in agriculture—introducing grapevines, better seeds, and farming methods. He established one of the first parish schools, which was coeducational (Valencia Co. Historical Society 1982: 17).

1859 A survey by the Surveyor General's Office placed the east boundary of Isleta Pueblo land along the base of the Manzano Mountains, rather than the highest points in the range. The Pueblos were deprived of 21,415 acres of grazing, fuelwood and timber, and hunting lands. A 1918 resurvey set the east boundary along the "backbone" of the Manzanos, restoring the claimed acreage (Brayer 1938: 58–59).

1859–65 Some gold dust was being recovered by Hispano and Anglo miners panning in the Arroyo Hondo (Pearson 1986: 4).

1850s The reports of railroad surveys stated that the shortage of surface water was a major drawback to establishing a route along the 32nd parallel (Clark 1987: 73).

1850s Antonio Jose Luna and Antonio Jose Otero of Valencia drove sheep to California market for higher prices. In one drive there were over 50,000 sheep. This successful venture led to wealth and political power for the two men (Espinosa and Chavez n.d.: 55).

1850s A sawmill was operating near Glorieta Pass and another near Taos (Bunting 1964: 11).

1850s U.S. Army personnel stationed at forts in the Socorro area mined coal at Carthage. Three decades later Carthage coal was used in smelters in the same area (Christiansen 1974: 69).

1850s Anglo prospectors ripped out beaver dams in search of gold in streams in the Abiquiu area (McDonald 1985: 121).

1850s Sometime during this decade the first public bath cabins were built at Jemez Springs (Browne 1973: 63–64).

1850s (late) (to 1860) More Hispanic settlers from Alameda settled at Placitas and helped construct an irrigation system, including a large reservoir called El Tanque de la Ciruela, located just to the east of the village (Batchen 1972: 2–3).

1860 (March 12) The U.S. Congress passed the Preemption bill, giving free land to individuals in New Mexico and adjoining territories (Brown 1970: 13).

1860 The U.S. Census Bureau counted 93,516 persons in New Mexico Territory, which included present Arizona and a small portion of Colorado's San Luis Valley (Workers of the Writers' Program 1940: 329).

1860 There were 830,000 cattle in the territory (Williams 1986a: 120).

1860 There were 306,000 sheep in Bernalillo County (Dortignac 1960: 47).

1860 The heirs of Luis Maria Baca received a grant of 100,000 acres, which included the Valle Grande in the Jemez Mountains (Scurlock 1981a: 138).

1860–70 Due to the demand at army posts, corn production in Valencia County increased from 53,587 to 77,854 bushels, even though the population decreased from 11,321 to 9,093 (Miller 1989: 57).

1861 (March) The commander of the Union troops in Santa Fe said that the town could not be defended "because it was commanded on all sides by hills" (Keleher 1982: 176).

1861 Some 1.5 million pounds of flour, 1,098 head of beef, and 1,400 bushels of beans were contracted from local suppliers by the U.S. Army (Frazer 1983: 179).

1861 U.S. troops from Fort Craig found coal on the site that was later named the Carthage coal field (Christiansen 1974: 39).

1862 (spring) The Confederate invasion from Texas resulted in depletion of livestock, crops, and food reserves along the Rio Grande Valley (Christiansen 1974: 32).

1862 (spring-summer) Mining operations were reduced sharply in New Mexico during the Confederate invasion (Christiansen 1974: 31–32).

1862 (summer) At the military post of Los Valles de la Sierra de San Ildefonso in the Jemez Mountains, soldiers dug out a hot and a cold artesian spring, which were used for bathing and drinking, respectively (Meketa 1986: 207).

1862 (winter) Because so many men had been serving in the Union Army to stop the advance of Confederate troops, and because much of the livestock, fodder, and foodstuffs had been consumed, stolen, or burned by the Confederates, the general populace of New Mexico experienced hardships (Meketa 1986: 187).

1862 Military personnel were cutting "hay" (native bunch grasses) in the Valle Grande. Some 400 tons of hay were cut around the headwaters of the East Fork of the Jemez, Santa Rosa, and San Antonio rivers (Meketa 1986: 205–206).

1862 The Homestead Act was passed by Congress, allowing a settler to take out a homestead of 160 acres on public lands. A patent to the land could then be obtained either by living on it for 5 years or by commuting it through payment of cash in 6 months (Westphall 1965: 43).

1862 A hill in the Valle Grande, Jemez Mountains, was a source of obsidian, which the penitentes in the area fashioned into sajadas, blades used to make incisions (Meketa 1986: 206).

1862–90 Intensive grazing by sheep herds in the upper Rio Puerco basin accelerated erosion (Maes and Fisher 1937: 10–15).

1863 Ordinances related to animal and traffic control, sanitation, public works, and zoning were passed by Albuquerque's board of aldermen (Simmons 1992: 24).

1863 The first significant discovery of silver in the territorial period was made at Pueblo Springs, near Magdalena (Northrop 1975: 23).

1863 U.S. troops from the military post of Los Pinos pursued unidentified Indians who had stolen cattle from near Valencia. The army captured about 100 head of cattle near Abo pass but saw no Indians (Stanley 1966: 13).

1864 (November 1) A patent for the Sandia Pueblo grant of 24,034 acres was issued. The east boundary was at the "top of the Sandia Mountains" (Brayer 1938: 72).

1864 President Lincoln issued patents to all of the Pueblos who had grants confirmed in 1858 (Sando 1992: 112).

1864–66 Estanislao Montoya of San Antonio farmed a large tract of land above Fort Craig, raising corn, barley, and oats (Miller 1989: 40).

1864–79 A new owner acquired the Montezuma hot springs and constructed the Adobe Hotel on the site. In 1879 the Santa Fe Railroad built a two-story stone bathhouse (Perrigo 1982: 22).

1864 (post) Following subjugation of the Navajo by the U.S. Army, and consequently fearing no more raids by this group, Laguna Pueblo livestock herders expanded onto distant rangelands. The governor assigned herding areas for a year's use; this was "a conservation area designed to preserve the grass" (Ellis 1979: 442).

1865 (January 18) The Territorial Mining Act was passed. It opened public lands to mining claims, provided the basis for patenting lode claims, and set forth a provision recognizing and protecting water rights (Christiansen 1974: 87–89).

1865 (May 25) Miners met and organized the Chama Mining District and adopted laws to regulate mining. These affected placer and lode claims and water rights (Christiansen 1974: 86–87).

1865 Gold was discovered near Nogal (Northrop 1975: 21).

1865–66 (winter) Fort Craig used bituminous coal from mines south and east of Socorro for heating fuel (Miller 1989: 120–121).

1866 (April 1) The Congress overrode President Johnson's veto of the Civil Rights bill, which gave equal rights to every person born in the United States except Native Americans (Brown 1970: 121).

1866 (July 27) The Atlantic and Pacific Railroad Company received a grant of 3,565,730 acres in New Mexico (Westphall 1965: 92).

1866 (late July) James Meline's party, passing through San Felipe Pueblo fields, saw another traveler turn his livestock to forage in a corn patch (Meline 1966: 118).

1866 (August 4) Meline described the Santa Fe plaza as "some three hundred and fifty feet square, was an open space of mud and dust..." and noted that some Americans had planted cottonwoods on the north side of the plaza. It had been more recently planted with a "rich carpet of alfalfa (known in some parts of the United States as chili clover) growing three feet high and bearing a purple blossom..." (Meline 1966: 152–153).

1866 (late fall) The new settlers of San Francisco Xavier on the Rio Puerco used cottonwood along the stream to construct their houses and outbuildings. This new town was located at a spring, El Ojito del Rio Puerco (Lopez 1980: 72–76).

1866 Some 161,000 pounds of beans were provided to territory posts by 10 local farmers (Miller 1989: 145).

1866 Salvador Armijo had manure hauled from his sheep corrals and spread on his agricultural fields around Albuquerque. Up to 2,000 wagon loads were used in a year (Armstrong 1984: 5).

1866 Some of the major mines in the territory included Old and New Placers for gold, Cerrillos for silver, San Adelia and Stevenson in the Organ Mountains for lead, Santa Rita and Hanover for copper, Pinos Altos and Stone Corral for lead, Taos for silver, Jemez for copper, and Estancia Basin for salt (Meline 1966: 171, 173–177).

1866 Lead-silver ores were discovered at Magdalena (Northrop 1975: 22).

1866 Rio Grande Pueblos were cultivating corn, chile, tobacco, onions, melons, peaches, apricots, plum, and grapes. They also were gathering pinyon nuts for food and trade. Hispanics were cultivating wheat, corn, oats, beans, pumpkins, melons, tomatoes, cabbage, onions, chiles, and beets along the Rio Grande. About 250 square miles were in cultivation in the territory. Manure was rarely used as fertilizer (Meline 1966: 156, 160, 162–163).

1867 An outbreak of scurvy occurred at military posts (Miller 1989: 43).

1867–83 Government forage agencies were established at Belen and Los Lunas. These civilian agents furnished forage such as hay, corn, oats, and barley for military animals, as well as water and corrals. They also prepared meals for express men and supplied fuel to army teamsters and small detachments of soldiers (Jensen and Miller 1986: 142–143).

1868 (June 1) The U.S. treaty with the Navajo was signed. A large reservation was to be established in their old homeland, farm implements and seeds were to be given to every head of a family who selected 160 acres of land as a home and began farming, and sheep and goats were to be distributed to families. Also, Navajos could hunt on lands contiguous to the reservation (Dale 1949: 61).

1868–75 Oak, pinyon, juniper, and mesquite (roots) were the primary fuelwoods supplied by contractors to the army (Miller 1989: 122).

1869 (September 23) An executive order creating the Fort Craig military reservation of 24,895 acres near San Marcial was issued (Westphall 1965: 146).

1869 Mesquite and pinyon were replacing coal as the heating fuel at military posts (Miller 1989: 121).

1869 The army paid Tomas Valencia for use of a bridge that he had constructed over the Rio Puerco on the road between Albuquerque and Socorro (Miller 1989: 311).

1869–71 Governor William A. Pile sold about three-quarters of the Spanish archives in Santa Fe for waste paper (Hill 1982: 10).

1869–73 The Navajo suffered crop failures (Dale 1949: 62).

1869–81 All of the salt supplied to military posts in the territory came from local sources (Miller 1989: 143).

1869 (to ca. 1900) Water from the La Constancia mill fell "20 feet onto a bed of volcanic boulders spread out over the fields and an orchard below" (Ellis 1955: 105).

1860s Lead ore was mined in the Sandia foothills east of the Las Huertas Valley to make rifle balls (Batchen 1972: 57).

1860s–70s A relatively large influx of new Spanish settlers to the upper Rio Pueblo valley led to overgrazing and scarcity of irrigated cropland (Carlson 1990: 34).

1860s–70s Most of the hay cut for the military by private contractors was harvested with hand sickles and scythes. Hoe-cut hay was frequently refused because large amounts of dirt and roots were mixed with the grass. In times of scarcity, however, it was sometimes accepted. The preferred grama grass hay was usually cut in the fall, while "bottom grass" was cut in June and July. "Inferior grasses" (such as vega and sacaton) were sometimes accepted. Army horses usually received a daily ration of 14 pounds of hay and 12 pounds of grain. The hay was cut native grasses. In 1870 some 4,950 tons of hay were contracted to private residents. It was believed that early frosts destroyed the nutritional content of native hay (Miller 1989: 92–95).

1860s–70s Malarial fevers, diarrhea, dysentery, and venereal diseases were common illnesses among the military (Miller 1989: 43).

1870 (pre) Agricultural fields at Santa Clara Pueblo were primarily located in the vicinity of Santa Clara Creek. Subsequently, when the Rio Grande ditch was constructed, field locations were moved closer to the river (Hill 1982: 26).

1870 (pre) Santa Clara Pueblos traded cornmeal, wheat, barley flour, and foodstuffs made from these to Plains Indians for buffalo robes, jerked meat, buckskins, buckskin clothing, and horses (Hill 1982: 63–65).

1870 (to early 1900s) Santa Clara farmers selected field sites of sandy loam. Alkaline or clayey soils were avoided. New fields were cleared of rocks and smaller trees, and weeds were pulled or burned. Large trees and boulders were left in the fields. Santa Clara farmers treated their agricultural seeds with "blue stone," a wild plant ground and mixed with other indigenous species, to protect the crop from insects and worms and to stimulate growth. Ashes were sometimes sprinkled around pumpkin plants as an insecticide (Hill 1982: 26–29).

1870 (July 9) The Placer Mining Act, an amendment to the 1866 Act, providing for the patenting of placers, was passed by Congress (Christiansen 1974: 88).

1870 The estimated number of acres of farmland under irrigation in the territory was 57,200, an increase of 2,700 acres over that of 1860 (Clark 1987: 29). Eighty-five percent of the farms in New Mexico were less than 50 acres. Contractor Jacob Schwartz promised the army 200,000 pounds of corn from fields near Tome. Thirty-six gristmills were operating in the territory; 30 were powered by water, four by steam, and two by horses. Some 55,000 pounds of flour provided to the army by Socorro mill owner Manuel Vigil were unfit for use. The army fed its work animals and cavalry horses more than 4,950 tons of hay and grain during the year (Miller 1989: 58, 81, 92, 132, 151).

1870 It was reported that there were 60 million acres of public land that could be cultivated in the territory, a requirement for pre-emption. This total exceeded the available public lands (Westphall 1965: 70).

1870 By this year Mariano Otero and Pedro Perea had established their headquarters for sheep operations on the Rio Puerco and Espiritu Santo grant lands (Bayer et al. 1994: 158). Jose L. Perea and Otero ran over 24,000 sheep in the Cabezon-Bernalillo area (Maes and Fisher 1937: 11).

1870 At Camp Apache, the army, using Apache workers, cut 15 tons of hay and 30 cords of firewood per day (Worcester 1979: 129).

1870 The invention of the refrigerated rail car spurred the growth of the cattle industry in the region. This expansion was partially financed by British capitalists (Ortiz 1980: 100).

1870 The U.S. Census Bureau counted 91,874 persons in New Mexico (Workers of the Writers' Program 1940: 431).

1870 There were 435,000 sheep and 14,000 cattle in the Middle and Upper Rio Grande basins (Harper et al. 1943: 49).

1870 There were 57,000 cattle in the territory (Williams 1986a: 120).

1870–73 A Hispanic individual was living at Espiritu Santo Spring. The land grant of the same name had been used for grazing since 1766 by the pueblos of Jemez, Zia, and Santa Ana (Bayer et al. 1994: 157).

1870–80s (early) Some of the best grass stands cut for hay were located near forts Union, Craig, and Santa Fe (Miller 1989: 99).

1871 (fall) Some 150 residents of Galisteo and Agua Fria harvested hay (Miller 1989: 101). Nathan Bibo of Cebolleta contracted to deliver 100,000 pounds of corn to Fort Wingate (Miller 1989: 57).

1872 (December 3) Four members of the Christian Brothers arrived in Bernalillo to open a school. They also established vineyards and a winery (Olson 1976: 42–43).

1872 Cabezon was founded on the old trail from Santa Ana Pueblo, across the Espiritu Santo land grant, and on to Fort Wingate. The Star Line Mail and Transportation Co. established a stage line operation along this route in 1875 (Bayer et al. 1994: 171, 173).

1872 The Mining Act passed this year updated the 1866 federal law. Both the earlier law and this piece of legislation were based on the view that mining "was the most important, if not the only reasonable, use of public land." Under the acts, any person could enter unreserved public domain and much of national forests to prospect and stake out as many claims as he wanted. The placer or lode claim remained valid as long as the miner recovered a minimum of $100 income from working the claim. A patent was obtained if the miner complied with surveying and other provisions of the Mining Law and then paid either $2.50 or $5.00 per acre for the claim (Clawson 1971: 123–124).

1872–78 Silver, gold, copper, and lead were discovered in the Raton Basin (Murray 1979: 79).

1870s (early) New Mexico farmers were raising more hogs owing to the abundance of corn grown the previous 2 years (Miller 1989: 135).

1873 Pedro Armijo of Albuquerque drove 12,000 sheep to the central Colorado gold mines to sell as meat (Towne and Wentworth 1945: 65).

1873 New Mexico Surveyor-General Proudfit openly supported the cattle industry in the territory (Westphall 1965: 23).

1873 A gristmill was operating at Isleta pueblo. It was abandoned and a second mill built, but it fell into disuse before 1893 (Poore 1894: 113).

1873 The Timber Culture Act, which allowed an individual to acquire a quarter-section of land through planting, protecting, and maintaining 40 acres of timber, was passed. Five years later the act was amended to reduce the acquired area to 10 acres. The act was a failure in New Mexico because the planting and cultivating of trees was not feasible without irrigation, and irrigated land was more valuable if farmed for crops and not trees (Baydo 1970: 156; Westphall 1965: 72).

1873–79 This was the first year that all military posts procured fuelwood from private contractors. Wood delivered included ponderosa pine, pinyon, juniper, oak, and mesquite (roots); prices ranged up to $1 a cord (Miller 1989: 122–125).

1874 The Pueblo population was about 7,000 (Larson 1968: 116).

1875 (March 3) The Right of Way Act provided for a 200-foot right-of-way for railroads and 20 acres for station grounds every 10 miles across public domain (Westphall 1965: 93–94).

1876 Territorial officials considered Indian lands to be disposable property, and as such, they could be purchased by non-Indians. The Supreme Court ruled that the Pueblos had undisputed title to their lands and could dispose of them as they saw fit. The Court also declared that they would not be protected by the Federal Government. Thus, their lands were subject to usurpation by dishonest non-Indians (Simmons 1979b: 214).

1876 The Territorial Assembly restated the traditional rights of travelers to free access to natural waters for themselves and their animals but excluded persons traveling with a large number of animals. Persons with migratory herds could not use the water of any natural spring or lake without obtaining permission from the owner and assuming responsibility for any damage done to his fields or private property (Clark 1987: 50).

1876 (post) A homesteader established a turbine-powered sawmill at Battleship Rock on the Jemez River. He logged the surrounding mountain slopes, hills, and mesa tops (Scurlock 1981a: 138).

1877 (March 3) Congress passed the Desert Land Act, which "extended the doctrine of prior appropriation to water used in the reclamation of arid public lands by irrigation" (Clark 1987: 38). The purpose of the act was to stimulate irrigation through individual enterprise. A settler could buy up to a section of land for $1.25 an acre if the claimant irrigated the acreage within 3 years (Buchanan 1988: 29; Westphall 1965: 76).

1877 Smallpox struck Las Vegas, and 82 deaths were recorded. Work in Old Town halted until the outbreak subsided (Perrigo 1982: 78).

Smallpox killed about 20 men and 100 boys at Santo Domingo Pueblo (Lange and Riley 1966: 93).

1877 (to late 1890s) Santa Ana, Zia, San Felipe, and Santo Domingo pueblos reported numerous squatters and livestock trespass (Bayer et al. 1994: 177–178).

1877–78 An outbreak of smallpox struck the Arroyo Hondo Mining District, and most mining operations were halted (Pearson 1986: 10).

1870s Excellent quality sheet mica was mined in the Petaca district and sold as window "panes" at Espanola and Santa Fe (Christiansen 1974: 53).

1878 Under the Organic Act, any timber cut on public lands and exported from the territory was liable to seizure by the U.S. Government (Ritch 1968: 43).

1878 The Timber and Stone Act was passed by Congress. Under this act, settlers and miners could buy up to 160 acres of land with potential timber or mineral resources for $2.50 an acre (Oakes 1983: 27).

1879 The first planing mill in New Mexico was established near Las Vegas (Bunting 1964: 11).

1879 New strikes of gold and silver-lead ores in the Cerrillos area led to the founding of Carbonatesville, Bonanza City, Turquoise City, Golden, and Cerrillos (Christiansen 1974: 62).

1879 The Alary family moved to Corrales from France and began cultivation of various crops and operation of a winery. The family also fished and caught frogs for food (Eisenstadt 1980: 12, 14).

1879 The U.S. Geological Survey was created by an act of Congress (Swift 1958: 45).

1879 (to August 1880) A Boston company purchased the Hot Springs property and built a stone, two-story bathhouse, walled up 20 of the 40 springs, and pumped hot water into the 14 bathrooms. The company also constructed a three-story hotel (Perrigo 1982: 22).

1879–82 Homestead certificates in northern New Mexico increased from 3 to 263 (Perrigo 1982: 107).

1879–82 The construction of the Southern Pacific and the Santa Fe railroads opened markets for working mines and brought in new prospectors (Northrop 1959: 26).

1879–80s Lack of adequate water hampered mining in the Cerrillos-San Pedro area. Wells and a 13-mile-long pipeline were basically unsuccessful ventures (Christiansen 1974: 63).

1879–89 Gas, electric lights, and telephone service became available at Las Vegas (Perrigo 1982: 30–31).

1879–91 Some 24,550 acres were taken by railroads from the public domain in the territory. By 1891, 622,684 acres of public domain were granted to individuals under the land laws (Westphall 1965: 93–95).

1870s The Perea family had a "fine vineyard" in Bernalillo. Nathan Bibo had a store and prospected for gold in the area (Olson 1976: 187–188).

1870s (late) Mariano Otero bought 25,000 to 30,000 pounds of corn annually at Cabezon (Maes and Fisher 1937: 14).

1870s–80s Hispanic farmers, would-be colonists, and Anglo miners from Pena Blanca and La Jara moved onto the Espiritu Santo land grant, hoping to use water from the Rio Puerco to irrigate their crops (Bayer et al. 1994: 158–159).

1870s–80s Truck gardens in the North Valley of Albuquerque, especially the one operated by Herman Blueher, which was located at the site of present Tiguex Park, furnished much of the produce for Albuquerque and surrounding communities. Some was shipped by train to the eastern United States. (Simmons 1982: 246, 273–274).

1880 (pre) Crude furnaces built of stone or adobe were used to roast or smelt gold and silver ores. A variety of fuels were used in New Mexico, but green pinyon or pinyon charcoal was preferred. Sometimes, manure from horses or other livestock was added to the fuelwood (Christiansen 1974: 95).

1880 (February 12) A general act provided that "every person who shall foul the water of any stream in the Territory of New Mexico, or throw into any ditch, river or spring of flowing water any dead or pestiferous animal or other filth, dirty vessels or other impurities that might injure the health of the inhabitants of any town or settlement of this Territory, on conviction thereof would be fined not less than one nor more than ten dollars" (Clark 1987: 31).

1880 (April 15) The Territorial Bureau of Immigration was organized. "Valuable mines of gold and silver" and grasslands "capable of producing sheep for the million" were extolled (Bureau of Immigration 1881: 7–8, 53).

1880 (spring-summer) There were some 10,000 acres under irrigation in the upper Rio Puerco valley (Cuba to Casa Salazar) (deBuys 1985: 217).

1880 The Denver and Rio Grande Railway, commonly known as the Chili Line, was constructed from Alamosa into northern New Mexico. The route passed Conejos to the new railroad town of Antonito across the Rio Grande and to the terminus at the new railroad town of Espanola. Some 160,000 spruce or pine cross-ties were used in construction between Alamosa and the New Mexico state line (Chappell 1969: 3–7).

1880 Mining activity in the Sandias and Manzanos increased sharply with the arrival of the railroad at Albuquerque. The Coyote Canyon and Hell Canyon mining districts were soon formed (Simmons 1982: 212, 238).

1880 Construction of the Atchison, Topeka, and Santa Fe Railroad was completed to Albuquerque (Marshall 1945: 142–143).

1880 New Mexico ranked fifth in wine production in the United States; 908,500 gallons were produced from 3,150 vineyards. In the following years the wine industry declined rapidly due to floods, drainage and salizination problems, frosts, and competition. Prohibition was the final blow to the business (Brown 1988: 8).

1880 White wine and hand-cut hay were being sold at Cabezon (Rittenhouse 1965: 64).

1880 One source reported 44,000 acres under irrigation in the Middle Rio Grande Valley (Wozniak 1987).

1880 By this year the total of irrigated acres was 94,900 (Clark 1987: 29).

1880 There were about 124,800 acres of land under irrigation in the Middle Rio Grande Valley (National Resources Committee 1938, pt. VI: 71).

1880 There were 3,000,000 to 4,000,000 sheep and more than 350,000 cattle in the territory (Williams 1986a: 120). Between 2 and 5 million sheep and 400,000 cattle were in New Mexico (Carlson 1969: 33; Gonzalez 1969: 48; Simmons 1988: 12; Wentworth 1948: 242). There were 583,000 sheep in Bernalillo County (Dortignac 1960: 47).

1880 A conservative group of Pueblos from Laguna left and established the village of Oraibi, southwest of Isleta (Dryeson 1975: 109).

1880 The U.S. Census Bureau recorded 119,565 persons in New Mexico (Workers of the Writers' Program 1940: 432).

1880 There were 1,015 blacks in the territory (Bancroft 1889: 723).

1880 (ca.) This year marked the beginning of fire suppression in the ponderosa pine-pinyon-juniper-oak zones of the mountains. Intensive logging and fuelwood cutting also began at this time. Intensive grazing continued. All of these activities have produced many changes in these montane forests. Currently, they are represented by early or middle successional stages—oak-juniper thickets and young ponderosa stands (Dick-Peddie 1993: 69).

1880–81 The mining of gold at The New Placers District developed, and pipelines to bring needed water from reservoirs and springs in the Sandia Mountains were under construction (Northrop 1975: 27).

1880–82 Building stone was brought into Albuquerque on the train from the west. During the first 5 months of 1882, more than 5,000 tons of stone were shipped to the town (Oppenheimer 1962: 34).

1880–82 Santa Fe Railroad tenders had a capacity of 2,000 to 4,000 gallons of water. They had to be refilled every 30 miles (Glover 1990).

1880–87 The Las Vegas Land and Cattle Company expanded its land holdings where it grazed sheep and cut "hay." Some of this land, on the old Las Vegas land grant, was in dispute (Perrigo 1982: 108–109).

1880–90 Cattle in the territory increased from 347,000 to 1,630,000 head, while sheep increased to 5,000,000 head (Bayer et al. 1994: 174).

1880–90 A decreasing supply of irrigation water due to increased upstream use contributed to a decrease in cultivated acreage in the Middle Rio Grande Valley (Hedke 1925: 10).

1880–1900 Narcisco Zamora was ferrying wagons across the Rio Grande at Bernalillo on his flatboat (Bayer et al. 1994: 174).

1880–91 Several trading posts and a general store were operating in Cabezon, serving local residents, travelers on the Star Line Stage Route, Navajos, and area Pueblos. These Hispanic residents owned herds of 16,000 and 10,000 sheep. The first also owned 2,000 cattle. By 1891 the village residents owned enough sheep to fill 17 freight wagons with wool (Rittenhouse 1965: 16–17, 31, 33, 36–39, 64–67, 70, 79).

1880–1900 (and 1919–20) Copper was mined in the foothills of the Sierra Nacimiento, a few miles northeast of La Ventana. Coal from the latter site was used to fire the boilers and the smelting furnaces at the copper mine (Glover 1990: 46).

1880–1916 Cattle from southern New Mexico were shipped north to grazing lands in Colorado's forests (Gjevre 1969: 19).

1881 (January 15) The Southwestern Stockmen's Association was formed at Silver City (Baydo 1970: 113).

1881 (November 2) Corn, onions, bread, cakes, pies, cantaloupe, watermelons, apples, and grapes were crops and prepared food items at Isleta Pueblo (Kessell 1980: 218).

1881 The residents of Taos Pueblo were raising corn, wheat, pumpkins, melons, chile, beans, apples, plums, peaches, grapes, and apricots. The Taos valley was "noted for its large production of wheat" (Nims 1980: 92, 94).

1881 Lt. John G. Bourke, visiting the Pojoaque Pueblo church, wrote "Within bowshot, is the orchard and vineyard of the pueblo and here growing in full luxuriance were apples, pears, peaches, apricots, plums, grapes, and different kinds of vegetables" (Kessell 1980: 72).

1881 Franz Huning planted some 1,500 trees on his land in Albuquerque. He operated the Molino de la Glorieta near his home known as Huning's Castle (Baxter 1885: 696).

1881 The spring water at Ojo Caliente reportedly cured "rheumatism, skin diseases, derangement of the kidneys and bladder, and especially of all venereal diseases" (Nims 1980: 90).

1881 Silver and placer gold were discovered in the Hopewell Mining District in Rio Arriba County (Christiansen 1974: 65).

1881 Fired brick became a favorite building material for houses and commercial buildings, especially among Anglos. Two new brick-making companies furnished this newly available construction material (Sonnichsen 1968: 232).

1881 Construction of the Santa Fe rail line through Lemitar caused the Rio Grande channel to shift eastward. The elevated rail bed acted as a levee; sections were washed out in 1884 and 1886 (Scurlock 1982a: 13).

1881–82 Mariano S. and Miguel Antonio Otero erected bathhouses and a hotel at Sulphur Springs just outside the west boundary of the Baca No. 1 grant (Otero 1935, I: 237–238, 241–277).

1882 (early) The California Placer Company was erecting sawmills on the lower Red River to produce lumber for mining flumes (Pearson 1986: 15–16).

1882 (April) The Montezuma Hotel opened under the management of Fred Harvey. Among the food imports for the dining room were green sea turtles (Perrigo 1982: 24).

1882 (September 22) The New Mexico Mining Association was organized at Albuquerque (Northrop 1959: 30).

1882 This may have been the last year that the Spanish scratch plow and oxen were used by Jemez Pueblo farmers (Poore 1894: 107).

1882 Las Vegas was again struck by smallpox outbreaks; at least 28 people died (Perrigo 1982: 78–79). An outbreak of smallpox struck Chilili late in the year (Lange and Riley 1966: 383).

1882 Copper and gold dust were being mined in the Tijeras District east of Albuquerque (Northrop 1959: 31).

1882 Depot Park was established in Albuquerque but became an environmental problem according to a story in the local newspaper. In the article it was written "the privy of the depot gives [the park] a very disagreeable odor and should be looked after" (Oppenheimer 1962: 35).

1882 There were an estimated 3 million head of livestock in the territory; horses and mules were not included. The average stocking rate was 20-animal-unit-years per section (Donart 1984: 1240).

1882–84 Cattle in Socorro County increased from 9,000 head to 60,000. Severe overgrazing in some areas ensued (Gehlbach 1981: 110).

1880s (early) The San Felipe de Neri church had "a beautiful garden in Albuquerque, with long alleys densely shaded by fruit and nut trees, and bordered with all sorts of small fruits" (Baxter 1885: 697).

1883 (January) Smallpox was "raging" at Punta de Agua (Lange and Riley 1970: 14).

1883 (March 24) The U.S. Supreme Court ruled that Indians by birth were aliens and dependents (Brown 1970: 391).

1883 Cattlemen were pressing for lands with water to be surveyed by the General Land Office (Westphall 1965: 27).

1883 Texas ranchers and their cattle forced Hispano and Pueblo livestock raisers off most of the Pajarito Plateau (Rothman 1992: 28).

1883 Bernalillo County had 475,000 sheep and 41,700 cattle on rangelands (Bancroft 1889: 787; Bayer et al. 1994: 174).

1883 A community water works began operating in Albuquerque (Simmons 1982: 228).

1883 The territorial population was about 130,000, which included some 97,500 Hispanics and Native Americans (Westphall 1965: 27).

1883–86 S.S. Farwell contracted with H.S. Buckman to cut 27 million board-feet on the Petaca grant. Crews employed by Buckman clearcut the Petaca land grant near Tierra Amarilla for railroad ties used in construction of the Chili line to Santa Fe. This cutting initiated an adverse cycle of environmental changes which is still evident today (Gjevre 1969: 27; Rothman 1989: 203).

1883–1907 Frank and George Bond acquired and logged the Las Trampas land grant (deBuys 1985: 185–186).

1884 There were about 2.5 million sheep and 400,000 cattle in New Mexico (Carlson 1969: 37).

1884–86 Livestock associations attempted to control overgrazing (Baydo 1970: 125).

1885 Some unidentified Pueblos were using a canoe, alternately paddling and hauling it with a rope, to cross the Rio Grande at their villages (Lange et al. 1975: 394).

1885 The Santa Fe Railroad's operation consumed 27,984 tons of coal per month (Glover 1990).

1885 (ca.) The priest at the San Juan Pueblo had planted currants, black cherries, and apricots in the garden of the church (Kessell 1980: 93).

1886 An estimated 5 million feet of lumber were used in the region (Ensign 1888: 141). The Pecos Lumber Co., headquartered at Glorieta, cut and milled 60,000 feet of bridge timber used in construction of the Chili rail line (Chappell 1969: 19–20).

1886 Officers at Fort Wingate incorporated and purchased 40,000 acres of the best land, claimed by Zuni Pueblo, from the railroad. The commander of the garrison became president of the Cibola Land and Cattle Company, which placed 12,000 cattle on the Zuni River watershed (Hart 1991a: II/3).

1886 At the Otowi siding of the Denver and Rio Grande Railroad the company constructed a water tank for replenishing locomotives. In the process of developing and using this facility, a natural pool, fed by a spring, was destroyed. This was San Ildefonso Pueblo's source of sacred water from the south (Hewett and Dutton 1945: 38–39).

1887 (pre) Anglo settlers had homesteaded and usurped the best lands, which became the Jicarilla Apache Reservation in north-central New Mexico. They had settled on arable land with control of water resources. Their livestock were overgrazing, so they cut grass for feed on other parts of the reservation. Jicarilla attempts to dry farm on poorer lands failed (Tiller 1983: 101–103, 453).

1887 (February 24) An act was passed by the Territorial Assembly authorizing the incorporation of companies to supply water for mining and milling as well as irrigation. They were granted right-of-way across territorial lands and the privilege of taking timber and stone from them (Clark 1987: 64, 132).

1887 The Santa Fe Railroad was completed from Albuquerque to Belen (New Mexico Historical Records Survey 1940: 24).

1888 (October 2) The New Mexico Legislative Assembly delayed immediate exploitation of the territory's water resources by some irrigation developers (Clark 1983: 65).

1888 Congress passed legislation that provided for the withdrawal of irrigable land from entry. Under this act, some 39 reservoir sites amounting to 40,170 acres were selected in New Mexico (Westphall 1965: 84).

1888 Saw logs of ponderosa pine up to 4 feet in diameter were being removed from the Manzano Mountains. An estimated 280 square miles constituted the well-timbered area of this range (Ensign 1888: 148).

1888 There were 3.5 million sheep and almost a million cattle, mostly from Texas, grazing New Mexico's ranges (Flores 1992: 8).

1888–91 A total of 88 irrigation companies were incorporated, and their irrigated land represented 40 percent of the new irrigated acreage for the 1890s (Westphall 1965: 82).

1888–92 Several sawmills operated in the Tres Piedras-Embudo area, providing railroad ties for the Denver and Rio Grande, or Chili Line (Chappell 1969: 32).

1889 (January 31) The Territorial Legislature passed a law providing for the election of three commissioners to protect springs and build appropriate dams (Westphall 1965: 25).

1889 (March 1) The International Boundary Commission, United States and Mexico, was created. This commission determined the volume of water in the Rio Grande, its conservation and use, hydroelectric power generation, flood control, and sanitation and pollution (Clark 1987: 227).

1889 The New Mexico Territorial Assembly passed an act to prevent overstocking of ranges. A person or corporation could graze on public lands only so much livestock as could be supported by waters for which the person or company had title. Others entering the range had to have sufficient permanent, living, and unfenced water to take care of their stock (Clark 1987: 54).

1889 The New Mexico School of Mines was created by the Territorial Legislature. The college, located in Socorro, held its first classes in 1892 (Christiansen 1974: 70).

1889–90 Responding to threats to their traditional grazing lands by Anglo ranchers, Hispanos formed Las Gorras Blancas. They cut barbed wire fences and telegraph wires and burned ranches of Anglos or Hispano sympathizers (Rothman 1992: 33).

1889–96 After Texas cattle left the Pajarito Plateau, Hispanic ranchers moved back, some patented homesteads (Rothman 1992: 29–30).

1880s The Territorial Legislature passed an ordinance that levied fines against anyone convicted of dumping trash in irrigation ditches or rivers (Carlson 1990: 37).

1880s Zia Pueblo had a meager supply of water because Jemez Pueblo and upstream Hispanic villages diverted most of the Jemez River water (White 1962: 85).

1880s The acreage in cultivation along the Middle Rio Grande continued to decrease due primarily to water-logging and increasing alkalinity (Scurlock 1988a: 136).

1880s Don Jose Leandro Perea of Bernalillo "had many flocks of sheep" in the Sandia Mountains area. A severe blizzard killed a large flock between Bernalillo and Placitas. Perea sent out the word to area residents that they could have the animals for their meat (Batchen 1972: 69).

1880s The completion of transcontinental railroads created a new, huge market for livestock; this resulted in a sharp increase in animal numbers (Brown 1985: 97).

1880s Anglo lumbermen established tie-cutting camps in the southern end of the Sangre de Cristo Mountains. Some of these were fenced and were located on traditional common lands of land grants (Perrigo 1982: 100, 108). Extensive cutting of trees in the hills around Lamy for the production of charcoal occurred (Bullock 1973: 38).

1880s Coal was mined at Monero and Amargo west of Chama (Christiansen 1974: 83–84).

1880s At Joseph's Hot Springs at Ojo Caliente in Rio Arriba County, mineral water was marketed, and several thousand gallons were sold. Sales here and at other hot springs locales increased in the next decade (Christiansen 1974: 66).

1880s (to early 1900s) Lumberman H.S. Buckman, who made a practice of cutting timber on land grants that had fallen into Anglo ownership, clear-cut timber on the Petaca and Ramon Vigil land grants (Rothman 1992: 29–30).

1880s (to early 1900s) Cochiti Pueblo grew corn, wheat, oats, alfalfa, pinto beans, string beans, havas, garbanzas, peas, chile, onions, cabbages, beets, muskmelons, watermelons, peaches, apples, apricots, plums, cherries, grapes, tobacco, and cotton (Lange 1959: 93–100). At Ranchitos de Santa Ana, now known as Santa Ana No. 1, there were two villages a half-mile apart. Each was surrounded by peach, apple, and plum orchards and small vineyards. The corn crop was "one of the finest to be seen on the Rio Grande." Some 750 acres were in cultivation, and other land was used for livestock grazing. Both fields and bosques-vegas were irrigated (Poore 1894: 432). Isleta Pueblo had 60 acres of peach, plum, and apricot trees. These fruits were eaten, dried for winter use, or sold (Ellis 1979: 356).

1880s–90s Railroads were granted almost 3,600,000 acres in New Mexico, which included usurpation of Hispanic and Pueblo grant lands (Westphall 1983: 144). Coal mined at Dawson was primarily used by the Santa Fe Railroad (Christiansen 1974: 83).

1880s–90s The first commercial agricultural development in the Middle Valley occurred in the Belen area (Wozniak 1987).

1880s–1908 The American Lumber Company, headquartered in Albuquerque, owned and logged 1.5 billion board-feet of virgin pine timber in the Zuni Mountains. Thirty to forty carloads of logs were shipped to the Duke City daily over 55 miles or rail line. By 1908 it was the largest manufacturing firm in the Southwest (Simmons 1982: 332).

1880s–1920s Hot springs were considered to be healant and therapeutic for rheumatism, eczema, psoriasis, and acne. Spas were developed at sites with hot springs over much of the state (Fox 1983: 218).

1890 An irrigation company in Tijeras Canyon failed because it selected land that was not suited to irrigation development (Westphall 1965: 82).

1890 By this year a total of 113 Hispanic land grants, totalling 5.4 million acres, were confirmed in the Upper and Middle Rio Grande basins (Dortignac 1956: 72).

1890 There were 1,517,000 sheep and 210,000 cattle in the Middle and Upper Rio Grande basins (Harper et al. 1943: 49).

1890 Cattle were grazing on the mesa above and to the west of San Felipe Pueblo. Horses were grazing on the floodplain around the village (Strong 1979a: 395).

1890 A 15-foot vein of lignite coal, as well as copper, gold, and silver, were discovered on or near the Rio Puerco on the Espiritu Santo grant (Bayer et al. 1994:159).

1890 The U.S. Census Bureau counted 160,282 residents in New Mexico (Workers of the Writers' Program 1940: 432).

1890 (ca.) An old Spanish coal mine was reopened near Las Huertas, north of Placitas. Santa Ana

Pueblo herders were grazing their stock in the area (Bayer et al. 1994: 174).

1890–1910 Santa Ana Pueblo had 600 horses, 150 burros, 2,000 cattle, as well as 30 yoke of work oxen and a large number of sheep and goats (Bayer et al. 1994: 170).

1890–1945 Hispanic residents from the Carnue grant grazed on Manzano Forest lands until the Forest Service closed it to grazing (Quintana and Kayser 1980a: 50).

1891 (March 2) The General Revision Act, passed by the U.S. Congress, authorized the President to "reserve any part of the public lands" and establish boundaries. Many lumbermen, ranchers, and miners protested vigorously (Athearn 1985: 129).

1891 The Forest Reservation Act was also passed by Congress, marking the beginning of the national forest system (Udall 1963: 104–105).

1891 The Territorial Assembly passed a statute requiring all persons, associations, or corporations who constructed or enlarged any ditch, canal, or reservoir taking waters from a natural stream to make a sworn written statement of such diversion, to be filed with the county probate court within 90 days after commencement of the work. Construction had to be completed within 5 years of commencement (Clark 1987: 117).

1891 The Timber Culture Act was repealed because of abuses and difficulty in successfully growing trees in the West (Walker 1977: 3).

1892 (January 11) The President created the Pecos Forest Reserve (Tucker 1982: 107; Workers of the Writers' Program 1940: 432).

1892 (May 12) The capitol building burned in Santa Fe, destroying many public records and documents (Hill 1982: 10).

1892 A logging company purchased 300,000 acres of timbered lands in the Zuni Mountains (Hart 1991a: II/3).

1892–93 Jemez Pueblo grew 10,000 bushels of wheat and almost as much corn. The fields were fertilized with livestock manure from old corrals. Forty barrels of wine were made each year. (Poore 1894: 107).

1890s (early) Jose Ignacio Suazo of Taos cut railroad ties above Cuba in the Nacimiento Mountains (Swadesh 1974: 120).

1890s (early) Water shortages began to occur in the Mesilla and El Paso valleys. The Mexican government alleged that these shortages were due to increased diversions from the Rio Grande by residents of southern Colorado and northern New Mexico (Clark 1978: 72).

1893 (March 11) Placido Romero of Tome drowned in the Rio Grande (Baca and Baca 1994: 97–98).

1893 San Felipe Pueblo had more irrigable land than any other pueblo; grains were the major crops. Cattle and burros were grazed on the mesa above the village. A few years before, a foot bridge was built over the Rio Grande, but since that time floods had partially destroyed it. At Ranchitos de Santa Ana Pueblo there were two villages, each surrounded by peach, apple, and plum orchards and small vineyards. Their corn fields produced "one of the finest [crops] to be seen on the Rio Grande." These and their pasture lands were irrigated. They had 2,000 cattle, 600 horses, 150 burros, and 30 yoke of oxen, which grazed on various tracts here and on the land grant. Zia Pueblo residents were cultivating only about 100 acres of wheat, corn, and chile. They complained that livestock from Santa Ana Pueblo had invaded and damaged their fields and irrigation ditches. Zia Pueblo's lands totalled 17,515 acres. Jemez Pueblo was cultivating some 1,400 acres, mainly on the west side of the Jemez River. They were fertilizing their fields with livestock manure. About 10,000 bushels of wheat, almost as much corn, other vegetables, and various fruit, including grapes, constituted the major crops. Their livestock, with that of Zia and Santa Ana pueblos, were pastured on a tract of land 50 miles long and 12 miles wide. Isleta Pueblo was cultivating about 2,500 acres of floodplain land stretching north from the village and west of the Rio Grande for 2.5 miles. Wheat, corn, and fruit, including grapes, were grown. The Espiritu Santo land grant was grazed by livestock from Jemez, Zia, and Santa Ana pueblos, as well as animals belonging to Hispanic residents of San Ysidro and the U.S. Cavalry. Recently, lignite coal, copper, gold, and silver had been found in the Rio Puerco valley portion of the grant (Poore 1894: 107–110, 113, 160).

1893 Thomas Catron owned 2 million acres of land grants and served as attorney or part owner for some 4 million acres. He also held interests in 75 grants (Bayer et al. 1994: 160).

1893 Livestock herders at Zia Pueblo were taking woodrats and other small game for food with bows and arrows and clubs (Poore 1894: 108).

1893 The U.S.D.A. Division of Forestry reported "without forest management no national water management is possible" (Clark 1987: 71).

1893 An earthquake hit the Los Lunas area, and some 20 adobe buildings in that community were destroyed and many others damaged (Northrop 1976: 85).

1893–1912 Accidents killed 287 coal miners in New Mexico. Most (146) died because of rock and coal falls, while 72 were killed in explosions. These figures were considerably higher than the national averages (Whiteside 1989: 172).

1894 Oil began to replace coal as fuel in Santa Fe Railroad locomotives (Worley 1965: 24).

1894–1909 A store owner in Lamy operated several charcoal kilns to provide the fuel for broiling steaks that were served in dining cars of the Santa Fe Railroad (Rittenhouse 1965: 71).

1895 (pre) Native grasses, watered by overbank flooding of the upper Rio Puerco, were cut and dried for use as hay. Some of this hay was hauled to Albuquerque and sold (Bryan 1928a: 278).

1895 (February 28) The Territorial Assembly passed one of its most significant pieces of legislation. This measure defined the meaning of acequia, or community ditch, and detailed its legal status. These multiple-owner ditches were to be considered to be "corporations or bodies corporate, with power to sue and be sued as such" (Clark 1987: 30).

1895 The Surveyor-General's Office surveyed Lot 1, small holding claim no. 869, owned by Vicente Lujan of Valencia. The land was described as being level with sandy loam soil. There were cottonwoods with willows along an acequia, and there were three houses, fences, stables, and cultivated lands, all valued at $1,400 (Sanslock 1990b).

1895–1925 Acreage for the raising of alfalfa and tree fruit decreased due to a reduction in available irrigation water in the Middle Rio Grande Valley (Hedke 1925: 35).

1890s (mid) A reservoir was built on the upper Santa Fe River, below the 1866 dam and reservoir. The new reservoir was far superior to the old one, but population growth eventually rendered it inadequate (Clark 1987: 33).

1896 By this year, irrigated acreage in the Middle Rio Grande Valley had decreased from an estimated 44,000 acres to 32,000 acres, primarily as a result of agricultural development in the San Luis Valley and the ongoing drought (Wozniak 1987).

1896 (July) Water at Taos Pueblo, usually adequate at this time, was scarce (Zubrow 1974: 18).

1896 There were about 105,000 acres of irrigated acreage in tributary drainages of the Rio Grande (Dortignac 1956: 30).

1896 There were 39 pre–1800 irrigation ditches, 9 pre–1850, 7 pre–1880, and 12 pre–1896 maintained by the Pueblos (Hedke 1925: 18).

1896 A few Santa Clara Pueblo families had chickens (Hill 1982: 37).

1896 Promotional pamphlets and brochures produced by the Territorial Bureau of Immigration proclaimed that gold, silver, copper, lead, iron, and coal deposits were inexhaustible (Northrop 1959: 31, 33).

1897 (February) President Grover Cleveland set aside more than 21 million acres of land in the western states as part of national forest preserves (Rothman 1992: 61).

1897 (June 4) Congress passed the Organic Act for National Forests, which embodied the concept of multiple-use of resources in conformity with state laws and federal rules and regulations (Clark 1987: 140). The act also authorized the Forest Service to manage grazing on public reserve lands. This soon resulted in the loss of free grazing for livestock owned by nearby land grant occupants in northern New Mexico (Brown 1978: 254).

1897 Otero gave out 60,000 sheep on a partido basis in the upper Rio Puerco basin (Maes and Fisher 1937: 14–15).

1897 The New Mexico Sheep Sanitary Board was created by the Territorial Legislature. Board inspectors had the power to quarantine infected sheep and to inspect all incoming and outgoing sheep as well. In 1904 the board ordered all sheep to be dipped to prevent the spread of rabies (Grubbs 1961: 287).

1897 Cochiti Pueblo built a bridge of wicker-woven basketry cribs, vertical wooden posts, and log planks across the Rio Grande (Lange 1959: 57–60).

1897 Cochiti farmers had constructed "summer huts," or field houses, of usually a one-room adobe or brush. Some had "a little shelter of boughs in front: one or two have little dome or arched brush huts erected on the flat roof of the hut proper" (Lange 1959: 102).

1897 An epidemic of eye disease broke out at Zia Pueblo (White 1962: 60).

1897 (late) (to late 1898) Some 118 Catholics died of smallpox in the Tome parish. Most of these deaths were children under the age of 13 (Baca and Baca 1994: 6, 111).

1898 (June 21) The President signed the Fergusson Act, which in part, earmarked 500,000 acres in New Mexico for the establishment of permanent reservoirs for irrigation purposes. On March 16 of the next year the Territorial

Assembly responded by creating the office of Commissioner of Public Lands and a Board of Public Lands. They were responsible for leasing, selling, and managing the lands. Under the act, federal public lands were transferred to the territory for schools and certain other public institutions (Clark 1987: 84).

1898 Less than 26,750 acres of an estimated 115,000 acres of arable land, from Cochiti to Sandia pueblos, was in cultivation. Some 32,000 fallow acres had been abandoned due to alkali accumulation and the formation of marshes in the soil (Follett 1898: 87–88).

1898 Some 632 Pueblo Indians were infected with smallpox; 42 of these individuals died (Thornton 1987: 102).

1898–1903 The Raymond Vigil grant was leased to timberman H.S. "Harry" Buckman, who employed "tie-gangs" to begin clearcutting of the ponderosa on this part of the Pajarito Plateau. Buckman illegally cut trees that were less than 8 inches in diameter at the base. As part of his logging operation on the Pajarito Plateau, he built an access road with a bridge over the Rio Grande. This structure was taken out by floods each year (Rothman 1992: 32, 33, 179).

1898–1920s Sweet potatoes, as well as alfalfa, apples, and grapes, were being grown in Corrales (Eisenstadt 1980: 17–18).

1898–1932 George Rinaldi developed a copper mine at La Bajada until about 1900, then moved to Bland, then Pena Blanca, where he began farming in 1904. He introduced cauliflower to the area. In 1918 he and his family moved to a ranch in Bernalillo. Rinaldi became involved in growing vineyards and orchards until his death in 1932 (Olson 1976: 201–203).

1899 (pre) The Indian agent reported that smallpox and diphtheria had severe effects at Zia Pueblo (White 1962: 101).

1899 The U.S. Congress declared it a misdemeanor to discharge refuse into any navigable streams or their tributaries, although the law did not apply to waste from properly supervised public works or waste in liquid state from streets or sewers (Clark 1987: 268).

1899 San Felipe Pueblo was located on both banks of the Rio Grande. The east bank settlement included numerous cultivated fields at the very edge of the river (Strong 1979a: 394).

1899 The cyanide process of ore reduction was first used in New Mexico at Albemarle in Colla Canyon in the Jemez Mountains (Scurlock 1981b: 51).

1890s–1902 The Zia Pueblo population grew from 92 to only 109 due to disease, inadequate water for farming, and poor crop harvests (White 1962: 101–102, 322).

1890s–1940s Louis Gross maintained large vineyards and fruit orchards in Bernalillo. Peaches and apples were his main tree fruit. Gross made wines from all three fruits and also sold them as produce (Olson 1976: 195–196).

1800s Residents of Adelino, across and down the river from Tome, would take a San Juan santo to the river to "look" at the dry sand in hopes he would bring rain (Ellis 1955: 106).

1800s Vegas near the Rio Grande in the Tome area were the source of terrones used in the construction of houses and buildings. The best cutter of terrones, reportedly, was an unidentified man who cut 1,000 blocks a day. Volcanic rock was hauled from Cerro Tome and used for low foundations of homes and other buildings in the area. These rocks helped protect the terron walls of structures against flood and marsh waters (Ellis 1955: 104).

1800s (late) Hispanic farmers in Frijoles Canyon reused prehistoric irrigation ditches (Rothman 1992: 115).

1800s (late) There was an increasing shortage of Spanish cropland on the south side of the Pojoaque River (Carlson 1979: 32).

1800s (late) The average Santa Clara farm was 6 acres, including lowland and highland plots (Hill 1982: 27).

1800s (late) Farming at San Ildefonso began a decline that lasted into the early 1930s. This resulted from a population decrease and Anglo and Hispano disregard for Pueblo land and water rights (Edelman 1979: 312).

1800s (late) As fenced rangelands became more common, cowboys spent less time chasing cattle and more time maintaining windmills, small irrigation ditches, and hay for winter feed (Murray 1979: 94).

1800s (late) A hotel and bathhouse were built at Ojo Caliente in Taos County. The five hot springs constituted a significant sacred place to the Tewa Pueblo (Hewett and Dutton 1945: 39–40).

1800s (late) Firewood wagons generally used the precursor of Highway 14 south of Tijeras. This old trail commonly gullied and became hard for wagons to negotiate (McDonald 1985: 21).

1800s (late) (to early 1900s) There was coal mining activity in the Tijeras area (Quintana and Kayser 1980: 50).

1800s (late) (to early 1900s) The Tewa Pueblo owned very few sheep, goats, and pigs. Each family had a few head of cattle, including oxen; one or two residents of Santa Clara owned as many as 60 head of cattle. Dogs, rabbits, ducks, and deer fawns were kept as pets (Hill 1982: 37).

1800s (late) (to mid 1900s) Sheepherders and other residents of the Tome area collected osha and other herbs in the Manzanos, especially at Osha Springs (Chavez 1972: 2–3, 21).

1900 (pre) "A good cover" of galleta, blue grama, and alkali sacaton grasses was found over much of the Rio Puerco watershed (Dortignac 1963: 508).

1900 (pre) Sorghum was grown at Santa Clara Pueblo; it was used in making syrup (Harrington et al. 1916: 110). Cotton was also grown at this pueblo (Hill 1982: 33).

1900 There were 3.5 million sheep and 843,000 cattle in the territory (Carlson 1969: 39).

1900 There were 1,732,000 sheep and 211,000 cattle in the Middle and Upper Rio Grande basins (Harper et al. 1943: 49).

1900 By this year the Upper Rio Grande "carried 533,000 animal units" (Bayer et al. 1994: 176).

1900 The U.S. General Land Office required ranchers to obtain permits to graze on public lands (Athearn 1985: 130).

1900 A stage line ran from Albuquerque to Jemez Springs via Santa Ana Pueblo. Narcisco Zamora ferried wagons across the Rio Grande at Bernalillo (Bayer et al. 1994: 174).

1900 The U.S. Census Bureau counted 195,310 persons in New Mexico (Workers of the Writers' Program 1940: 433).

1900 The populations of major Middle Valley towns were as follows: Santa Fe, 5,603; Albuquerque, 8,848; Belen, 673; and Socorro, 1,512 (Sayles 1987: 132).

1900 (ca.) At springs in Coyote Canyon at the west foot of the Manzano Mountains, water reportedly good for kidney and bladder problems was bottled and sold. Topham bottled 10,000 gallons in 1903; Harsch bottled 25,000 gallons (Jones 1904: 3303).

1900 (ca.) The Reliance Gold Mining Co. was organized to mine the placer gold in Hell Canyon in the Manzanos (Jones 1904: 192).

1900-04 The Pino family of La Cienega used Frijoles Canyon as a base for their sheepherding. Some of the family members lived in prehistoric cavate rooms (Rothman 1992: 63).

1900–30 Loss of common lands, loss of access to those lands, and reduced surface water contributed to the decline of Hispanic villages in the Las Vegas area (Perrigo 1982: 129–130).

1900–39 Spanish New Mexicans lost about 70 percent of their private or community land grants (Eastman and Gray 1987: 96).

1900–45 Alameda stock raisers were grazing their herds, primarily sheep, on common lands across the Rio Grande, west of the community, and on the east side of the railroad tracks (Gerow 1992: 49).

1901 (December 3) President Teddy Roosevelt delivered a message on the need for conservation of natural resources, the first such speech by the Nation's leader. His emphasis was on reclamation and forest reserves (Clark 1987: 134).

1902 June Congress passed the Federal Reclamation Act to assist irrigation development in the western states. The U.S. Reclamation Service was also established. This agency's major responsibility was to construct irrigation works for the reclamation of arid lands (New Mexico State Engineer Office 1967: 78, 81). The act authorized the Secretary of the Interior to construct irrigation projects in New Mexico and 15 other territories or states. Users of irrigation waters would repay the costs of construction over a 10-year period, and small farmers could irrigate 160 acres or less with water from federal irrigated projects (Clark 1987: 79–82; Wozniak 1987).

1902 (summer) In the upper Arroyo Hondo, new mine-related developments were underway. These included the erection of a four-story mill and smelter using fired bricks made onsite. Charcoal was also being made (Pearson 1986: 41).

1902 Theodore Roosevelt created the San Isabel Forest and San Juan Forest reserves in southern Colorado (Athearn 1985: 130).

1900s (early) Crop plants cultivated at Jemez Pueblo included corn, wheat, alfalfa, melons, gourds, chile, grapes, and cotton (for ceremonial use). Domesticated animals included the horse, burro, goat, dog, cat, turkey, and chicken. Crop plants cultivated at Laguna and Acoma included corn, wheat, alfalfa, beans, squash, pumpkins, melons, gourds, chile, cabbage, beets, and carrots. Livestock raised included sheep, goats, cattle, horses, mules, pigs, turkeys, and ducks (Bandelier and Hewett 1937: 97, 104).

1903 Valencia was a sheep-raising and farming community with a population of 900. Gurule Feliz and Jesus Sanchez were owners of general merchandise stores, and Sanchez was also postmaster (Ives 1903: 496).

1903 Margarito Romero of Las Vegas was cutting timber for railroad ties on the Pecos Forest Reserve and in Gallinas Canyon. He claimed the latter area was part of the Las Vegas land grant, and his family had rights to cut on the acreage (Perrigo 1982: 116).

1903 Prosperous gold mining in the Cochiti District was a factor in creating the new county of Sandoval, formerly the northern part of Bernalillo County (Northrop 1959: 35).

1904 There were 30,000 sheep owned by small operators grazing in the Cabezon-Cuba area. One sheep man in Cuba owned 32,000 animals, and another had 20,000 (Maes and Fisher 1937: 15, 18–19).

1904 The Las Vegas land grant board reserved all of the unoccupied grazing lands for use of residents and declared all common watering places were to be kept open and accessible to them. One person was limited to 4,000 sheep and 400 cattle, which could be grazed on the old grant (Perrigo 1982: 118–119).

1904 The wine and brandy produced in Valencia County was a highly regarded commodity (Gallegos 1970: 74).

1905 (July 29) The Santa Clara Reservation, some 33,044 acres, was created by executive order (Lange 1982: 2).

1905 (September 30) The crop harvest at Nambe Pueblo was reported as good (Kessell 1980: 66).

1905 (October 12) The Jemez Forest Reserve was created, precluding continuance of traditional grazing and other activities on this former ejido land. The period of fire suppression was also begun (Rothman 1989: 208–209; Tucker 1992: 107).

1905 (November 4) Father Ralliere of Tome collected "a large amount of grass [hay] from the Rinconada lands and from the swamps of Manuel and Julian Torres" (Ellis and Baca 1957: 21).

1905 The Legislative Assembly enacted a code that declared natural waters as belonging to the public, and all citizens had the right to appropriate them for beneficial use (Clark 1987: 117).

1905 The principal crops grown in Valencia County included wheat, barley, oats, alfalfa, corn, and grapes (Frost and Walter 1906: 375).

1905 (late) Edgar Hewett drafted an "Act for the Preservation of American Antiquities" and sent it to Congress, where it was passed. In early June of the next year, President Theodore Roosevelt signed it into law (Rothman 1992: 80).

1905-07 Ranchers, including Governor George, Miguel A. Otero, and Solomon Luna, "believed that federal land use regulations were detrimental and were administered with discrimination against ranchers." Some of these ranchers considered the defeat of grazing regulations on public lands more important than securing New Mexico statehood (Richardson 1958: 278–280).

1905–10 Fire suppression became Forest Service policy; heavy stocking of the national forest reserves was thought to be desirable due to the resulting destruction of vegetation that might fuel a fire (Brown 1985: 124).

1905–25 The Jicarilla Apache population decreased from 815 to 635 due to tuberculosis and other diseases (Tiller 1983: 454).

1906 (January 1) A new regulation charging a grazing fee for livestock on national forest reserves went into effect (Rowley 1985: 60–63).

1906 (June 11) The Forest Homestead Act, which allowed individuals to file on any forest reserve land considered unfit for timber, was passed by Congress (Rothman 1992: 85).

1906 (June 25) The Fergusson Act was amended by permitting the Secretary of the Interior to approve grazing leases in excess of the 640-acre-limit. Following this enactment, grazing leases became the primary source of revenue from territorial lands (Clark 1987: 85).

1906 (November 5) The Magdalena and San Mateo national forest reserves were created by Presidential Proclamation (Baker et al. 1988: 25; Tucker 1992: 107).

1906 (November 6) The Manzano National Forest Reserve was created by Presidential Proclamation. Manzano became Cibola National Forest on December 3, 1931 (Tucker 1992: 107, 109, 112).

1906 (November 7) The Taos Forest Reserve was created by President Theodore Roosevelt. Some 330,000 acres, including the Taos Blue Lake, composed the reserve land. Less than 2 years later this reserve was redesignated as the Carson National Forest (Baker et al. 1988: 25; Tucker 1992: 108; Wood 1989: 74).

1906 There were 5,875,000 sheep, 1,050,000 cattle, 225,000 goats, and 100 horses in the territory (Frost and Walter 1906: 376).

1906 There is some evidence that extensive logging of the Manzano and Gallinas administrative units of the present Cibola National Forest had occurred prior to its establishment date (Tainter and Levine 1987: 150). A timber operation was begun on the Jicarilla Apache Reservation (Tiller 1983: 453).

1906 Congress passed the Antiquities Act giving presidents the power to create "national monuments for the preservation of historic landmarks ... and other objects of historic or scientific interest" (Udall 1963: 132).

1907 The loss of traditional grazing lands on the old Las Vegas land grant caused 500 Hispanic villagers to seek redress (Perrigo 1982: 121).

1907 The Las Trampas Lumber Company purchased the grant of the same name from Frank Bond. In a subsequent agreement, the lumber company gave use-rights to Hispanic heirs on the grant for grazing, wood gathering, and cutting of unmerchantable timber. However, the company did not live up to the agreement. (Ebright 1994: 155, 158–160).

1907 A.B. McGaffey purchased 24,750 acres of the Santa Barbara land grant and 41,000 acres of the adjacent Mora grant not long afterward. Workers from his Santa Barbara Tie and Pole Company cut every tree to timberline that would make ties. Cutting continued until 1926 (deBuys 1985: 227).

1907 The Jicarilla Apache began to summer pasture their livestock in the higher, northern part of the reservation and to winter pasture them in the lower, summer part (Tiller 1983: 453).

1907 Construction on the railroad from Clovis to Belen was completed (Myrick 1970: 35–36).

1907-08 (summers) At Buckman's, near Cochiti Pueblo, logs floated down the Rio Grande were being taken out of the river. It was also known as "The Boom," and a camp for the workmen was located on the east bank of the river (Harrington 1916: 441).

1907-08 (winter-spring) Some 100,000 ties were cut in the Jicarilla Mountain Rio del Pueblo area. Spring runoff was too low to float the logs down the Rio Embudo to the Rio Grande until a thunderstorm created enough water to make this possible (Gjevre 1969: 37).

1908 (February 6) Congress passed a measure prohibiting the assignment of entries to corporations or associations, limiting them to individuals who were qualified desert entrymen under the Desert Land Act (Clark 1987: 136).

1908 (April 16) The Manzano National Forest was created from the forest reserve of the same name and also included the Mt. Taylor Forest Reserve (Tucker 1992: 112).

1908 (June 26) The Carson National Forest was created by combining the Taos National Forest with part of the Jemez National Forest (Tucker 1992: 109, 112, 114).

1908 (July 2) The Pecos River National Forest Reserve was designated a national forest (Tucker 1992: 113).

1908 The Ramon Land and Lumber Company purchased the Ramon Vigil grant and cut some $25,000 worth of timber. A large amount of this was seized by the Federal Government during a dispute over the north boundary of the grant (Ebright 1994: 243).

1908 A dozen different, independent mining operations were working in the Sandia Mountains (Northrop 1959: 36–37).

1908-09 (winter) Logging operations were begun on the Jicarilla reservation, and 80,000 board-feet of timber were cut. The sawmill produced railroad ties, primarily for the Rio Grande and Southwestern Railroad (Tiller 1992: 110–112).

1909 The Enlarged Homestead Act provided that 320 acres could be acquired when all provisions were met (Worster 1979: 87).

1909 The U.S. Bureau of Soils announced "The soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that cannot be exhausted; that cannot be used up" (Worster 1993a: 73).

1909 Cuba sheepmen petitioned for the elimination of 150,000 acres from area national forests for their use as grazing lands (Richardson 1958: 281).

1909 The Territorial Legislature authorized two types of voluntary organizations: water users' associations and irrigation districts. For the latter, irrigation systems could be constructed for their members. The assembly also passed a provision for the drainage of seepage and other waters in unincorporated towns and villages by action of the county commissioners on petition of a majority of the residents and after investigation by the county surveyor (Clark 1987: 110, 112).

1909 William Howard Taft issued a Presidential Proclamation establishing Gran Quivira National Monument (Carroll et al. 1991: 1).

1909–18 F.J. Otero grazed up to 200,000 sheep and several thousand cattle on the Baca No. 1 location (Scurlock 1981a: 142).

1910 H.W. Yeo recorded 55 pre–1540 irrigation ditches, two pre–1700, six pre–1800, five pre–1850, six pre–1881, and five pre–1911 construction dates (Hedke 1925: 20).

1910 Hispanics and Native Americans in Albuquerque began to contract tuberculosis from incoming "lungers." Most victims were female housekeepers (Simmons 1982: 345).

1910 A sawmill was established at the Jicarilla Apache agency. Two years later the Navajo

Lumber Company contracted for 130 million board feet of timber (Christiansen 1974: 63).

1910 The Peterson dam and reservoir were constructed on the Gallinas River to furnish Las Vegas with water. Water for the reservoir was supplied by a wooden flume extending from an upstream diversion dam (Perrigo 1982: 28).

1910 A group of Santo Domingo residents, claiming "ownership" of the Chalchihuitl Mine, removed turquoise. At the time, the American Turquoise Company had title to the mine; the Tiffanys of New York were the principal stockholders (Tyler 1964: 185).

1910 The U.S. Census Bureau counted 327,301 persons in New Mexico (Workers of the Writers' Program 1940: 433).

1910 The populations of major Middle Valley towns were as follows: Santa Fe, 5,072; Albuquerque, 13,163; Belen, 1,733; and Socorro, 1,560 (Sayles 1986: 132).

1910–11 The Office of Grazing Studies was established by the U.S. Forest Service in 1910. Regional Offices of the OGS were organized at Denver and Albuquerque (Price 1976: 7).

1911 Congress passed the Weeks Law, calling for a cooperative fire protection plan between the Forest Service and participating states. The legislation also authorized funds for acquisition of forest lands to protect stream watersheds (Buchanan 1988: 30; Otis et al. 1986: 5).

1911 Measles killed 22 Catholic children in the Tome parish (Baca and Baca 1994: 6).

1912 On the 1-million-acre Carson National Forest there were 200,000 sheep, 7,000 cattle, and 600 homesteads (Flader 1978: 9).

1912 The State Legislature passed a mining law governing operators, supervisors, and miners. The basic ventilation standard to 100 cubic feet of air per man per minute and 300 cfm for each animal. "Gassy" mines had to be inspected daily (Whiteside 1989: 174).

1912 The Tonque Brick and Tile Company was established at the Tonque Pueblo site on the Tonque Arroyo, east of present I–25. "Large areas of the banks of Tonque Arroyo were processed for clay" until the operation closed in 1942 (Barnett 1969: 27).

1912–17 The Forest Service increased its effort to control grazing to protect rangelands, watersheds, and wildlife. Livestock numbers were reduced (Roberts 1963: 115–116).

1912–26 Timber for railroad ties was harvested from 65,000 acres in the Santa Barbara and Mora areas. More than 2 million ties were produced from ponderosa pine, spruce, and fir (Cook 1954: 36).

1913 The U.S. Supreme Court ruled in the Sandoval case that the Pueblos had no right to alienate their land, and consequently all titles to lands purchased from them were invalid. In the settlement of the Sandoval case, the Pueblos were recognized as Indian tribes under federal trusteeship. As a result, the imposition of various debts and liens against the Pueblos occurred. Irrigation works, drainage of land, and construction of bridges and roads were constructed by the Bureau of Indian Affairs. The Pueblos were charged for these services, even though some of the ditches were dug where there was no water. From this time to passage of the Pueblo Lands Act of 1924, non-Indian claimants evaded return of lands to the Pueblos (Brayer 1938: 26; Sando 1992: 120).

1913–33 New Mexico coal mine deaths for this period rose to 8.8 per thousand, with a total of 734 fatalities (Whiteside 1989: 174–175).

1914 (spring-summer) Excessive water in the Caribel Mine near Red River halted mining during this period (Pearson 1986: 120–121).

1914 A firm purchased logging rights to 117 million board feet of timber in the Carson National Forest. Ponderosa pine and Douglas fir were the two principal species harvested and sent to the company's sawmill at La Madera (Chappell 1971: 129–130).

1917–18 The Sherwin-Williams Paint Company financed mining of lead and zinc in the Magdalena Mountains (Fergusson 1951: 307).

1918 (fall) The worldwide influenza epidemic spread to the Tome area. This Spanish flu struck more than one-half the population of Belen (Melzer 1982: 216–228).

1918 Some 47,007 acres of farmland were being irrigated in the Middle Rio Grande Valley (Hedke 1925: 20).

1918–45 Hundreds of burros that had been used by the military in World War I were released on rangeland west of Alameda, where they grazed until the population disappeared by the end of World War II (Gerow 1992: 49).

1920 The U.S. Census Bureau counted 360,350 persons in New Mexico (Workers of the Writers' Program 1940: 434).

1920 (ca.) The first wells were dug at Santa Clara Pueblo by the government. A well in the northwest plaza of the village was drilled and installed with a hand-pump, which was replaced by a windmill in 1925 (Hill 1982: 41).

1900s (early) Jemez Pueblos brought grapes to the Guadalupe area along the Rio Puerco, which they traded for other agricultural produce with Hispano residents. The latter took their wheat to Jemez to be milled (Garcia 1992: 115, 121).

1900s (early) Good harvests of a variety of crops were common in the Guadalupe area in Sandoval County, including wheat, corn, beans, squash, cabbage, tomatoes, chile, pumpkins, and cantaloupes (Garcia 1992: 113, 121, 123).

1900s (early) The Santa Ana flour mill operated at Llanito, in Sandoval County (Olson 1976: 93).

1900s (early) The American Lumber Company was established in Albuquerque. Logs for the mill came from the Zuni and San Mateo mountains north of Grants (Balcomb 1980: 56).

1900s (early) Hispanic homesteaders in the Sandia Mountain foothills ran goats instead of sheep because of the rugged terrain (Davis 1986: 103–104, 109; Scurlock 1983: 14).

1900s (early) Coal from the Gallup and Madrid mines was a primary fuel used in Albuquerque. Wood collected by Spanish Americans from the Sandia Mountains was another principal heating and cooking fuel at this time (Balcomb 1980: 52–53).

1900s (early) Bear Canyon on the west flank of the Sandia Mountains was a favorite recreational area for residents of Albuquerque. The cold, pollution-free stream, lined by cottonwood and box elder, was the major attraction (Balcomb 1980: 63–64).

1900s (early) Diphtheria epidemics struck Lemitar, causing loss of life (Scurlock 1982: 14).

1923–24 Rancher Robert Thompson purchased the 55,000-acre Alameda land grant. The ranch headquarters was located on the north edge of Corrales. Some 3,000 to 5,000 herefords were grazed on the surrounding grasslands (Eisenstadt 1980: 21–22).

1926 The major crops in the Middle Rio Grande Valley included corn, alfalfa, grain, fruits, and truck garden vegetables. Some cotton was grown south of Albuquerque, and tobacco was being considered as a commercial crop (Rodey and Burkholder 1927: 3).

1926 The Atchison, Topeka, and Santa Fe Railroad contracted to provide 34,256 linear-feet of trestle piling, 237,498 board-feet of native pine bridge timber, 81,610 board-feet of native pine box culvert timber, and 60,000 native pine track ties for construction of the Cuba Extension rail line from San Ysidro to north of Cuba (Glover 1990: 48).

1926 Large-scale development of mining operations at Willow Creek was begun by the American Metal Company (Northrop 1959: 39).

1928 The Cleary coal mine produced 10,500 tons of coal during the year (Glover 1990: 51).

1930 By this year Frank Bond controlled the best grazing lands in the Jemez Mountains. He leased land for grazing his sheep from the Forest Service, and after 3 years of use, his forest grazing rights became permanent (Rothman 1990: 129).

1930 By this year the Cochiti reservation was completely fenced (Lange 1959: 219).

1930 The U.S. Census Bureau reported the population of New Mexico as 423,317 (Workers of the Writers' Program 1940: 434).

1935 Two marijuana dealers were operating in Dixon. In addition to being smoked for its hallucinogenic properties, marijuana was used as a remedy for rheumatism and other maladies (Curtin 1965: 127; Weigle 1975: 185).

1930s (mid) Most of the residents from the middle Rio Puerco-of-the-East valley moved upstream to the higher Cuba area, where agriculture was still relatively reliable (Calkins 1937: 18–19).

1940 The U.S. Forest Service and Bureau of Land Management began to fence federal land in the Rio Puerco-of-the-East valley and traditional grazing lands on Mesa Prieta and the San Mateo Mountains, including Mount Taylor (Garcia 1992: 23).

1941–43 Each family on the Rio Puerco was permitted to graze 15 head of sheep in its grazing precinct by the Grazing Service. This number of livestock was considered below the minimum needed for subsistence (Forrest 1989: 159).

1942 There were 14,972 acres under cultivation in the Rio Puerco basin (Harper et al. 1943: 11).

1950 There were about 240,000 residents in the Middle Rio Grande Basin (Williams 1986b: 153).

1960 There were about 400,000 residents in the Middle Rio Grande Basin (Williams 1986b: 153).

CHAPTER 4

THE MIDDLE RIO GRANDE BASIN: HISTORICAL DESCRIPTIONS AND RECONSTRUCTION

This chapter provides an overview of the historical conditions of the Middle Rio Grande Basin, with emphasis on the main stem of the river and its major tributaries in the study region, including the Santa Fe River, Galisteo Creek, Jemez River, Las Huertas Creek, Rio Puerco, and Rio Salado (Fig. 40). A general reconstruction of hydrological and geomorphological conditions of the Rio Grande and major tributaries, based primarily on first-hand, historical descriptions, is presented. More detailed data on the historic hydrology-geomorphology of the Rio Grande and major tributaries are presented in Chapter 5.

Historic plant communities, and their dominant species, are also discussed. Fauna present in the late prehistoric and historic periods is documented by archeological remains of bones from archeological sites, images of petroglyph and pictograph sites, and recorded observations. Three major classes of vertebrates are discussed—mammals, birds, and fishes. A brief section on insects follows.

This chapter provides historical baseline data and context for determining environmental change, which is addressed in Chapter 5. Additional data are presented in the chronology at the end of the chapter.

GEOLOGY-PHYSIOGRAPHY-SOILS

The Rio Grande and its parent landform, the Rio Grande rift, dominate the physical setting of the study region. Both extend roughly north and south from southern Colorado through New Mexico to the Texas border, a total reach of 500 miles (Fig. 40). The upper part of the rift, or the Upper Rio Grande Basin, is included in the Southern Rocky Mountain Physiographic Province, while the remaining reach, or the Middle Basin, is part of the Basin and Range Province. The Upper and Middle basins are divided into smaller, structural subbasins, such as the Espanola and Albuquerque subbasins. These subbasins are separated by old terraces or basalt flows that constrict the Rio Grande to a narrow valley. These topographic units vary from 30 to 100 miles in length and from 10 to 35 miles in width (at their widest points). Constricting narrows occur near or at Cochiti, San Felipe, and Isleta pueblos; San Acacia, just north of Socorro; and north of San Marcial. The San Luis basin, which is closed, and the Taos Gorge, are special physiographic features in the Upper Basin (Crawford et al. 1993: 7; Fox et al. 1995: 52–54; Hawley 1986: 26).

The main two basins are flanked by fault-block mountains, such as the Sandias (Fig. 40), or volcanic uplifts, such as the Jemez, volcanic flow fields, and gravelly high terraces of the ancestral Rio Grande, which began to flow about 5 million years ago. Besides the mountains, other upland landforms include plateaus, mesas, canyons, piedmonts (regionally known as bajadas), volcanic plugs or necks, and calderas (Hawley 1986: 23–26). Major rocks in these uplands include Precambrian granites; Paleozoic limestones, sandstones, and shales; and Cenozoic basalts. The rift has filled primarily with alluvial and fluvial sediments weathered from rock formations along the main and tributary watersheds. Much more recently, aeolian materials from abused land surfaces have been and are being deposited on the floodplain of the river.

The Middle Rio Grande—including major tributaries such as the Santa Fe River, Las Huertas Creek, Jemez River, Rio Puerco, and Rio Salado—drains 24,760 square miles (Fig. 41). Headwater elevations range from 8,000 to 12,000 feet, and the Rio Grande channel in the Middle Valley reach descends from 5,225 feet at Cochiti to 4,450 feet at San Marcial (Crawford et al. 1993: 7).

Four broad soil types occur in the study region: entisols, which occur on the Rio Grande floodplain; aridisols, which occur over the warmer and drier portions in the lower elevations of the basins; mollisols, which occur on the cooler and wetter upland portions of the basin; and inceptisols, which occur in the higher elevations of the Sangre de Cristo and Taos mountains and in the San Juan Mountains of Colorado, at the headwaters of the river (Maker and Daugherty 1986: 65).

Entisols are recent occurrences of soil formation on floodplains, so no major soil horizons have developed. Derived primarily from transported sediments that historically were deposited by overbank flooding, they are relatively rich soils that have supported agriculture for centuries. The texture of arid soils ranges from loamy sands to clays, usually calcareous, and they are not suitable for dryland farming. They are subject to abuse by various land-use activities, resulting in relatively severe water and wind erosion. Mollisols, with deep, organic, surface-subsurface matter, are dominantly grassland soils. These are fertile soils of high organic content, but they are subject to severe erosion if abused. Inceptisols are young soils that occur on relatively steep mountain slopes where annual precipitation is above 14 inches. They are formed

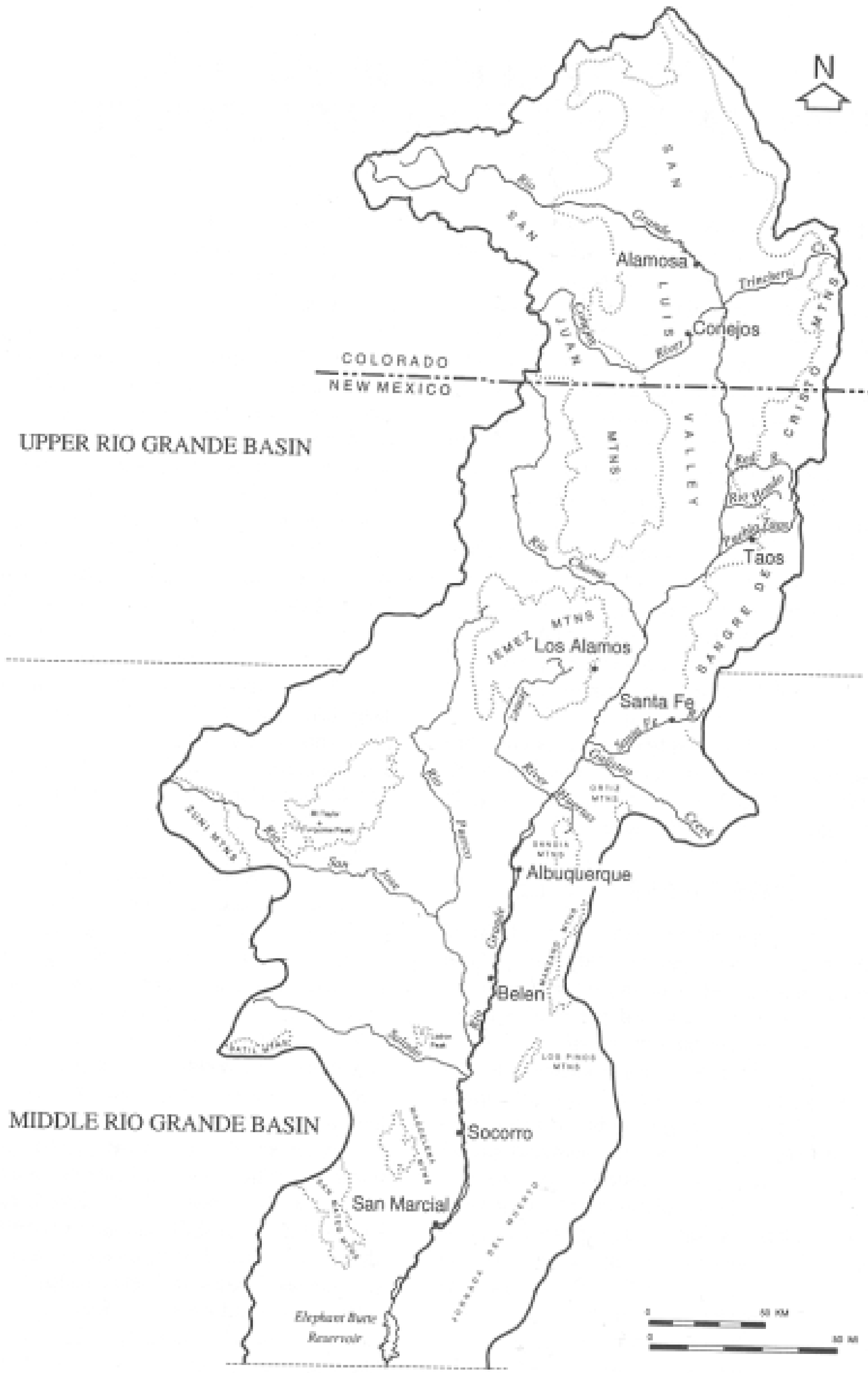

Figure 40—Study region: streams and mountain ranges.

Figure 41—Middle Rio Grande Basin: major streams, mountain ranges, and historic settlements.

from weathered rock sediments, including volcanic pumice (Maker and Daugherty 1986: 66).

HYDROLOGY-GEOMORPHOLOGY

Rio Grande

The Rio Grande, the fifth largest river in North America, flows 1,885 miles from southern Colorado to extreme southern Texas, where the river empties into the Gulf of Mexico. Across New Mexico, the river extends for some 470 miles from just above Ute Mountain to Anthony at the Texas border (Fig. 40). Its discharge area in the state is 32,207 square miles. For the Middle Valley, the Rio Grande flows for about 160 miles, with a total drainage area of 24,760 square miles (Fig. 42); the direct tributary drainage area is about 12,800 square miles (Crawford et al. 1993: 7; Snead and Reynolds 1986: 57; Table 44).

Early in the historic period the various Spanish expeditions applied different names to the Rio Grande (Hammond and Rey 1966):

Year	Expedition	Name
1540	Coronado	Tiguex
1540	Coronado	Tibex
1540	Coronado	Nuestra Senora
1581	Rodriguez-Chamuscado	Guadalquivir
1582–83	Espejo	Rio del Norte, Rio Turbio
1590	Sosa	Rio Bravo
1598	Onate	Rio Bravo and Rio del Norte

The only descriptive name for the physical condition of the river among these is turbio, which in English means "muddy." This term was no doubt used when the Rio Grande was carrying runoff water.

From 1598 until the arrival of the Americans, the river in New Mexico was generally known as the Rio del Norte. In the colonial period, the name Rio Grande was usually given to the stretch of the river below the mouth of the Rio Concho, below Big Bend National Park, to the Gulf of

Figure 42—The Rio Grande at Albuquerque. Cottonwood, Russian olive, salt cedar bosque (center), Sandia Mountains (center back). Photo by author.

Mexico. Between this confluence and El Paso, the river was called the Rio Bravo. Early Anglos in New Mexico and Texas named the entire river the Rio Grande (Ayer 1965: 213; Pearce 1965: 134; Sanchez 1991, personal communication).

Some time later, in 1776, Fray Dominguez explained the name Rio del Norte: "The river is called the Rio del Norte because it comes from the north many leagues beyond Taos. . . . It is so many leagues long that even though the settlers of these regions have penetrated very far north for various purposes again and again, they have not found the source of this river" (Adams and Chavez 1956: 7).

When the first Hispanics reached the Middle Rio Grande, the valley ecosystem had been impacted relatively little by human activity. Perhaps some 25,000 acres of floodplain had been cleared by the Pueblo for cultivation, primarily irrigated by bank overflow or runoff from tributary streams or arroyos. Wing diversion dams and irrigation ditches were probably few in number. This ecosystem was one of dynamic equilibrium defined by a collection of environmental processes predicated on change. These processes included varied flow, including floods and associated shifting channels, erosion, and deposition

Table 44—Principal tributaries of the Rio Grande in the Middle Valley.

Tributary	Length (miles)	Drainage area (sq. mi.)	Mountain sources	Confluence with Rio Grande	Stream character
Rio Santa Fe	35	250	Sangre de Cristo	Below Cochiti	Perennial
Las Huertas Creek	15	29	Sandia	Below Algodones	Perennial in headwaters
Rio Jemez	60	1,060	San Pedro and Jemez	Above Bernalillo	Perennial in headwaters
Rio Puerco	140	6,220	Nacimiento	At La Joya	Ephemeral
Rio Salado	70	1,381	Datil	Above San Acacia	Ephemeral

Source: Harper et al. 1943: 7

of sediments. The Rio Grande was a "braided, slightly sinuous aggrading river with a shifting sand substrate." Riparian vegetation evolved and changed with these floods, deposition, and low flow caused by seasonal or more extended drought conditions (Crawford et al. 1993: 16, 19; Fig. 43).

Prehistoric and early historic evidence of large fish species in the river indicates that the Rio Grande "was a clearer, larger, and more stable stream than it is known to have been during the past century." These riverine conditions supported large fish species such as the longnose gar and shovelnose sturgeon, now extinct due presumably to the historic reduction in the river's flow (Gehlbach and Miller 1963: 7, 16–19). Historical flows were generally perennial, except for those periods of severe, extended drought. Flow levels were also seasonal, as they are today, with greatest flows in the late spring during peak runoff from snow melt, or in mid to late summer from rain runoff. Low runoffs usually occurred in June and October-November (Bullard and Wells 1992: 23–25). During high flows the river would sometimes shift from a higher channel to one of lower elevation on the valley floor, a process known as avulsion. Even during extended dry periods there probably was some flow, and relatively deep water holes in the streambed were maintained.

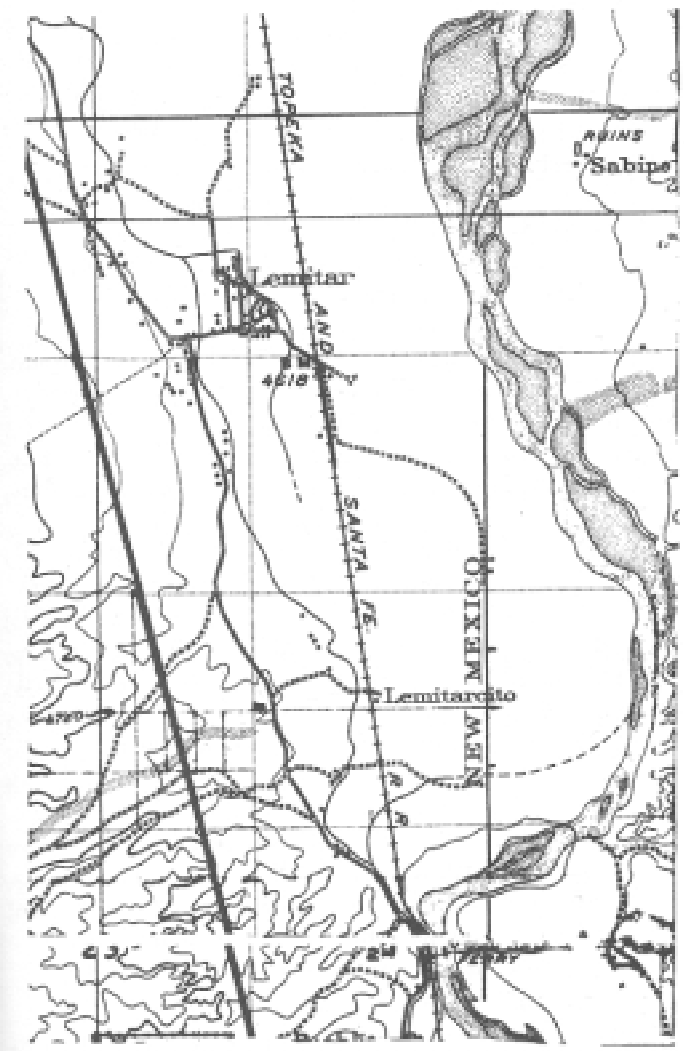

Figure 43—Meanders and multiple channels (braided) of the Rio Grande east and southeast of Lemitar, 1906. USGS 7.5-minute quadrangle map.

The Rio Grande above the mouth of the Jemez River was probably characterized by cooler water than that of the more recent past. The streambed was composed of mostly cobble and gravel. Below this confluence, the river was primarily a warmwater habitat characterized by shifting sand substrate. By the late 1800s this condition may have extended upstream, replacing the cooler water, as flows were depleted and sedimentation increased, resulting in a more shallow river (Crawford et al. 1993: 38).

A few early historical descriptions of the Middle Rio Grande follow:

> Alvarado, 1540:
>
> "This river of Nuestra Senora flows through a broad valley planted with fields of maize and dotted with cottonwood groves" (Bolton 1969: 184). He also described it as "a large and mighty river" (Hodge 1946: 352).
>
> Espejo, 1583 (near San Marcial):
>
> ". . . along the river banks there were many cottonwood groves and some patches of white poplars four leagues wide" (Hammond and Rey 1966: 219).
>
> Castano de Sosa, 1590:
>
> "A deep river" and "the river with much water" (Schroeder and Matson 1965: 129, 144).
>
> Obregon, late 1500s:
>
> ". . . swift and beautiful, surrounded by numerous meadows and farms . . ." (Hammond and Rey 1928: 291).
>
> Fray Benavides, 1630:
>
> "It has likewise many rivers in which fish are in great abundance; and great sloughs [esteros], and particularly the Rio del Norte" (Ayer 1965: 36–37).

Mention was made in the 1600s of an extensive stand of cottonwoods, which stretched from Alameda Pueblo to Albuquerque along the east side of the river (Adams and Chavez 1956: 145). Known as the Bosque Grande de San Francisco Xavier, it was a prominent feature in the valley until at least the early 1700s. South of this gallery forest were the open wetlands called the Esteros de Mejia. This mosaic of cienegas (marshes), charcos (ponds), and esteros (swamps) was located in the Albuquerque neighborhood of Barelas (Simmons 1982: 40). These riparian features were sustained by a high water table and periodic flooding of the Rio Grande.

Figure 44—Wetlands near Iselta Pueblo. Note cattail in foreground and cottonwood bosque in background. Photo by author.

Floods commonly caused shifts in the course of the river. The westward shift of various reaches of the Rio Grande from San Felipe to south of Belen in the early 1700s to about 1769 is relatively well documented. Before 1709 the Rio Grande flowed east of present Bernalillo, which was founded in the early 1800s. Earlier Bernalillo settlement sites were located to the north and on both banks of the river, at Angostura and Llanitos. As the channel shifted westward several hundred yards between 1709 and 1739, the church and several homes were washed away at colonial Bernalillo, then located on the west side of the Rio Grande. Another consequence of this avulsion was a subsequent boundary dispute between Santa Ana and San Felipe pueblos. By 1763 residents of upper Bernalillo had been forced to move upriver to higher land at Algodones (Adams and Chavez 1956: 152; Bayer et al. 1994: 90; Bowen and Sacca 1971: 51; Chavez 1957: 3; Sargeant 1987: 38–40; Snow 1976: 172–175).

In 1766, at the south end of the present Bosque del Apache National Wildlife Refuge, Royal Engineer Nicolas de Lafora found "plenty of pasture" in the valley, all the way north to San Acacia. He also noted "swampy ground with a great deal of coarse grass and reeds" (Kinnaird 1967: 88; Fig. 44). North of Tome, he continued to travel up the east side of the Rio Grande over "a plain extensively forested with poplar trees [cottonwood] along the river's edge" (Kinnaird 1967: 89–90).

The benefits of flood deposition of sediments rich in nutrients was long known to Pueblo and Hispano farmers. A Spaniard from the Rio Abajo commented "The water brings with it a thick mud which serves as manure for the land, leaving on top of the irrigated earth a glutinous scum resembling lard" (Simmons 1982: 96).

Fray Atanasio Dominguez, a fairly keen observer from the colonial period, recorded descriptions of the Rio Grande and various reaches in 1776. For the entire river reach in the region he wrote

> From the places where the headwaters on this river are to be seen, one observes a great abundance of water. As it declines toward the south it acquires more and more water from the many rivers (large and small) that keep joining it from the east and west from above Taos to below El Paso, where it joins still others (Adams and Chavez 1956: 7).

From Santo Domingo he wrote "The pueblo is located very near the Rio del Norte on a plain on the east bank.... It has a very fine view in all directions, made pleasant by the river and its woods and poplar groves" (Adams and Chavez 1956: 137).

And for the Albuquerque area he observed

> It stands on the same plain [as Santo Domingo] and so near to the Rio del Norte that the church and convent are about two musket shots from it. . . . The rest of what is now Albuquerque extends upstream to the north, and all of it is a settlement of ranchos on the meadows of the said river for the distance of a league. . . . Some of the lands are good, some better, some mediocre. They are watered by the said river through very wide, deep irrigation ditches. . . . (Adams and Chavez 1956: 144, 151).

And at Isleta he observed "The little rise on which the pueblo stands is as small as I said in the beginning, and it lies on the very meadow of the Rio del Norte, which sometimes overflows its bed up above the pueblo when it is very high and forms a very wide branch at a distance from it" (Adams and Chavez 1956: 207).

He also noted that the Rio Grande had shifted eastward from its channel, which had run close to Belen in 1769. Part of Tome's houses and agricultural fields were destroyed by this avulsion; some Belen residents subsequently planted cultigens in the abandoned river bed (Adams and Chavez 1956: 8).

In 1782 Fray Agustin de Morfi described the river:

> The Rio Grande del Norte crosses the kingdom from north to south, almost in a straight line. Its source is not yet known. . . . The river receives within and without the kingdom many others [tributary streams] which increase its flow. . . . From its sources [the Rio Grande] as far as the presidio of La Junta, its banks are shady . . . (Thomas 1932: 90).

Some observations were clearly made in drought years, such as 1803, when Governor Chacon wrote ". . . it does not carry much water upon crossing it as is believed" (Simmons 1985: 164). Zebulon Pike, who traveled downriver from Taos in March 1807, described the Rio Grande as a navigable stream above Santa Fe, but found its flow diminished below, which he "attributed to numerous canals and the dry sand soil through which the river courses, where much of the water which flows from the mountains must be absorbed and lost." Even so, he noted the river to be 3 to 4 feet deep and about 300 yards wide at the Santo Domingo Pueblo ford, and 3 feet deep and 400 yards wide at the Barelas crossing south of Albuquerque (Coues 1987, II: 615, 621, 729–730).

Don Pedro Bautista Pino described the river in 1812 as follows:

> This imposing Nile is, so to speak, the heart of the territory, for the richest settlements are located on its banks, which are truly picturesque. The variety of its luxuriant groves, the beautiful forests that embellish it, the diverse perspectives presented by its vegas which are cultivated by a multitude of laboring men . . . The thousands of birds that live there, as well as the many palatable fish that live in its waters. . . . The waters . . . are in themselves sparkling and clear, but the Puerco de Abiquiu river, which flows into it at Chama, muddies them (Carroll and Haggard 1942: 21).

The channel of the Rio Grande changed again in the early 1800s in the Bernalillo-Alameda area. A westward shift of the channel forced Hispanic residents north of the Kuaua ruins from their homes. In about 1814, some residents resettled on the new east bank of the river on the north edge of Sandia Pueblo land in the Los Cocinitas part of present Bernalillo (Bowen and Sacca 1971: 48–49, 60; Lange and Riley 1970: 176).

In the 1820s farmers in the Middle Rio Grande Valley began to notice that cienegas and esteros were forming on the floodplain, apparently due to the dumping of excess water from irrigation ditches (Wozniak 1987). This phenomenon may have contributed to the increasing waterlogging of the valley throughout the remainder of the century.

More detailed descriptions of the Rio Grande and its valley were recorded with the coming of more Anglo-Americans in the 1830s and 1840s. Santa Fe Trail trader Josiah Gregg (1966, v. I: 140–141) observed

> The Rio del Norte . . . decreases in volume of water as it descends. In fact, above the region of tide-water, it is almost everywhere fordable during most of the year, being seldom over knee-deep, except at the time of freshets. Its banks are generally very low, often less than ten feet above low-water mark; and yet, owing to the disproportionate width of the channel (which is generally three or four hundred yards), it is not subject to inundations. Its only important rises are those of the annual freshets, occasioned by the melting of the snow in the mountains.

His estimate on the width of the river is consistent with earlier observations but inconsistent with later ones. For example, A. Wislizenus (1969: 34–35) described the Rio Grande near Albuquerque in mid July 1846 as "about 100 yards wide, and as usual, sandy, shallow, everywhere fordable and nowhere navigable, not even for canoes." Had this not been a drought year with apparently no or little summer rain on the watershed, the river flow would have been greater and therefore wider and deeper. Wislizenus did find a pond about 6 miles south of Valencia on the east side of the river.

In late September Lt. William Emory crossed the river just south of Albuquerque, where "its width was about twenty-five yards, and its deepest part just up to the hubs of the wheels" (Calvin 1968: 79).

Between Lemitar and Socorro, a doctor with the U.S. Army described the Rio Grande as ". . . a rapid stream, about 120 or 200 feet wide, dividing off, so as to make many islands, the water is muddy and reddish, near the color of the Red River" (Ames 1943: 20). The same individual described the river valley south of Cochiti Pueblo: "In one place it looked a little like the Missouri Bottom, the river here is a rapid stream, about 120 or 200 feet wide, dividing off as to make many islands, the water is muddy and reddish, near the color of the Red River" (Ames 1943: 20).

In October 1846 Lt. J.W. Abert (1962: 66, 72, 127) noted that the river near San Felipe "runs with great rapidity, and is from three to four feet deep." At Valverde on November 24 he observed "The river here is full of sand bars" and "the water is very low." He also recorded several ponds along the road between Bernalillo and Albuquerque.

The late summer rains of 1849 were probably at or above seasonal normals, as the Rio Grande was "over six feet deep" at La Joyita (Hannum 1930: 223–224), and "probably three hundred yards wide, the stream rapid, its depth four feet" at the Barelas crossing (McNitt 1964: 153).

Four years later, on November 10, Lt. A.W. Whipple described the river at the Barelas Ford:

> The bed of the stream is about 500 yards wide, with a channel upon each side from three to four feet deep, and a temporary island of sand and clay in the centre, occupying about one third of the width. In one or two places there were quicksands sufficient to make the passage laborious. The current of the stream is rapid. . . . Our own

observations made the fall five feet per mile at this place (Foreman 1941: 119).

This "quicksand" was sometimes a problem for other wagon caravans crossing at the Barelas ford, then just south of Albuquerque in the mid 1800s (Hall 1960: 169; McNitt 1964: 153).

In the early 1850s, a U.S. Army surgeon noted that the river in the Socorro area varied from 200 to 600 yards wide, depending on runoff amounts from upstream. He also observed that a change in the stream's channel occurred every year (Hammond 1966: 24–25).

At Atrisco, on the west bank of the river near the Barelas Ford, and to the south in the La Mesilla area, the river shifted to the west in 1860 and 1867–68, respectively. At Atrisco the avulsion was temporary, as the Rio Grande moved back to its former channel after a few weeks (U.S. Surveyor General and U.S. Court of Private Land Claims 1894). At Mesilla, it moved from the west edge of the town to the east side, where it flows today (Bell 1965: 242; Cozzens 1988: 277).

The severity and frequency of major flooding along the Rio Grande began to increase in the 1870s due to the aggrading riverbed and more rapid runoff in the watershed caused primarily by intensive grazing and logging. (Wozniak 1987).

In 1873 a traveler crossing the river at Barelas found the river to be about 4 feet deep and 200 yards wide (Beadle 1973: 491). Later in the decade another traveler along the Rio Grande crossed the river at Isleta, finding it about 300 feet wide and 3 to 4 feet deep (Cozzens 1988: 274–275). Just to the south, the 1884 flood caused a westward shift in the river's channel in the Los Lunas-Los Lentes area (Crawford et al. 1993: 24).

The aggradation of the river bed continued to increase over the last quarter of the 19th century due to increased sedimentation and diversion of water for irrigation, especially in the San Luis Valley of southern Colorado. In the summer of 1879 the Rio Grande ceased flowing from Albuquerque to El Paso, as it did often in the 1880s (Clark 1987: 89; Miller 1879: 69). During this period, before construction of any major dams in or above the Middle Valley, an estimated 75 billion pounds of sediment was carried annually in irrigation systems and floodwaters (Simmons 1991b: 69, 77). The sediment load carried by streams in the basin continued to increase into the early 1900s (Sullivan 1924: 6–7).

In 1893 Indian agent Henry R. Poore (1894: 111) described the river near Sandia Pueblo as having several large islands, which rose about 6 feet above the level of the river and were covered by cottonwood groves. The uppermost island was estimated to be 700 acres.

In 1907, W.T. Lee (1907: 31) described the Rio Grande north of El Paso as "mainly a floodwater stream subject to great fluctuations in volume."

The first streamflow gauging station in New Mexico and the United States was established by the U.S. Geological Survey (USGS) on the Rio Grande near Embudo in January 1889. A number of others were established along the river and major tributaries from 1895 to 1941 (Table 45).

Santa Fe River

The Santa Fe River, which has its headwaters at Santa Fe Lake in the Sangre de Cristo Mountains some 5,000 feet above Santa Fe, has a valley long occupied by various human groups (Fig. 45). As a result, this riparian system has been impacted severely, and the river's ecosystem has been modified greatly. The stream flows through the core of historic Santa Fe, westwardly, through Agua Fria, which in the early colonial period was a settlement of Hispanics on the Camino Real and before that the site of Quemado Pueblo. Now, Agua Fria is a neighborhood of the capital city. From this old village site the river continues its westerly flow, through new, scattered homes and businesses, past the airport, and on to Cieneguilla, the site of the late prehistoric-early historic pueblo and historic Spanish settlement. Flowing at the base of a basaltic mesa, the river moves west past ruins of corrals and field walls, the early colonial settlement of Cienega, and on to east of Tetilla Peak, an important landmark on the "Royal Road." Near here the stream receives waters from Cienega Creek and begins to flow through a canyon on La Majada Mesa, which eventually deepens to some 300 feet. At the south edge of the mesa's escarpment, the river leaves the canyon. This disengorgement was first named Las Bocas by the early Chamuscado-Rodriguez expedition of 1582. The near-deserted, 18th century land grant village of La Bajada,

Table 45—Upper and Middle Rio Grande streamflow gauging stations.

Station	Establishment date
Red River (near Questa)	April 1910
Near Taos	December 1916
Embudo	January 1889
Rio Chama below El Vado Dam	1913
Rio Chama near Chamita	October 1912
Otowi Bridge	February 1895
Santa Fe River (near Santa Fe)	June 1910
San Felipe	October 1925
Jemez River (near Jemez Dam)	June 1936
Albuquerque	October 1941
Near Bernardo	June 1936
Rio Puerco	July 1951
Bluewater Creek (near Bluewater)	June 1927
Rio San Jose (at Grants)	October 1912
Rio Puerco (near Bernardo)	November 1939
San Acacia	April 1936
San Marcial	1936

Source: Cruz et al. 1993

named for the steep escarpment that extends about 9 miles east-west from just below the Waldo interchange to almost the Rio Grande, is found here, and across the river are the ruins of San Marcos Pueblo. The river now turns even more westerly over its narrow, bosqueless floodplain until it meets the Rio Grande across from Cochiti Pueblo. From this confluence to its headwaters at about 12,000 feet elevation in the mountains, the river flows about 37 smiles.

As indicated above, the Camino Real followed the Santa Fe River from later Santa Fe through the canyon to La Bajada. Prior to the opening of this important Spanish road, which would link colonial New Mexico with Mexican settlements, Pueblo Indians had long followed the river from local and distant villages to trade, hunt, or gather various resources prior to Spanish arrival. They continued to use this route into the early colonial period and to occupy the villages of Tze-nat-ay (San Marcos), Tzi-gu-ma (Cienega), near the confluence of the river with Cienega Creek, Cieneguilla, and Quemado (Patterson-Randolph 1990: 6).

The first European to reach the upper Santa Fe River may have been Castano de Sosa on January 8, 1591. He described the event: "It was bitterly cold and snowing. When we emerged from the sierra, we came to a river, frozen so hard that the horses crossed on the ice without breaking through" (Hammond and Rey 1966: 280).

Eight years later the first Spanish colonists settled at San Juan Pueblo on the east side of the Rio Grande near its confluence with the Chama River, about 30 miles northwest of Santa Fe. After a few months, they moved across the river to a second pueblo called Yunque. The seat of government for the New Mexico Province remained here until 1609, but abuse of and conflict with the Tewa Pueblos, as well as competition for limited and decreasing natural resources, forced the Spanish viceroy to order relocation of the capital to the Santa Fe River, some 23 miles to the southeast. Here, the town of Santa Fe was founded on the banks of the mountain stream, at the foot of the Sangre de Cristo Mountains (Horgan 1965: 5, 14, 16–18; Simmons 1991: 182).

With the new provincial capital established at the northern terminus of the Camino Real, the road along the Santa Fe River was traveled frequently by residents, traders, and government officials. For example, in July 1613 Fray Isidro Ordonez walked from Santo Domingo Pueblo to Santa Fe, a trip of 9 hours (Sanchez 1987: 81). The mission supply caravans traversed this route every 2 or 3 years from 1620 to 1679, stopping at the paraje of the Alamo hacienda or nearby Rancho Golondrinas. Mission churches had been established at Cieneguilla, Cienega, and San Marcos pueblos along the Santa Fe River by the 1620s (Patterson-Randolph 1990: 6; Schroeder 1979: 244–247).

By the early 1660s Cienega had also become a Spanish village, consisting of scattered estancias or haciendas, like Alamo (Hackett 1937: 261). Sheep, cattle, and horses from these establishments were grazed along the river as well as in nearby uplands, and the floodplain and terraces were farmed by irrigation. Within 2 decades, however, the entire Santa Fe valley was depopulated by the Spaniards when driven out by the Pueblo uprising of August 1680 (Sando 1989: 55).

In late 1692, when Governor and General Diego de Vargas marched up the Camino Real to the Cieneguilla Pueblo, its inhabitants fled to nearby mesas (Bailey 1940: 138). In the following year, following reconquest and reoccupation by the Spanish, Vargas issued a land grant for the Cieneguilla area. Cienega and Quemado were also reoccupied on the grant early in the next century (Westphall 1983: 20). At this time, according to descendants of the original grantees, the Santa Fe River ran "full," and cottonwood and willow grew along its banks (Munoz 1945: 73). A cienega east of the Palace of the Governors was a prime, spring-fed habitat for livestock grazing (Ebright 1994a: 90–91). The river's water was noted to be clear in 1726, and in this same year the Pino Ranch was founded at the mouth of Cienega Creek, a major tributary.

Eighteen years later, the river was described as having "crystalline waters and abundant trout" within the capital village (Hackett 1937: 27, 34, 399). Santa Fe had by this time evolved into a rancheria, or a scattering of houses and fields along the river valley (Simmons 1974: 61). By 1760, the river was generally dry during the summer due to diversion for irrigation. Continuing cold temperatures caused the river to freeze over in winter (Adams 1954: 47, 65, 105). Periodically, the river flooded, as in 1767, when property was damaged and destroyed in Santa Fe and the river channel shifted into the Rio Chiquito, now covered by Water Street (Twitchell 1963, I: 447). Subsequently, a stone embankment was built to prevent flood damage in the village (Adams and Chaves 1956: 40).

River flow continued to be insufficient for irrigation farming along the reach below Cienega, according to Fray Dominguez in 1776. The springs at this location did result in a flow to the Rio Grande confluence the rest of the year, and the farmlands around the old pueblo of Quemado (later Agua Fria) and Cieneguilla were "fertilized" by overbank flooding of the Santa Fe (Adams and Chavez 1956: 41, 43). In 1782 Father Morfi provided basically the same description and referred to "excellent" trout in the river (Thomas 1932: 92).

By the late 1700s the Upper Valley population had so severely impacted the surface water, grazing lands, and fuelwood sources that the governor recommended moving the capital to the confluence of the river and the Rio Grande, across from Cochiti Pueblo (MacCameron 1994: 35). The center of government was not moved, of course.

As the flow of the river diminished from use, and as woodlands and forests were cut, the river ecosystem continued to decline (Hewett and Dutton 1945: 147). Around Cienega, especially at Rancho de las Golondrinas, however, the springs continued to flow, and harvests were good into

Figure 45—Cattle grazing along the Santa Fe River, ca. 1915. Note willow (left center) and cottonwoods (left back). Photo courtesy Museum of New Mexico Photo Archives, Santa Fe (negative no. 135254).

the 19th century. The area was known throughout the province for its dependable productiveness in the early to mid 1800s (Baxter 1987: 74–75). In October 1846 Abert (1962: 65) described Cienega as "well settled" and "a well watered place . . . and the neighboring hills are full of springs."

Degradation of the water quality of the river due to refuse and dirty streets in Santa Fe apparently was a problem by 1833, as the City Council issued regulations forbidding the throwing of trash or dead animals into irrigation ditches and streams and mandating the cleaning of streets. The burning of rubbish piles was also prohibited (Simmons 1992: 224).

When the American army arrived in the late summer and fall of 1846, during an extended drought, various military units found little or no grass for their livestock or wood for fires. Fodder and fuelwood were purchased at Santa Fe or Agua Fria, as Quemado was now called (Abert 1962: 65; Denevan 1967: 701; Frazer 1983: 11; Sunseri 1979: 75). No water was found in the river below Cienega on October 19 (Cooke 1964: 92–93). Four years later, however, troops found "good grass and water" and "sufficient fuel" at Agua Fria (McNitt 1964: 7). In contrast, a group of Anglo immigrants found denuded grasslands in 1849 from Santa Fe to Galisteo and noted that the area had been cut by deep arroyos, some to a width of 12 feet (deBuys 1985: 216–217).

In the 1850s Santa Fe experienced critical water shortages (Clark 1987: 33). The available river water, nonetheless, was described as "excellent" for drinking. Trees "for miles around" had been cut for fuelwood and construction (U.S. Surgeon-General's Office 1856). A dam was constructed near the headwaters of the Santa Fe River in 1866, but the water supply was still not sufficient to meet the town's needs (Clark 1987: 33).

Another flood struck, this one on the lower reach of the river, on July 13, 1866. Two years later, on April 18–20, rainstorms over the watershed caused the river to flood, and a bridge was washed out. This event was followed by still another flood on September 7 (Lange and Riley

Figure 46—Jemez River sandy streambed and floodplain at Santa Ana Pueblo ca. 1920–30. Photo by Jessie L. Nusbaum, courtesy Museum of New Mexico Photo Archives, Santa Fe (negative no. 158158).

1966: 339; Lange, Riley and Lange 1975: 107, 144, 445). On August 19, 1872, the river peaked at more than 1,000 cfs (USGS 1994). Eight years later the flow again could not meet the demands of the residents of Santa Fe, and reservoirs were subsequently constructed and wells drilled. A piped-water system was also constructed from one of the reservoirs above town in 1881 (Simmons 1992: 206; Thomas et al. 1963: D–10).

By 1899 irrigation farming on the Cieneguilla grant ceased, perhaps due to overuse of surface water upstream and general degradation of the ecosystem (Pratt and Snow 1988, Chap. 4: 46). Upstream wetlands, such as the cienega in Santa Fe, had been desertified by this time. Only Cienega Street remains as physical evidence of this marsh (Ebright 1994: 99–101).

Periodic floods continued, such as the one of September 29 or 30, 1904, and that of 1919, which had the highest annual daily flow recorded from 1910 to 1993. A flood on September 23, 1929, was estimated to be above 1,500 cfs (USGS 1994). In more recent years, the flow of the Santa Fe River has continued to diminish. In 1960, the acequia madre at Cienega flowed at 650 gallons per minute; in 1993 it flowed at only 133 gpm.

Grazing of the watershed continues, as does the development of houses and businesses in the valley (Fig. 45). The once "excellent" trout populations have long since disappeared, as have most of the fertile soils. Some cienegas occur, however, on the Ranchos Golondrinas property. Above Cienega, cottonwoods no longer occur along the river; some Russian olive is growing on the floodplain and appears to be spreading.

Jemez River

In February 1583 Espejo described the Jemez River near Zia Pueblo as "a fine river with a good volume of water" (Hammond and Rey 1966: 180). This general description suggests that the river was clearer and carried more volume than in the recent historic period. The Jemez, as other tributary streams, flooded periodically. These bank overflows damaged or destroyed Santa Ana Pueblo fields, which by the early 1700s, or perhaps even earlier, forced the residents to find better fields at its confluence with the Rio Grande (Kessell 1980: 168).

At Zia Pueblo in 1776 Fray Dominguez noted that the Jemez water was alkaline and, combined with sandy field soil, was at times unproductive. He also observed that the Jemez River at Jemez Pueblo was less alkaline and the fields more productive (Adams and Chavez 1956: 175, 181). At Santa Ana he wrote that the river flow was too erratic to reliably produce crops each year (Adams and Chavez 1956: 170).

Much later, in October 1846, Lt. J.W. Abert (1962: 71) described the Jemez River valley below Santa Ana as ". . . very sandy; the bed of the stream three-quarters of a mile in width, contains, in many places, no water . . ." (Fig. 46).

In 1893 the river was divided into two channels above the Santa Ana Pueblo. These channels undoubtedly changed with floods. There was a major flood in 1890, and another slightly less severe flood, about 15,000 cfs, swept along the lower Jemez in 1900 (USGS 1994). The most severe flood of this century occurred May 6–15, 1941; 2 years later the Jemez daily mean flow on May 24 was zero. That was the lowest level reached since flow measurements were begun in 1936 (USGS 1994). The highest mean daily flow since that time, some 3,640 cfs, occurred on the lower reach of the river in 1958 (USGS 1994).

Las Huertas Creek

Las Huertas Creek originates at about 8,600 feet on the north side of the Sandia Mountains below Capulin Peak in the Cibola National Forest (Fig. 41). Several springs occur at this location, and many of them are situated on the Cooper-Ellis Ranch, a privately owned, late 19th-century homestead about 5 miles south of Placitas. The creek flows down a canyon along the north slope of the Sandias following a south-trending fault zone between the uplifted Montezuma Mountain block and the main Sandia block (Kelley and Northrop 1975: 90–91). The canyon has been formed by downcutting of the stream and is long and narrow with cliffs of Pennsylvanian Madera limestone. At about 6,000 feet, just outside the boundary of the national forest, the creek turns to the west past Ojo de la Casa, and the late Spanish Colonial site of San Jose 1768–1821, about a mile north of Placitas. Here the creek opens into a relatively wide valley bordered by hills and ridges covered with pinyon-juniper woodland, which becomes increasingly sparse at lower elevations downstream. The width of the valley floor varies from about 300 to 750 feet. Elevation in the valley ranges from 6,100 feet at Ojo de la Casa to 5,680 feet at San Jose to 5,480 feet at the south end of the study area (US Geological Survey 1954).

The valley fill is composed of alluvial fan material, which at some locations, such as San Jose, is made up of gently sloping (0–3 percent), silty clay loam soil derived from shale and sandstone, known as Haverson Loam. The adjacent terraced uplands consist of gravelly Ildefonso Sandy Loam on 10 to 35 percent slopes or Harvey Loam on 10 to 15 percent slopes (Soil Conservation Service n.d.). Chert nodules found eco-cultural contexts in the valley probably came from the Madera formation; Pedernal chalcedony and other cherts were brought from quarries in the Jemez Mountains (Hibben 1941: 28–30; Kelley and Northrop 1975: 97–98). Obsidian for some artifacts noted on the surface may have been obtained in the same range.

Several major springs are located in the drainage, and all were used historically for domestic and agricultural purposes (Delara and Delara 1983; Scurlock 1995b: 4–5). These springs are Rosa Castilla, San Francisco, Oso Negro, and Ojo de Casa. Not surprisingly, flows of these springs and Las Huertas Creek were reportedly greater in the past than at present (Delara and Delara 1983; Montoya 1983); trout were found in the deeper pools of Las Huertas Creek as late as the 1930s (Hibben 1941: 8; Jim Iknayan 1983, personal communication).

Five major plant communities were present during the historical period—mixed conifer, above 7,800 feet; pinyon-juniper, above 6,200 feet; a savannah pinyon-juniper woodland on the valley terraces, upper slopes, and ridge and mesa tops, above 5,800 feet; and a riparian or mesophytic plant community along Las Huertas Creek and around the springs (Naylor 1964: 95–95). Valley or narrow-leaf cottonwood and willow species were the major floral constituents. Below 6,000 feet were Great Basin grasslands, now a juniper-bunch grass savanna, down to about 5,500 feet (Fig. 47). Below this and extending across the bajada to the Rio Grande floodplain, the zone has been modified to a grassland-shrubland. Both of these communities have been altered by human activity such as overgrazing, farming, house construction, and the introduction of exotic species. The dominant plants of the terraces and mesas/ridges today include blue grama, ring muhly, galleta, three awn, sand dropseed, rabbitbush, broom snakeweed, pinyon, and juniper. During the historical period, dominant plants included black grama, sideoats grama, blue grama, New Mexico feathergrass, galleta, western wheatgrass, alkali sacaton, Indian ricegrass, Apache plume, winterfat, and sparsely scattered one-seed juniper and pinyon (Soil Conservation Service n.d.).

The dominant plants in the riparian community below 6,000 feet today include watercress, spearmint, willow, valley cottonwood, salt cedar (or tamarisk), and, along the margins, Apache plume. Watercress and spearmint were introduced by the Spanish in the early historic period; salt cedar was introduced by Anglos in the early 20th century (Campbell and Dick-Peddie 1964: 499; Scurlock 1983a: 7–8).

The fauna found in the valley and the adjacent bajada and Sandia Mountains also has changed during the last 400 years, primarily as a result of human activity. A number of large mammals hunted by the various eco-cultural groups of the area before 1900 have been decimated or extirpated, including the Merriam elk, pronghorn antelope, gray wolf, bighorn sheep, grizzly bear, and mountain lion (Bailey 1931: 22, 40, 310–312, 326, 362–363). Smaller mammals such as the coyote, rock squirrel, red squirrel, jackrabbit, desert cottontail, gray fox, badger, rock squirrel, and porcupine can still be found in varying numbers (Clothier 1957).

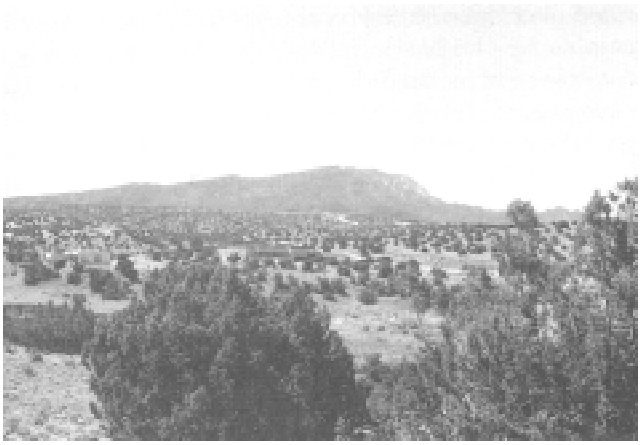

Figure 47—Juniper savanna on ridges above Las Huertas Creek. Sandia Mountains (center back). Photo by author.

More than 100 species of birds have been recorded in the Las Huertas canyon and valley and in the Placitas area (Scurlock 1995b). Two of these, the bald eagle and peregrine falcon, are considered endangered by the U.S. Fish and Wildlife and the New Mexico Game and Fish Commission. There remains some habitat for the rare and endangered willow flycatcher. Species that were important for their meat or feathers in the historic period include various ducks and geese, sandhill crane, wild turkey, blue grouse, scaled quail, mourning dove, band-tailed pigeon, golden eagle, red-tailed hawk, common raven, great-horned owl, and red-shafted flicker (Smith 1973: 96; Tyler 1979: 8, 52–53, 253).

Two invertebrates, the Sandia hairstreak butterfly and the blue silverspot butterfly, have been considered for inclusion on the federal list of endangered species.

In the century preceding Spanish arrival in northern New Mexico in 1540, there were a number of relatively large Pueblo villages along drainages east of Sandia and San Felipe pueblos. Some of the archeological manifestations of these include San Antonio, Paako, San Marcos, and Tonque. Tonque Pueblo, a pottery-making center located about 7 miles northeast of Placitas, supplied most of the glazewares that are found on sites in the area dating to these periods. Some of the lead used for the glaze decorations may have come from Sierra de la Mina, near Tecolote, about a mile northeast of Placitas. Along the entire "spring belt" of Tonque Arroyo, on which this village was located, are numerous "one- or two-room glaze sites situated on narrow stream terraces." These probable field house sites indicate that the people of Tonque were farming some distance from the main pueblo (Warren 1972: 36–38, 41).

Located on opposite sides of Las Huertas Creek in the center of the study area was a 15–20 room pueblo site dating to A.D. 1350–1450 on the south side, and a protohistoric pueblo on the north side, which later became the site of the land grant village of San Jose de las Huertas. Also present along these streams and large arroyos are numerous "field houses" dating to the late prehistoric and early historic periods (Scurlock 1995b).

The Pueblo population probably peaked in the valley between A.D. 1400 and 1650. During this 250-year period much of the canyon and valley floors was probably in cultivation, with the Pueblos living seasonally in small pueblos or one- or two-room field houses situated along both sides of the valley and located on geological terraces or benches. Runoff waters down tributary arroyos were directed onto agricultural fields, as probably were the floodwaters of the Las Huertas Creek during the spring snow melt upstream in the Sandias and following summer thunderstorms. Irrigation ditches may have been utilized in controlling some of this water, but certainly not to the extent nor with the sophistication that the Spanish later employed. Ditch irrigation was noted at the mouth of Las Huertas Creek by an early Spanish expedition of the late 16th century (Wozniak 1987).

This seasonal activity pattern among area pueblos continued into the recent past and was documented a little more than a century ago by anthropologist Adolph Bandelier. An informant at Santo Domingo related to him that almost all of the villagers were gone from the pueblos from April to September or October to work in the outlying farms or ranchos (Lange and Riley 1966: 265). Based on the relatively large number of Pueblo field house sites dating to this period, this land use pattern seems to have been the dominant one in the Las Huertas valley at the time of Spanish contact.

The first Spaniards probably visited the valley in the late 16th century, and within a few decades after Hispanic colonization, a few miners were working deposits of lead, copper, and silver in the northern portion of the Sierra de Sandia and living in the Tecolote area. Probably during this period the valley was named Las Huertas, or the gardens, by these early Spaniards. Rancho de Las Huertas was probably established in the area during the mid 17th century (Scurlock 1983a: 12–13).

Following their expulsion by the Pueblo Revolt, reconquest, and resettlement of the Middle Rio Grande Valley, some Hispanos returned to Las Huertas valley to raise livestock, mine, and perhaps trade with resident Pueblos. There is a 1714 reference (Chavez 1957: 4) to a watering hole (aguaje) known as Naranjo close to the north end of the Sandias. This landmark was probably along Las Huertas Creek because in the same document there is a reference to the minas paraje de las Guertas (Huertas) found within the vicinity of the aguaje (Chavez 1957). In 1765 nine Spanish families petitioned the governor to grant them land in the valley; 2 years later the San Antonio de las Huertas land grant was granted and settled. The village founded by the grantees, San Jose de las Huertas, prospered until intense Apache raids, and perhaps drought, forced the settlers to retreat to more protected and well-watered settlements along the Rio Grande in 1823–26 (Scurlock 1983: 13–15).

The settlers soon constructed an irrigation system utilizing the waters of Las Huertas Creek, the nearby Ojo Rosa Castilla, and runoff from tributary arroyos (Fig. 48). Fruit trees and grapevines were planted, and corn, wheat, beans, squash, onions, and chile were cultivated. Cotton and punche, a local variety of tobacco, also were grown (Smith 1973: 90).

Livestock raising, primarily goats and sheep, was also a major subsistence activity. In summer, villagers herded their flocks on common grant lands or up Las Huertas canyon to meadows along the north slope of the Sandias. Winter grazing lands were located on lower areas of the grant or on nearby mesas between the grant and the river. The hunting of deer, bear, and small mammals and the gathering of wild edible plants supplemented the food produced by farming and ranching (Smith 1973: 90–95).

Trade was conducted with area Pueblos and, at times of peace, with the Faraon Apaches and Comanche. Spanish livestock and grain were exchanged for Pueblo pottery and woven items. Residents of San Felipe Pueblo brought pottery to later Placitas to trade as recently as the early 1900s (Delara and Delara 1983). The same items and punche were traded to the Apache and Comanche for hides, dried buffalo meat, and sometimes captives, who were adopted as household servants (Jones 1979: 143).

San Jose's isolation and nearness to the Faraon Apaches, who lived in the Sandia Mountains, did not preclude more families from coming to the village. By the first decade of the early 19th century the population had risen to 284 (Olmstead 1981: 144–147).

In 1810 the Faraon Apaches stepped up their raiding in the Rio Abajo, including the village of San Jose. Raids continued over the next few years, not only by the Apaches but also by the Navajos. As a result, the Alcalde of Alameda received an order to increase the mining of lead in Las Huertas for the production of musket shot "to castigate the enemies of the state" (Spanish Archives of New Mexico 1818). Nevertheless, the raiding continued, and in 1823 the governor ordered the residents of San Jose to abandon their village and to move to more protected settlements along the Rio Grande. Within a short time, most of the settlers had moved to the east bank of the river and established the settlement of Los Algodones, just south of San Felipe Pueblo (Smith 1973: 49–50). Others moved to Albuquerque, Cienega, or Socorro. A few families remained in the village, but they too left by 1826 (Smith 1973: 50–51). One informant (Montoya 1983) cited drought conditions as the reason for abandonment, while to others "there was not enough room to plant" (Delara and Delara 1983). The drought of 1815–21 and the onset of long, cold winters were probably causal factors of Apache and Navajo raiding.

Figure 48—Abandoned acequia madre (center) at Spanish colonial site of San Jose de las Huertas. Photo by author.

Within 15 years, some original and some new land grant settlers had returned to the valley, but instead of concentrating at the site of San Jose, which probably had fallen into ruin by this time, they dispersed over the land grant to establish ranchos and new plazas. Also, perhaps, the valley had been overfarmed and overgrazed to the point that relatively large numbers of individuals could no longer subsist at San Jose. However, a few families, some descended from original land grantees, continued to farm and raise livestock on a small scale in the Las Huertas valley using the colonial period irrigation system and a new ditch system that was constructed on the south side of the creek in the late 1840s. By the mid 19th century a new central village, the Plaza of San Antonio, or Las Placitas, was founded (Scurlock 1983: 15–17).

Following U.S. occupation and acquisition of New Mexico as a territory in 1846 and establishment of the Surveyor-General's Office in Santa Fe in 1854, villagers of the San Antonio de las Huertas land grant petitioned for confirmation of their title. They were denied because of confusion over the exact location of the east boundary. In 1881 the land grant heirs petitioned the Surveyor-General again, but they were refused for the same reason. In 1891 the Surveyor-General's office had been replaced with the Court of Private Land Claims to litigate the outstanding land grant claims. With Thomas Benton Catron as their attorney, the heirs' claim was heard by the court in 1897. Of the 130,000 acres claimed, the Court of Private Land Claims confirmed only 4,763 acres. As payment for his services, Catron received the east one-quarter, or 1,191 acres, of the grant (Montoya 1983; Smith 1976: 40–41).

Traditional irrigation farming and livestock raising continued throughout the first half of this century, although some of the homesteads in the valley were abandoned, perhaps due in part to the dry conditions of the 1940s–

50s. In the 1960s and 1970s the hippie commune of Tawapa, one of the largest in New Mexico, was concentrated along Las Huertas Creek from just south and east of San Jose to near Ojo Rosa Castilla. In more recent years, the area has experienced a housing boom, which has further degraded environmental conditions.

Rio Puerco-of-the-East

The Rio Puerco is a 170-mile-long tributary (the longest) of the Rio Grande with a drainage area of 6,220 square miles in the Middle Basin (Snead and Reynolds 1986: 57; Fig. 42). This river is the best documented of all of the tributaries in terms of associated land use and resultant environmental impact and change. It has been called the "abused basin" in recent decades, and as such, the environmental conditions of the drainage are still being studied by the U.S. Forest Service, the Bureau of Land Management, and the state's Environmental Improvement Division, to name just three concerned public agencies (Dortignac 1963; Harper et al. 1943).

The earliest historical description of the Puerco drainage is that of Juan de Onate in late October 1599. When he crossed the stream near Cabezon Peak on that date, Onate noted that the water was deep and had many cottonwoods along its banks. He called the stream "La Torriente de los Alamos" (a rapid stream with cottonwoods) and observed that the valley was "lush, rich, and fertile" (Lopez 1980: 71, 77).

Almost 100 years later, in 1692, General and Governor Vargas crossed the Rio Puerco west of the later site of Albuquerque, noting that the water was so deep that the soldiers had to carry provisions and equipment on their shoulders (Lopez 1980: 76; Twitchell 1963, I: 381). The Rio Puerco valley at this time was rich in grasses, bosques, springs, and charcos, small lakes or ponds. The floodplain was periodically inundated by overbank flows from the shallow stream channel (Lopez 1980: 71). Subsequent governors granted community and grazing grants within the drainage in the 1740s–60s. Also, the Navajo, with their many sheep, had moved into the area in the early part of this period (Bailey 1980: 98–99, 113; Lopez 1980: 72; Simmons 1982: 106–107; Wozniak 1987). In 1766 a Spanish traveler at the mouth of the stream noted that its waters were always "muddy and turgid" (Kinnaird 1967: 89). Intensive grazing by both groups and droughts resulted in topsoil erosion in the basin and the beginning of entrenchment of the Puerco during this period (Bailey 1980: 89–90; Love and Young 1983).

In 1774 a Spanish priest reported that poor crop harvests in the valley due to drought and related Navajo raids forced Hispanic settlers to abandon the upper and middle Rio Puerco. He wrote this about the river in 1776: "Its water is as dirty as the gutters of the streets, since its bed is of black clay and its bottom very treacherous with mire" (Adams and Chavez 1956: 254).

Spaniards, including the Montoyas, moved back to a grazing grant near Cabezon Peak on the Puerco in 1818, but fled when Navajos again stepped up their raiding on livestock in 1821. A member of the family returned in 1827 or 1828, but he and his family were forced to leave 6 or 7 years later (Rittenhouse 1965: 19).

Apparently recovered somewhat because of the Spanish hiatus, the environment of the upper Puerco valley was a "grassy wilderness" with "swampy vegas," "clear water," and "willow-lined banks" in the 1830s and 1840s (Maes and Fisher 1937: 10; Quaife 1967: 133). Seasonal dry periods and larger droughts caused the river to dry up over its lower reach part of each year, as it does now. In mid October 1846, west of Atrisco, Lt. Abert (1962: 74–78) described the valley as "wide, flat, overgrown with varieties of artemisias and coarse grass" and the river banks as "10 or 12 feet high" and "a few cottonwood trees" in the river bed, which was dry. To the north, near the abandoned town of Poblazon, the banks were 30 feet high. A short time later, 2 to 3 miles below the mouth of the Rio San Jose, Abert (1962: 92–93) noted that the Puerco's water was thick with mud.

North of Cabezon Peak in 1849, Lt. J.H. Simpson (McNitt 1964: 29) commented on the thin fringe of cottonwood along the Puerco and "water only here and there, in pools—the fluid being a greenish, sickening color, and brackish to the taste." He estimated the height of the river bank to be 20 to 30 feet and the width of the river at about 100 feet. Another member of Simpson's expedition wrote "The Puerco was a miserably dirty and little stream of brackish water lined with high cut soil banks and cottonwoods" (McNitt 1964: 29).

In 1853 the Puerco near present Interstate 40 was described at 100 feet wide and its streambed 18 feet deep with scattered pools of water (Foreman 1941: 119; Rittenhouse 1965: 27–28). About this same time, the channel at La Ventana was about 8 feet deep and in the lower reach of the river about 20 feet (Bryan 1928: 276; Dortignac 1962: 588).

A few years later, to the north, in the Cabezon-Casa Salazar area, the upper Puerco valley had marshy meadows (Maes and Fisher 1937: 1–4). This condition may have resulted from "rest from grazing" and "wet years" in the 1850s. By 1862, with the threat of Navajo raids almost nil, Hispanics and Anglos began to graze the upper Puerco intensively (Maes and Fisher 1937: 10–15). Irrigation facilities—dams, ditches, and headgates—were constructed in the valley. Water was easy to divert and relatively abundant because of the shallow channel and vegetation, which mitigated damaging floods (Maes and Fisher 1937: 12; Tuan 1966: 588–589).

In the Cabezon area, in the 1870s, the Rio Puerco channel was shallow, with a wagon road crossing marked by large logs laid in the stream bed. There were "large groves of cottonwood trees, high grass, and weeds." The channel at La Ventana was about 8 feet deep (Dortignac 1963: 507). By 1877 there were "high banks marked by recent cave-ins and falling trees" (Bryan 1928a: 268, 273). At the end of the decade there were some 10,000 acres under cultivation in the upper river drainage, and cut, native hay was being sold in Cabezon (deBuys 1985: 217; Rittenhouse 1965: 64). A major flood, which undoubtedly eroded banks and downcut the river channel more, occurred in the area in 1880 (USGS 1994). The farming and ranching communities of Cabezon, San Luis, Guadalupe, and Casa Salazar had a combined population of over 700 residents at this time (Garcia 1992: 5).

During this decade the number of sheep in the area increased to over 100,000, and there were about 9,000 cattle (Scurlock 1990a: 18; Fig. 49). Many of these animals were owned by ricos Jose L. Perea of Bernalillo and Mariano Otero of Las Vegas. By the turn of the century sheep numbers had increased to several hundred thousand head. Harvests of corn and other irrigated crops were good during this period, probably due to moister conditions from above-normal precipitation (Maes and Fisher 1937: 11–12, 14). By the turn of the century there were some 10,000 acres under irrigation in the upper Rio Puerco valley (deBuys 1985: 217).

Accelerating entrenchment of the Rio Puerco was underway, and irrigation farming became more difficult as the water level of the river dropped in the 1880s (Bryan 1928: 274, 279). Various facilities of an extensive irrigation project were constructed by the Rio Puerco Irrigation Company in the early 1890s, which were destroyed by flash floods (Bryan 1928a: 274; Dortignac 1962). Three Hispanic villages in the middle and lower reaches of the basin were abandoned between 1887 and 1894 (Bryan 1928a: 276–277).

In spite of the increasing number of livestock on the basin's rangelands, "good" bunch grass cover was present in the 1890s, probably due to two wet years during the decade (Bryan 1928; Dortignac 1963: 508). Intensive grazing continued into the early decades of the next century; in 1937 there were relatively large numbers of livestock on 75,284 acres of public lands in the Upper Basin. Droughts and intensive floods contributed to severe erosion during this period (Calkins 1937: 6; Maes and Fisher 1937: 15–19, 34; Fig. 50). Continued entrenchment of the river became a problem for irrigation farmers in the Cabezon area (Bryan 1928a: 274). Irrigated lands in the same area dropped to 3,000 acres, a decrease of 70 percent in less than 3 decades (Harper et al. 1943: 52). Some farmers may have shifted their operations to the Puerco valley above Cuba, where there were 5,500 acres under irrigation in 1939 (Dortignac 1960: 48).

A surveyor referred to a "new channel" for the river at Cabezon in 1899; it was 198 feet wide. Seven years later the channel at the same location had widened to 244 feet, with a depth of 20 feet. At nearby San Luis the depth of the Puerco channel was the same (Bryan 1928a: 271–273; Tuan 1966: 589; Fig. 49). To the north, at La Ventana, the river channel was 15 feet deep in 1913 (Dortignac 1962: 588).

As the river dropped farther below its floodplain, water for irrigation farming became increasingly difficult to obtain. Only about 3,000 acres were in cultivation in the valley from Cuba to Casa Salazar in 1925 (deBuys 1985: 217: Harper et al. 1943: 52). Two years later the depth of the Puerco channel was 22 feet at San Luis and about 40

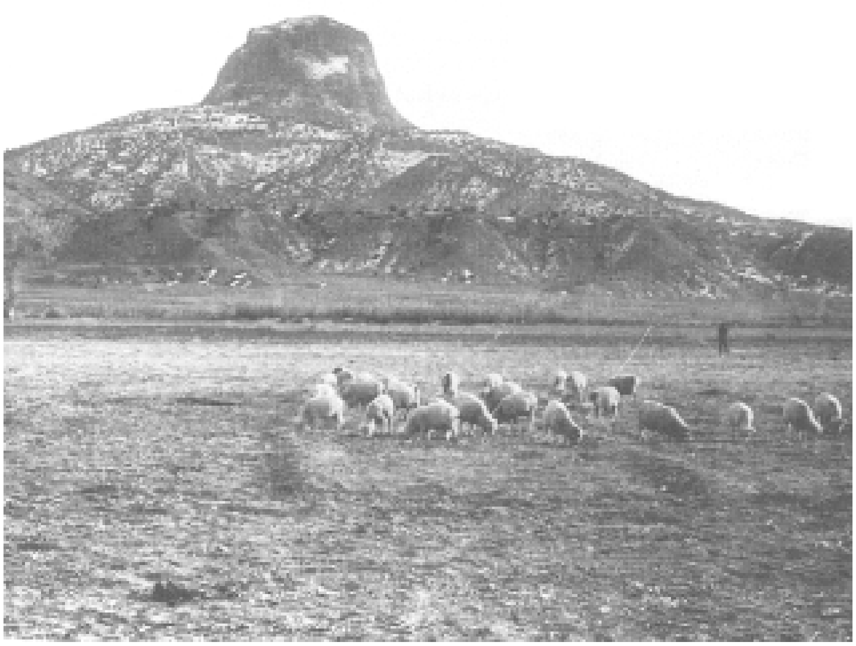

Figure 49—Sheep grazing near Rio Puerco (center) and Cabezon Peak (back), 1880s. Note denuded soil (foreground). Photo by Henry Schmidt, courtesy Center for Southwest Research, University of New Mexico.

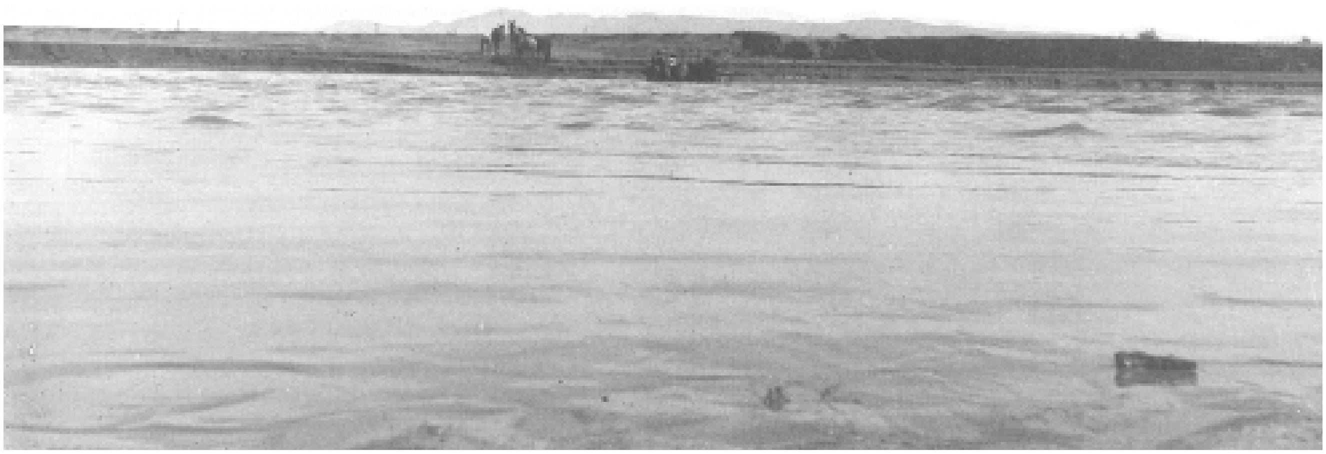

Figure 50—The Rio Puerco in flood near San Luis (?), 1905. Photo by R. H. Chapman, courtesy U.S. Geological Survey Photo Archives, Denver.

feet at La Ventana (Bryan 1928: 275; Dortignac 1962: 588; Tuan 1966: 589). To the south, below the Santa Fe Railroad tracks, the channel was also about 40 feet deep that year (Tuan 1966: 593). The following year, 1928, the channel depth at Cabezon had increased to 40 feet (Bryan 1928a: 274).

A major flood occurred on the Rio Puerco, contributing to the ongoing downcutting, at least in the upper and middle reaches of the river (Tuan 1966: 593; USGS 1994). Alluviation occurred on the lower Puerco, sometime between 1930 and 1940, and the river channel was raised about 14 feet (Tuan 1966: 593). The volume of the Puerco channel was 267,000 acre-feet (Dortignac 1960: 47).

Continued, intensive grazing and resulting erosion contributed to this process. In 1936–37 there were 14,500 cattle-units on the 150,715 acres of Upper Valley rangelands; the grazing capacity was estimated to be only 4,300 units. These lands included 56,240 acres of public domain, 19,044 acres of Forest Service land, and 75,431 acres of private land (Calkins 1937: 6; Maes and Fisher 1937: 34).

In an attempt to control grazing, the U.S. Forest Service began to fence its lands in the valley, as well as on Mesa Prieta and the Mount Taylor area in 1940 (Garcia 1992: 23). The newly created Grazing Service began reducing the numbers of livestock grazing on public lands in the basin through the issuance of permits (Forrest 1989: 159).

Residents of San Luis, Cabezon, Guadalupe, and Casa Salazar continued to leave as environmental conditions worsened in the late 1930s-early 1940s. Floods in 1941 and 1943 helped spur this exodus, as did the drought years of 1944–48. The most severe drought of this century followed in 1951–56 (Tuan et al. 1973: 58, 143–145; USGS 1994). By the 1960s the population had decreased to its lowest level over the past century.

Entrenchment continued in the 1950s and early 1960s in the Upper Valley (Tuan 1966: 589). The channel was about 55 feet deep at La Ventana in 1962 and 36 feet at San Luis, 43 feet at Poblazon, and 36 feet at San Ignacio in 1964 (Dortignac 1960: 47, 1962: 588; Tuan 1966: 589).

A summary of chronological change for the Puerco is given in Table 46. Impacts and changes are addressed in Chapter 5.

Table 46—Rio Puerco-of-the-East: historical conditions and environmental changes, 1599–1964.

Date	Descriptions of vegetation/water	Channel depth	Channel width	Source
1599	"Many cottonwoods"			Lopez 1980: 71
1700s mid	"Belly-high grasses, vast bosques, and wooded thickets"			Lopez 1980: 71
1760s		Lower R.P. began entrenchment		Love and Young 1983:
1845	"Grassy wilderness, swampy vegas, willow-lined banks"			Maes and Fisher 1937: 10
1846	"Few cottonwood trees"; "Overgrown with varieties of artemisias and coarse grass"; "Little pools of water"	10–12 feet (lower)		Abert 1962: 74
1846	"Thick with mud"	30 feet (Poblazon)		Abert 1962: 77, 92–93; Tuan 1966: 589
1849	"Slightly fringed with cottonwoods"	20–30 feet (near San Luis)	100 feet	McNitt 1964: 29
1850s (early)		8 feet (La Ventana)		Dortignac 1962: 588
1853		18 feet (Interstate 40 W)		Rittenhouse 1965: 27–28
1855		20 feet (lower river)		Bryan 1928a: 276
1860	"Marshy meadows"			Maes and Fisher 1937: 1–4
1860s		"Shallow" (Cabezon)		Maes and Fisher 1937: 12
1874		8 feet (La Ventana)		Dortignac 1963: 507
1875		"Shallow" (San Luis)		Tuan 1966: 588–589
1876–1880		"Shallow" (Cabezon)		Bryan 1928: 273
1877		"High banks" (San Luis)	26.4–29.2 feet	Bryan 1928a: 268, 275
1870s	"Large groves of cottonwood trees, high grass, and weeds"	"Shallow" (Cabezon)		Bryan 1928a: 273
1880 ca.	"Hand-cut hay"	8 feet (Cabezon)		Bryan 1928a: 274
1881		"Deepening" (lower)		Bryan 1928a: 277
1887		3 feet (Guadalupe)	30 feet	Bryan 1928a: 274– 275
1890		"Deepening" (Cabezon)		Bryan 1928a: 274
1895	"Native hay cut"			Bryan 1928a: 278
1899		198 feet (Cabezon)		Bryan 1928a: 271– 273
1900	"A good cover of bunch grasses"			Dortignac 1963: 508
1906		20 feet (San Luis and Cabezon)	244.4 feet (Cabezon); 405.9 feet (near Guadalupe)	Bryan 1928a: 271–274

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Table 46—Rio Puerco-of-the-East: historical conditions and environmental changes, 1599–1964 (continued).

Date	Descriptions of vegetation/water	Channel depth	Channel width	Source
1913		15 feet (La Ventana)		Dortignac 1962: 588
1927		40–41 feet (La Ventana)		Bryan 1928a: 275
1927		22 feet (San Luis)		Tuan 1966: 589
1927		40 feet (lower)		Tuan 1966: 593
1928		40–41 feet (Cabezon)		Bryan 1928a: 274
1940		26 feet (lower)		Tuan 1966: 593
1959		50 feet (La Ventana)		Dortignac 1960: 47
1964		55 feet (La Ventana)		Dortignac 1962: 588
1964		36 feet (San Luis)		Tuan 1966: 589
1964		30 feet (Poblazon)		Tuan 1966: 589
1964		36 feet (San Ignacio, lower)		Tuan 1966: 589

Rio Salado

The Rio Salado rises on the north side of the Datil Mountains and flows south-south eastward, between the Ladron Mountains and the Bear Mountains. This stream empties into the Rio Grande near San Acacia.

Lorenzo Padilla, the first settler who came to Santa Rita on the river in 1880, said the channel was "inconsiderable, and the broad flat of the valley seemed a propitious place for farming." The area was surveyed into townships by Daniel Currey in 1882. About 100 inhabitants resided in Santa Rita at this time. The width of the stream bed varied from about 12 to 49 feet at one location. An intense rain and a flood in 1883 washed out the road and formed a new stream channel. A 1918 survey by Paul B. Moore of Magdalena at the same place reflects a radically different river than that recorded by Currey in 1882; the width of the Rio Salado ranged from 330 to 550 feet (Bryan 1927; Table 47). Since 1918 the channel has continued to widen, and most of the agricultural land in the valley has been destroyed.

Table 47—Changes in width of Rio Salado, 1882 and 1918.

Location (sections in T2N, R4W)	Width (feet) 1882	1918
Sections 23 and 24	13.20	525.00
Sections 14 and 23	18.48	330.10
Sections 14 and 15	11.88	441.30
Sections 15 and 16	48.84	550.00

FIRE

The Southwest is an excellent region to study fire patterns and statistics in montane woodlands and forests, owing to long and well-preserved tree-ring records. Forest lands have evolved since the last ice age with the influence of relatively frequent, episodic fires that were generally of low intensity. Fire frequency is correlated with the occurrence of fuel sufficient to effectively spread the fire over the landscape. This frequency, for pre–1900 fires, varies from 2 to every 10 years for ponderosa and mixed-conifer forests. Fires in the higher spruce-fir and lower pinyon-juniper occurred between 50 and 300 years and were of high intensity. These conflagrations generally killed most of the overstory trees, leaving some patches of live trees, with regeneration of conifers or aspen in the burned areas. Forest fires in this zone were generally large—5,000 to 50,000 acres (Baisan 1994: 1). Many of these large fires burned for months at a time, some beginning as early as April and persisting into August (Swetnam 1990: 9).

Fire history for the Southwest, regionally and in specific locales, has been examined by Ahlstrand (1979, 1980), Bahre (1991), Dieterich and Hibbert (1990), Humphrey (1974), Komarek (1969), Robinson (1990), Swetnam (1990), Swetnam and Baisan (1995), and Young and Evans (1980).

Climatic patterns of wet-drought cycles also affected the frequency and extent of forest fires in the region. Generally, the fire history of the study region is characterized by large, widespread fires occurring during drought years, but not all severe years were large regional fire years. The most favorable conditions for fires in ponderosa pine forests were extremely dry years, preceded by wet years, which produced above normal amounts of vegetative fuels. During these wet periods, fires were small and infrequent. Conversely, smaller areas were burned in summer or fall after exceptionally wet springs. Most fires were probably low intensity which, spread generally up drainages and across grassy areas. Pre–1900 settlement fires maintained open stand conditions, and this thinning action prevented catastrophic crown fires, which have occurred in this century (Baisan 1993: 6; Swetnam and Baisan 1995: 2, 3, 5; Swetnam and Betancourt 1990).

Recent studies on the effects of sheep grazing on fire regimes of ponderosa pine forests in northern New Mexico indicate a correlation between the extent and duration of grazing and a decline in fire frequency. This decline occurred prior to organized fire suppression, which generally began about the turn of the century. Intensive grazing by sheep severely reduced grasses, which were the fuel necessary for the spread of fire in the regional, high frequency fire regimes of these forests. In some instances, the complete elimination of fires occurred due to this intense grazing (Savage and Swetnam 1990); Touchan et al. 1994: 1, 5, 8–9).

The largest fire year for the Southwest, documented by tree-ring analyses, was 1748, the second largest 1851, and the third largest 1773. These were all associated with extended drought periods. For 1700 to 1900 the "regional fire occurrence times series ... shows a pattern of about 20 large regional fire years (more than 19 sites) occurring against a background of smaller fire years" (Swetnam and Baisan 1995: 16, 18). In mixed-conifer forests, large fires occurred in extreme drought years with no consistent lagging relations.

Regional national forests have experienced the highest number of annual, lightning-caused fires in the United States (Swetnam and Betancourt 1990: 1017). In the southern Rocky Mountains thunderstorms with lightning occur on 70 or more days a year (Keen 1987: 43). Fires caused by lightning normally begin in the spring and reach their highest incidence late June to early July. A significant decrease usually follows as summer rains progress (Swetnam and Betancourt 1990: 1017).

Fire frequency in the study region generally declined sharply after 1880 until about 1900–10, when fire suppression became common. This change, according to Touchan et al. (1994), was also due to intensive grazing and trampling by livestock, which reduced or removed potential fuels.

In some specific areas, such as the El Malpais National Monument, where islands of lava rock were virtually inaccessible to livestock, fire frequency remained about the same throughout the protohistoric and historic periods. From 1407 to 1991 there were some 66 fires, or a fire every 8.2 years. At two sites in the Jemez Mountains, one in the central portion of the range and the other on the west slope where grazing was intensive at various times, the averages were 9.9 and 11 years, respectively. There was a decline in fire frequency beginning at the end of the 19th century at the first site, probably due to intensive grazing and initiation of fire suppression, while there was a decrease in fire occurrence in the late 18th and early 19th centuries at the other site, which also coincided with a period of heavy grazing (Touchan et al. 1994: 2–9).

Fire history studies on the Pajarito Plateau, in the southeastern part of the Jemez Mountains, revealed a fire frequency in the ponderosa forest of 15.1 years prior to 1894. This date marks the beginning of the ongoing period of fire suppression for the area. Tree-ring samples taken from Burnt Mesa and Escobas Mesa showed a fire frequency of 14 years between 1786 and 1792. Post-suppression fire frequency for 1894–1977 was 41.9 years, and none of these was a major fire until the La Mesa fire of 1977 (Foxx 1981: 7, 35). Fires were specifically dated to 1797, 1806, 1822, 1842, 1870, 1878, and 1893 (Robinson 1990: 142).

The forests and woodlands of the Sandia Mountains have been protected from fire since the early part of this century by the National Forest Service. There was one fire in the Juan Tabo-La Cueva canyons area early in July 1965 and a smaller fire in June 1990 near the headwaters of Las Huertas Creek. The earlier fire was the most extensive fire in the Sandias in this century; 550 acres were burned up the canyon to the crest at 10,678 feet elevation (Cooper 1988:4).

Preliminary work on the fire history of the La Luz area on the west side of the Sandia Mountains revealed a somewhat different pattern (Baisan 1993, 1994). From 1506 to 1675 fires were very frequent but patchy. No fire-scarred trees dating 1675 to 1706 were found. Fires for the period 1706 to 1781 were less frequent and patchy. No fire scars were found after 1781 until the present (Baisan 1994: 2).

Fires for the first period have been interpreted as a combination of natural (i.e., lightning-caused) and incendiary fires started by Pueblo or Apache groups. The hiatus from 1675 to 1706 may have been due to lack of fuel, as a result of fires in the previous period. The less frequent and patchy fires for the third period (1706–81) have been attributed to natural fires quickly sweeping through the area. The grazing of sheep on the site probably reduced the available grass fuels to the point that after 1781 no fires occurred (Baisan 1994: 2).

Another factor in reducing fuel loads was the herding of goats in the Sandias from the late 1700s to the mid 20th century. Their browsing pattern of feeding on shrubs would have removed even more fuels, virtually precluding any fires in the area. Also, intensive fuelwood cutting by residents of Albuquerque, Corrales, Alameda, Bernalillo, and Sandia Pueblo throughout the 19th century would have removed much of the pinyon-juniper and scrub oak species. Following establishment of the Cibola National Forest in 1906, a policy of fire suppression was another major factor in fire cessation here.

A fire history study in the northern Manzano Mountains indicates a period from 1550 to 1636 when relatively frequent, spreading fires occurred. This was followed by a period (1637–1723) of infrequent, spreading fires, and then, from 1724 to 1773, by a period of episodic, widespread fires. From 1773 to about 1810, there were no fires in the area. This absence of fires may have been due to intensive livestock grazing, especially sheep, and fuelwood cutting by Hispanic residents in the greater Albuquerque area (Baisan 1993: 4).

Fires did occur in the northern Manzanos from 1811 to 1842, then frequency declined until 1904, after which time no more fires occurred. Lack of intensive grazing and firewood cutting may have created the fuel to sustain fires until 1842. Sharp increases in grazing and cutting after that year may have caused the decrease, and organized fire suppression probably accounts for the cessation of fires after 1904 (Baisan 1993: 4–5).

PLANT COMMUNITIES

The following brief reconstructions of historic plant communities in the study region are based primarily on the work of Brown (1982), Brown and Lowe (1980), Crawford et al. (1993), Dick-Peddie (1993), Gross and Dick-Peddie (1979), Leopold (1951), and Watson (1912) and secondarily on various historical sources cited in the following pages. Changes in floodplain communities, and their dominant species, are presented in Table 48. Following these community descriptions are selected historical observations on the region's flora, included as supplemental material. The next section will deal with impacts on these communities over the last 150 years.

Riparian

As long as 2 million years ago a riparian cottonwood woodland, or bosque, existed along the Rio Grande. The cooler, wetter conditions that prevailed at that time in New Mexico also supported several associated plants, including birch (*Betula* sp.), western chokecherry (*Prunus virginiana*), willow (*Salix* spp.), and cattail (*Typha* sp.). When the Spanish arrived in the 16th century the banks, sand bars, and adjacent floodplain areas were vegetated with scattered bosques of varying-age valley cottonwood (*Populus deltoides* ssp. *wislizeni*) (Fig. 51), with a willow (*Salix* sp.) and salt grass (*Distichlis spicata*)-dominated understory (Table 48). Open, grassy areas, or vegas, were also present. Cattails and other wetland species grew in and around ponds, marshes, and swampy sites. Other major plants associated with the bosques included New Mexico olive (*Forestiera pubescens* var. *pubescens*), baccharis (*Baccharis wrightii*), false indigo bush (*Amorpha fruticosa*), wolfberry (*Lycium andersonii*), and, in southern reaches, mesquite (*Prosopis glandulosa*). All of these plant communities were considerably modified by human activity during the historic period (Crawford et al. 1993: 27–28; Dick-Peddie 1993: 151–152; Table 48).

Besides cattails, other common plants such as sedges (*Carex* spp., *Eleocharis* sp.) rush (*Juncus* sp.), scouring rush (*Equisetum hyemale*), buttercup (*Ranunculus cymbalaria*), pepperwort (*Marsilea vestita* ssp. *vestita*), mosquito fern (*Azolla mexicana*), reed grass, or carrizo (*Pragmites australis*), and yerba mansa (*Anemopsis californica*) grew around wetlands or on areas with high water tables. The deeper water of swamps and ponds held floating plant communities of algae (*Spirogyra, Vaucheria, Oedogonium*) and duckweed (*Lemna minor*). The submerged species of water plants were milfoil (*Myriophyllum spicatum*) and hornwort (*Ceratophyllum demersum*) (Crawford et al. 1993: 28; Table 48).

These plants and the communities they made up were adapted to a dynamic, moist, floodplain environment with an unstable substratum. Relatively high moisture availability originated from periodic floods, standing surface water, and shallow ground water. These floods scoured new and old channels, washed away stands of trees and understory vegetation, created new wetlands, and formed new channels and sand bars. Flood actions resulted in the creation of gradients across the floodplain, which resulted "in a dynamic successional sequence in a riparian habitat continuum" (Reichenbacher 1984: 15, 20). Flooding is basically an erosional-depositional process promoting "forest and age diversity on the floodplain" and in its meandering "creates the distribution of the different communities and age classes" (Crawford et al. 1993: 28). Fire, natural and human caused, probably played a lesser role in the creation, composition, distribution, and age structure of these communities. These dynamic processes were present until their alteration and modification in the early 1900s (Crawford et al. 1993: 29; Table 48).

Grasslands

Grasslands covered much of the study region between stream floodplains and up to 6,000 to 7,000 feet elevation in the early historic period. This botanical zone has been called desert grassland, desert-grassland transition, desert savanna, desert shrub grassland, and grassland transition. These various names suggest the obvious transitional nature of this plant community (Brown 1982: 122–131; Dick-Peddie 1993: 106–107). With intensive grazing of these communities for 200 to 400 hundred years, forbs and shrubs have replaced various bunch grasses favored by livestock. Various grama species and other bunch grasses were the dominant types in these "seas of grass," as they were sometimes called in the historic period. Prior to the arrival of the Spanish, various Native American groups intentionally burned these grasslands periodically. Lightning-caused fires may have occurred even more frequently. These burns may have killed encroaching woody forbs and shrubs and stimulated vigorous growth. The complete role of fire in the maintenance of these grass-

Table 48—Historic floral community dominant plant species, Middle Rio Grande Valley.

Period	Communities/dominant species
Spanish Colonial (1540–1680)	Bosque (riparian woodlands)
	Cottonwood groves—*Populus deltoides* ssp. *wislizeni* (discontinuous)
	Willows—*Salix exigua, S. gooddingii, S. amygdaloides* (understory areas and river edge)
	New Mexico olive—*Forestiera pubescens var. pubescens* (isolated understory areas)
	Seepwillow—*Baccharis salicifolia* (isolated understory areas)
	False indigo bush—*Amorpha fruticosa* (isolated understory areas)
	Wolfberry—*Lycium andersonii* (isolated understory areas)
	Mesquite—*Prosopis* sp. (southern reach; isolated understory areas)
	Salt grass—*Distichlis spicata* (understory areas)
	Common reed grass—*Phragmites australis*
	Cienegas, esteros, charcos (wetlands)
	Algae—*Spirogyra, Vaucheria, Oedogonium* (deeper water)
	Duckweed—*Lemna minor* (deeper water)
	Chara spp. (shallow water)
	Water-milfoil—*Myriophyllum spicatum* (shallow water)
	Hornwort—*Ceratophyllum* sp. (shallow water)
	Cattail—*Typha latifolia* (shallow water margins)
	Sedge—*Carex* sp., *Eleocharis* sp. (shallow water margins)
	Rush—*Juncus* sp. (shallow water margins)
	Scouring rush—*Equisetum hyemale* (shallow water margins)
	Buttercup—*Ranunculus cymbalaria* (shallow water margins)
	Pepperwort—*Marsilea vestita* ssp. *vestita* (shallow water margins)
	Mosquito fern—*Azolla mexicana* (shallow water margins)
	Coyote willow—*Salix exigua* (wet banks)
	Cottonwood (wet banks)
	Vegas (meadows)
	Sedges (wet meadows, water edges)
	Rush (wet meadows)
	Common Reed Grass (wet meadows)
	Salt grass (wet meadows)
	Yerba Mansa—*Anemopsis californica* (wet meadows)
	Appearance of naturalized exotic plants such as alferillo (*Erodium cicutarium*), horehound (*Marrubium vulgare*), dandelion (*Taraxacum officinale*), mallow (*Malva neglecta*), etc.
Middle-late Spanish Colonial-Mexican Republic (1681–1846)	Similar to plant communities distribution above but fewer or no stands of cottonwoods around settlements, more ditches with *Chara*, sedge, rush, bullrush, and willow species.
Territorial (1846–1912)	Bosque (riparian woodlands)
	Similar to above but fewer stands of cottonwood, with generally smaller trees; more ditchside habitat.
	Cienegas, esteros, charcos (riparian wetlands)
	Increase due to rising water table and increasing soil alkalinity, dense ditchside thickets and stands of willow, senna (*Senna bauhinioides*), sunflower (*Helianthus annuus*), and goldenrod (*Solidago* spp.).
	Vegas (meadows)
	Appearance and spread of exotic species such as curly dock (*Rumex crispus*), Russian thistle (*Salsola kali*), and Johnson grass (*Sorghum halepense*) (southern reach).

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Table 48—Historic floral community dominant plant species, Middle Rio Grande Valley (continued).

Period	Communities/dominant species
Statehood (1912–present)	Bosque (riparian woodlands)
	More extensive stands of young and maturing cottonwoods and understory willow species dominant until 1940s. Major reduction in wetland and aquatic species.
	Bosque eradicated in local areas inundated by major reservoirs or by floodplain clearing for development.
	Cienegas, esteros, charcos (wetlands)
	Extensive until 1930s drainage and reclamation or inundation by reservoirs.
	Appearance of tamarisk, or salt cedar (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), Siberian elm (*Ulmus pumila*), and tree of heaven (*Ailanthus altissima*) and spreading rapid.
	Increase in four-wing saltbush (*Atriplex canescens*), Russian thistle.

Sources: Crawford et al. 1993: 28; Hedke 1925: 23; Watson 1912, Hink and Ohmart 1984, Scurlock 1988a, 1993a, and Soil Conservation Service 1994

Figure 51— Three men in a "ferry" boat on the Rio Grande, 1880s. Note honey mesquite (left center), valley cottonwood seedlings on sandbar (upper center), and scattered, older cottonwoods (back). This locale is now inundated by Elephant Butte Reservoir. Photo courtesy New Mexico Bureau of Mines Photo Archives, Socorro.

lands, however, is uncertain (Bahre 1991: 138–141; Dick-Peddie 1993: 106–107). Intensive grazing has so denuded many stands that today their scant, patchy condition will not carry extensive fires. Other factors, such as climatic change and fire suppression, probably have a role in compositional change in this community (Bahre 1991: 42–53).

Various travelers across the region in the early to mid historic period commonly referred to the vast stretches of densely growing grama and other bunch grasses. By the middle 1800s, recorded historic observations, and particularly field notes from public land surveyors later in the century, indicate that changes in plant composition had already occurred or were in progress. The species of grass more palatable to livestock had been decimated, followed by encroachment of shrubs and woody or herbaceous species, including introduced ones. For determining more recent changes, the technique of repeat photography (i.e., rephotographing a view of vegetation at the same historical location) has been used to document these changes (Dick-Peddie 1993: 9–20).

Using surveyors' notes on public lands in New Mexico from the 1870s and 1880s, Gross and Dick-Peddie (1979) reconstructed "primeval vegetation types," including grasslands, for about 1880 (Fig. 52). Based on this map, desert grassland and sand scrub were generally found east of the Middle Rio Grande Valley, reflecting a subsequent change by an invasion of saltbush, creosotebush, juniper, sand sagebrush, or yucca. West of the river, juniper and pinyon at higher elevations constituted the major invader species into grasslands (Dick-Peddie 1993: 11). In some locations, the present composition has led to classification of this community as savanna.

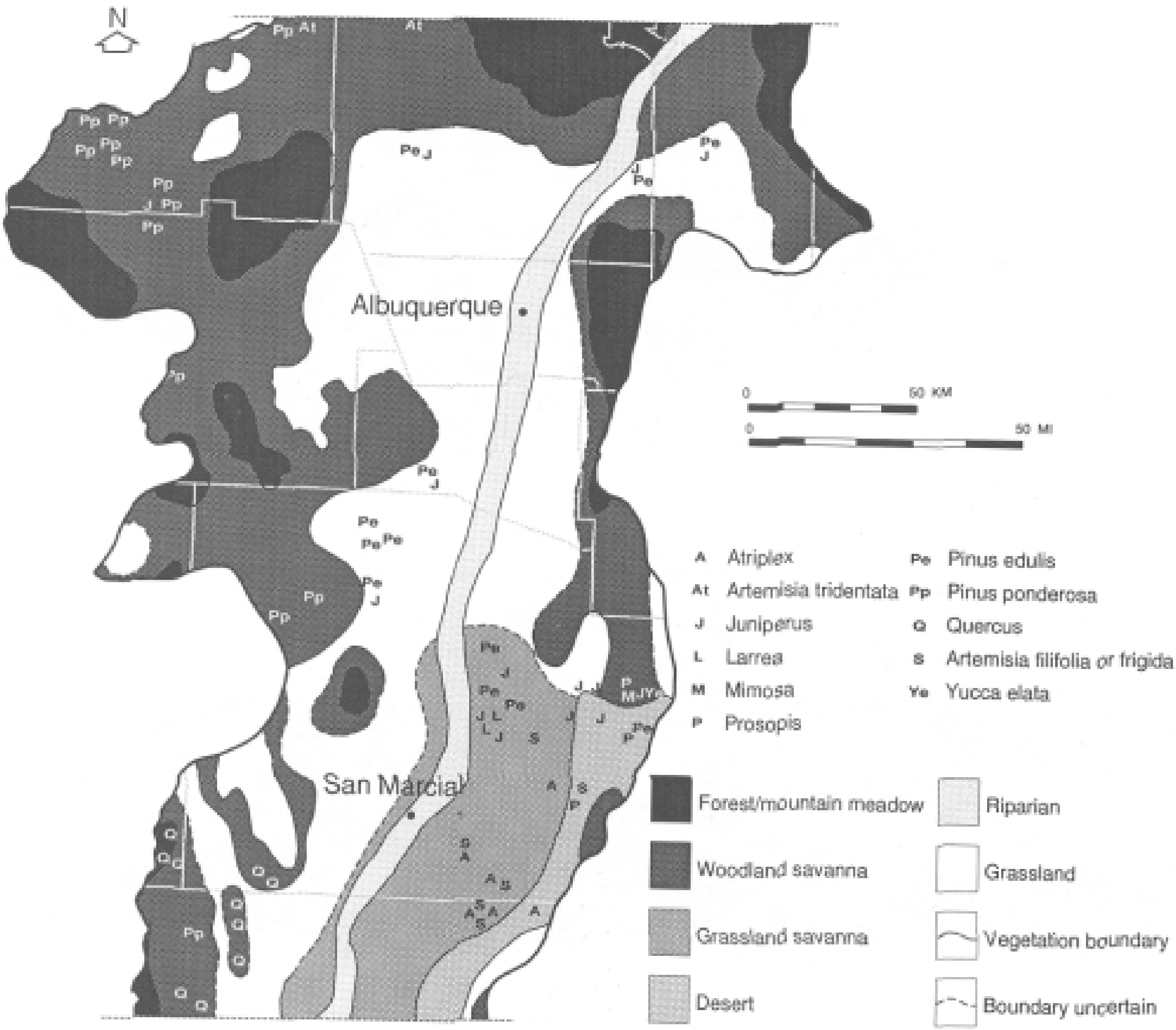

Figure 52—Reconstructed primeval vegetation types, 1870–1900 (after Gross and Dick-Peddie 1979).

Desert Grassland

The desert grassland community flanks the Middle Rio Grande Valley from the Cochiti Pueblo area to about Socorro (Fig. 53). Much of the desert grassland occupies sites that were previously plains-mesa grasslands. Intensive grazing, fire suppression, and perhaps other factors have resulted in the invasion of forbs and shrubs; their composition is highly variable. The dominant grass of this community is black grama (*Bouteloua eriopoda*). Other grama species are present, as are the dominants tobosa (*Hilaria mutica*), fluff grass (*Erioneuron pulchellum*), and bush muhly (*Muhlenbergia porteri*). Some common, associated shrubs and forbs include saltbush (*Atriplex* spp.), prickly pear (*Opuntia* spp.), *Yucca* spp., feather peabush (*Dalea formosa*), and snakeweed (*Gutierrezia sarothrae*) (Brown 1982: 112, 115–131; Dick-Peddie 1993: 106–108, 117–118; Fig. 51).

Plains-Mesa Grasslands

Generally occurring on intermountain mesas and bajadas at elevations between 5,500 and 6,500 feet are the plains-mesa grasslands, which were historically more extensive, but human disturbance over the last 200 years has reduced their range. These communities were made up of 90 percent grass species such as blue grama (*Bouteloua gracilis*) across the region, western wheatgrass (*Pascopyrum smithii*) and galleta (*Hilaria jamesii*) on northern mesas, and Indian ricegrass (*Oryzopsis hymenoides*) on bajadas. Various dropseed (*Sporobolus* spp.) species, along with Indian ricegrass, occur on some sandy northern and central mesas. At the extreme south end of the study region black grama and various dropseed species occur. Alkali sacaton (*Sporobolus airoides*) dominated swales across the region, sometimes in association with tobosa. A number of other shrubs, forbs, and herbaceous plants, such as *Yucca* spp., saltbush, sagebrush (*Artemisia* spp.), and rabbitbrush (*Chrysothamnus* spp.), make up the other ten percent of the vegetative cover. Due to climate and land forms, the plains-mesa grassland vegetation of New Mexico demarks the southwestern boundary of the continental grassland (Dick-Peddie 1993: 105–106; Soil Conservation Service 1994)..

Figure 53—Desert grassland near Isleta Pueblo. Bunch grasses, broomweed, and scattered four-wing saltbush (behind fence) are dominant species. Photo by author.

Scrublands

Four scrubland plant communities have been recognized in the region: Great Basin desert scrub, Chihuahua desert scrub, plains-mesa sand scrub, and montane scrub (Dick-Peddie 1993). Intensive grazing, fire, fire suppression, and climatic variations have shaped these associations in the historic period. These communities are dominated by shrub species adapted to lower moisture availability and other poor or severe climatic, geomorphologic, and edaphic conditions. The Great Basin desert occurs to the west and northwest of Albuquerque. Dominant species in the Great Basin community are shadscale (*Atriplex confertifolia*), fourwing saltbush (*A. canescens*), sagebrush, winterfat (*Krascheninnikovia lanata*), and rabbitbrush (Dick-Peddie 1993: 129–130; Soil Conservation Service 1994).

The Chihuahua desert scrub community occurs in the southern part of the study region, extending from Socorro south to the boundary below San Marcial. Originally smaller in extent, intensive grazing coupled with climatic fluctuations and fire suppression have resulted in extensive enlargement of its historical range in the last century or more. This increase has included the replacement of the two previously discussed grassland communities. The two major plant species are creosotebush (*Larrea tridentata*) and tarbush (*Flourensia cernua*), with soaptree yucca (*Y. elata*), white thorn (*Acacia* spp.), and various cacti species in association (Dick-Peddie 1993: 131–132; Soil Conservation Service 1994).

The third community, the plains-mesa sand scrub, flanks the Middle Valley from Cochiti to Socorro and is also found to the east of the Bosque del Apache National Wildlife Refuge. This vegetative type is determined by deep-sand areas, as well as by climatic conditions. Common plants include sand sagebrush (*Artemisia filifolia*), broom snakeweed, and *estafiata* (*Artemisia frigida*). Dominant grasses include hairy, blue, and sideoats grama (*Bouteloua hirsuta, gracilis, curtipendula*), alkali sacaton, and mesa dropseed (*Sporobolus flexuosus*) (Dick-Peddie 1993: 128–129).

The last scrub community, the montane scrub, generally occurs in patches or strips within more extensive types of upland vegetation. This community occurs on exposed rocky slopes or ridges subject to variable and severe climatic conditions. A number of species of common shrubs are present: mountain ninebark (*Physocarpus monogynus*), buckbrush (*Ceanothus fendleri*), Mormon tea (*Ephedra torreyana*), mountain mahogany (*Cerocarpus montanus*), Apache plume (*Fallugia paradoxa*), scrub oaks (*Quercus* spp.), banana yucca (*Y. baccata*), and gooseberry (*Ribes* spp.) (Dick-Peddie 1993: 123–127).

Juniper Savanna

The juniper savanna community is an ecotone between grasslands and woodlands in the region; widely scattered juniper or oak species (less than 130/acre) occur in a grass matrix (Fig. 47). All of the regional juniper savanna is composed primarily of one-seed juniper (*J. monosperma*) and several major grasses, including three grama species, plains lovegrass (*Eragrostis intermedia*), galleta, sixweeks threeawn (*Aristida adscensionis*), and Indian ricegrass. Gambel oak (*Quercus gambelii*) or gray oak (*Q. grisea*) in place of juniper are less common in grassland stands. This community, which may have formed in the historic period, has expanded extensively due to intensive livestock grazing, climatic variation, and fire suppression (Dick-Peddie 1993: 87, 91–93).

Pinyon-Juniper Woodlands

The pinyon-juniper woodlands occur on lower mountain slopes and higher mesas, generally between 6,000 and 7,500 feet. The community is dominated by pinyon (*Pinus edulis*) and one-seed juniper or alligator juniper (*J. deppeana*) (Fig. 54). Blue grama grass is generally present, and in some instances understory shrubs such as mountain mahogany, skunkbush (*Rhus trilobata*), and Gambel or wavy leaf (*Quercus undulata*) oaks. The Gambel oak may be codominant with the conifers. This community has also extended its range into grasslands over the past 100 years or so, owing primarily to overgrazing and fire suppression (Dick-Peddie 1993: 87–90). This zone has been heavily used since the late prehistoric period for collecting of fuelwood, construction materials, and medicinal and edible plants. Understory grasses were intensively grazed throughout the historic period.

Ponderosa Pine

Ponderosa pine (*Pinus ponderosa*), the most important commercial species in the region, is dominant in this community, which occurs from about 7,200 to 8,500 feet. Other tree species, such as Gambel oak, pinyon pine, and Rocky Mountain juniper (*Juniperus scopulorum*), sometimes occur in association. Common understory shrubs include Fendler buckbrush (*Ceanothus fendleri*) and gooseberry (*Ribes* spp.). A number of grasses are found here, including Arizona fescue (*Festuca arizonica*), bluestems (*Schizachyrium* spp.) and gramas, mutton grass (*Poa fendleriana*), mountain muhly (*Muhlenbergia montana*), and pine dropseed (*Blepharoneuron tricholepis*). Severe disturbances, such as intensive logging or fires, have often led to prolonged midsuccessional dominance by oaks, junipers, or pinyon. Intensive grazing and fire suppression have also led to an interruption in successional stages in this community (Dick-Peddie 1993: 66–68, 76–78; Soil Conservation Service 1994).

Subalpine and Mixed Coniferous Forest

These forests generally occur in the region between 8,500 and 12,000 feet, where there is relatively heavy snow accumulation and a short growing season. These communities are important to the watershed because of their storage of water and discharge from deep snowpack. The two diagnostic tree species in the subalpine are corkbark fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*). Engelmann spruce, Douglas fir (*Pseudotsuga menziesii*), and white fir (*Abies concolor*) form communi-

Figure 54—Pinyon-juniper at El Malpais National Monument, Cibola County. Photo by author.

Figure 55—Mixed conifer forest above riparian zone (leafless boxelder trees on right), Sandia Mountains. Photo by author.

ties in the lower part of this zone (Fig. 55). Limber pine (*Pinus flexilis*), Douglas fir, boxelder (*Acer negundo*), Rocky Mountain maple (*Acer glabrum*), and aspen are present in some ecological situations. Meadows with a diversity of grasses, sedges, and wildflowers occur in this community. Numerous grasses (32 species) are found scattered through the forest as well. The subalpine forest has been utilized historically for logging, hunting, plant gathering (medicinal and edible), and recreation, primarily hiking and skiing. These uses, and fire suppression since the turn of the century, have modified the composition of this community (Dick-Peddie 1993: 51–66, 76–77).

Alpine Tundra

The alpine tundra, which is the highest of all plant communities, is found in only one area in the Middle Basin, on the higher peaks of the Sangre de Cristo Mountains north of Santa Fe. This virtually treeless zone is found above 12,000 feet and is made up of several sub-communities, or associations, determined by microclimates, topography, and soil types or surface rocks (Dick-Peddie 1993: 47–48).

Perhaps the most common plant association is the "cushion," composed of several low-growing species, including *Carex rupestris*, a rhizomatous sedge that helps form sod. Some of the other dominant plants include alpine sage (*Artemisia scopulorum*), cushion yellow aster (*Tonestus pygmaeus*), and bistort (*Polygonum bistortoides*) (Dick-Peddie 1993: 49).

Another association is fellfield, or rock field, which supports cushion-like, perennial plants that "hug" the ground. Some of these plants include alpine forget-me-not (*Eritrichium nanum*), alpine clovers (*Trifolium* spp.), and moss-pink (*Silene acaulis*) (Dick-Peddie 1993: 48).

A third association is known as kobresia turf, named for the principal species found there, *Kobresia myosuroides* Another common plant of this sub-community is alpine avens (*Geum rossii*) (Dick-Peddie 1993: 48–49; Soil Conservation Service 1994).

Still another association is the rock outcrop, or rubbleland, made up of talus, stone-stripe, or rock-detritus. Characteristic plants include a groundsel (*Senecio atratus*) and two yellow, flowered saxifrages (*Saxifraga chrysantha* and *S. flagellaris*). A variety of lichens are widespread in this association (Dick-Peddie 1993: 49).

Native Americans camped and hunted in the tundra of the Sangre de Cristos as early as 3,000 years ago, perhaps to hunt bighorn sheep and snowshore hare in summer. In the historic period, Pueblo, perhaps Apache, and Hispano people hunted and herded their livestock here. The Pueblos also maintained shrines (and still do) on some of the higher peaks. In more recent years recreational use has caused some adverse impacts, especially affecting vegetation along trails and around camps (deBuys 1985: 21–27, 31–38).

FAUNA

Mammals

From the late prehistoric period to the arrival of the Spanish, Native Americans hunted virtually every species of mammals in the region for food, hides, or body parts. Bones and other physical remains of various mammal species, as well as various birds, reptiles, and amphibians, have been identified and recovered from a large number of late prehistoric archeological sites (Hewett and Dutton 1945; Hibben 1975; Marchiando 1977; Schaafsma 1980; Young 1980). Petroglyphs, pictographs, and especially kiva wall murals also document some of the local fauna (Table 49). From this evidence, and from early historic observations, the species, their ranges, and their relative numbers can be reconstructed to varying degrees.

The pre-Spanish Middle and Upper basins supported a diverse number of vertebrate species with relatively abundant populations. More than 140 mammals, more than 400 birds, a fair number of reptiles and amphibians, and 31 fishes were found in the study region. Important as game animals to Native Americans were bison, pronghorn, elk, deer, bighorn sheep, and various rabbit species. These mammals, as well as others such as grizzly bear, and black bear, wolf, beaver, and river otter, were hunted and trapped for their hides and furs by Indian groups, as well as by the later Spanish and early Anglo Americans.

At one Anasazi archeological site of the same period, Pottery Mound, near Los Lunas, 33 animal species have been identified, including bear, jaguar, mountain lion, wolf, coyote, fox (?), bald eagle, parrot, macaw, and whooping crane (Table 50). Macaws and parrots represent border or interior "Mexican" species, probably brought up the Rio Grande as caged or skinned specimens.

The early Spanish explorers and missionaries, in the period 1540–1766, primarily described the common large mammals, species that were of interest for their meat, hides, or coarse furs. These species included bison, mule deer, and white-tailed deer, elk, pronghorn, bighorn sheep, gray wolf, and Mexican wolf, black bear, grizzly bear, mountain lion, bobcat, cottontail, and jackrabbit. Two of these—buffalo and the elk—were curiosities, and live specimens of each were even shipped to the King of Spain (Simmons 1978: 19, 22). Other species, such as pine marten, ermine, beaver, river otter, porcupine, fox, and jaguar, are mentioned less frequently in the documents (Ayer 1965: 37; Bolton 1946: 353; Espinosa 1942; Hodge 1946: 350; Kinnaird 1958: 95; Weber 1971: 12–13).

Terms such as "large numbers, abundant, infinite, and inexhaustible" were used by various Spaniards in describing mammal populations. These descriptors were used into the early 19th century, especially for bear, bison, deer, elk, bighorn sheep, and rabbits. Wild horses were also present on grasslands in relatively large numbers (Ayer

Table 49—Fauna identified from faunal remains and kiva murals—Kuaua Pueblo.[a]

Mammals	Birds	Reptiles and amphibians	Insects
Pronghorn antelope	Goose sp.	Rattlesnake sp.	Butterfly sp.
Badger	Cooper's hawk	Water snake sp.	Caterpillar sp.
Bat	Red-tailed hawk	Tortoise	Cricket sp.
Bear	Sparrow hawk	Frog sp.	Bedbug sp.
Bison	Hawk sp.	Tadpole sp.	Worm sp.
Bobcat	Bald eagle	Newt sp.	
Coyote	Golden eagle		
Deer	Quail sp.		
Elk	Turkey		
Fox	Sandhill crane		
Gopher	Macaw (introduced through trade)		
Cottontail sp.	Roadrunner		
Jackrabbit	Owl sp.		
Mole	Hummingbird sp.		
Mountain lion	Swallow sp.		
Bighorn sheep	Jay sp.		
Crow			
Magpie			
Mountain bluebird			
Loggerhead shrike			

[a] Occupied ca. 1325–1600.
Sources: Dutton 1963

1965: 37; Carroll and Haggard 1942: 99–100; Coues 1987: 597; Hodge 1946: 350; Kinnaird 1967: 95; Simmons 1991b: 168; Thomas 1941: 112–113).

Hunting of mammals by Spaniards was generally at a subsistence level, and sport hunting, practiced by only the well-to-do explorer, landholder, or government official, was even rarer in the 16th and 17th centuries. Obviously, there was some impact on animal populations; for example, the Jicarilla Apache believed that bighorn sheep were driven from the valleys into the mountains of northern New Mexico by Spanish hunting pressure. Much more impact on these mammal populations was generated by governors, encomenderos, and traders, who obtained meat, furs, and hides for consumption, export, or personal use from various Native American groups. The most important meat and hide animals were bison, mule deer, elk, and pronghorn, but the total number of animals taken is unknown, although it was undoubtedly less than the Santa Fe Trail trade in hides that occurred from 1821 to the 1850s. For example, in 1639 the governor shipped 122 painted buffalo hides and 198 chamois skins (pronghorn? bighorn sheep?) south to present northern and central Mexico. In 1660 another governor exported 1,350 deerskins and a quantity of buffalo hides to Parral. At the end of his term he had 1,200 pronghorn hides and four bundles of elk skins. Under the encomienda at Pecos Pueblo in 1662, 18 buffalo hides, 37 buckskins, and 66 antelope hides were collected in 1 month from resident Indians (Weber 1971: 12–21).

Table 50—Fauna identified from Pottery Mound kiva murals.

Mammals	Birds	Reptiles	Insects
Jaguar	Mallard	Rattlesnake	Dragonfly
Mountain lion	Whooping crane	Gila monster?	Mosquito
Wolf	Red-tailed hawk		Grasshopper
Coyote	Bald eagle		
Skunk	Quetzal		
Bear	Military macaw		
Fox	Thick-billed parrot		
Pronghorn	Roadrunner		
Deer	Magpie		
	Great horned owl		
	Pileated woodpecker		
	Swallow		
	Raven or crow		
	Yellow-headed blackbird		
	Yellow warbler		
	Yellow-breasted chat		
	Horned owl		
	Phainopepla		
	Bluebird		

Source: Hibben 1975: 65–67, 110–111, 115

Hispanic settlers used hides and robes primarily for clothing and bedding. Other uses included the manufacture of teguas (moccasins, from skin), furniture (skin), picture "canvas" (skin), musical instruments (bone), and bedding (hide) (Boyd 1974: 118, 251, 256; Reeve and Cleaveland 1979: 155–156).

Pueblo and Spanish hunters, sheepherders, and farmers were sometimes attacked and mauled by grizzly bears. This species, as well as mountain lions and wolves, preyed on sheep, goat, and horse herds, but very limited attempts were made to control this predation. Dogs, which could fend off all but grizzly bears, were a deterrent to livestock losses of this kind (Ebright 1994: 229; Simmons 1978: 35).

Following Spanish resettlement in 1693–1700, trade in animal hides with regional Native American groups increased relatively sharply. Nomadic Indians brought skins to the settlements for trade, as well as to an annual summer or fall trade fair, where a brisk exchange in hides and meat occurred. Bison, elk, deer, and pronghorn remained the key barter items. The exchange of skins and coarse furs, encouraged by government officials and stimulated by market demand, increased over the century, and by the early 1800s they were probably the main export items of New Mexico (Adams and Chavez 1956: 252–253; Scurlock 1991b; Weber 1971: 22, 28, 30–31).

Bison ranged seasonally as far west as the San Agustin Plains and the grasslands of northeastern Arizona in the late prehistoric period (Callenbach 1996: 17–18) and the Salinas and Galisteo provinces in the early colonial period (Bailey 1971: 152–156). A herd was also reported in the Chama River valley as late as the 1690s. There was a mountain race of bison in the southern Rockies in Colorado, but whether they occurred in northern New Mexico is speculative (Christman 1971: 46). All of these bison were either exterminated or driven eastward due to pressure by Navajo, Apache, Pueblo, and Hispanic hunters. By the late 1700s, intensified hunting pushed them farther eastward, across the Pecos River (Bailey 1971: 12–13; Hammond and Rey 1966: 87; Weber 1988: 126). The Estancia valley and upper Galisteo basin were two areas so impacted. By the early 1800s, Hispanic buffalo hunters from the Rio Grande drainage, called ciboleros, were taking 12,000 animals annually from the Pecos River onto the Southern Plains. By the mid 1800s the hide trade, spurred by Anglo traders, began to decimate the Southern Plains herd. During this period remnant, small herds or individual bison sought refuge in secluded valleys and high mountains across the region. For example, two buffalo were killed near Santo Domingo Pueblo in the early 1800s (Christman 1971: 44–47; Griffin 1947: 22, 51; Henderson and Harrington 1914: 13–14).

Two species of mammals, the Norway rat and house mouse, that were introduced in the colonial period have been naturalized. The horse and burro, also brought by the Spanish, became feral by the 1700s (Findley 1987: 107–108, 149–150).

At the time of the opening of the Santa Fe Trail in 1821, with its subsequent flood of traders and trappers entering New Mexico (Hafen and Hafen 1993: 93), populations of hunted and trapped mammals, except for the buffalo, were probably near their early historic (1500s) levels. Trappers found beaver, black bear, and grizzly bear, deer, and elk to be common along unsettled riparian corridors and in the mountains. By 1826, however, beaver populations in the Upper and Middle Rio Grande and adjacent mountain ranges, especially the Sangre de Cristo and Jemez, were decimated overall and extirpated in reaches of many streams (de Buys 1985: 93; Flores 1992: 8; Weber 1971: 65,215, 224). Trapping of beaver, however, remained relatively intense in some areas of the region over the next 20 years, owing to the continued market demand back east. Traders also continued to obtain pelts through a brisk trade with Native Americans. Some 5,000 beaver skins were transported over the Santa Fe Trail from New Mexico in 1834 (Table 51).

A couple of trappers during this period saw "great numbers of bears," up to 220 in a single day, and a third trapper claimed to have seen 50 or 60 grizzly bears in a day in the region (Cleland 1963: 44; Pattie 1966: 52). The former number is probably an exaggeration, but the latter may be accurate. For the 1830s and 1840s bears, as well as wolves, were described as common. Deer and elk were noted by one observer as only fairly common regionwide, while another referred to them, as well as bear, as "well stocked" in the Sangre de Cristo Mountains (Bodine 1979: 255; Gregg 1966, I: 192–195; II: 207–210). Bighorn sheep were also still relatively common in some canyon and mountain locales, and pronghorn were still commonly found on the bajadas and other grasslands of the study region in the mid 1800s (Henderson and Harrington 1914:

Table 51—Beaver (pelts) trapped or shipped over the Santa Fe Trail,1824–1841.[a]

Year	Pounds/pelts[b]	Value[c]
1824	4,820/	$14,460
1825–26	33,333/	$100,000
1826	2,044/	
1827	1,843/1110	
1827–28	398/240	$1,194
1828	1,200/	$5,000
1829	951/240	$4,298
1831	993/	$2,980
1831–32	13,182/	
1832	4,700/	ca. $14,100
1833	3,088/1,860	$9,264
1834	8,300/ca. 5,000	$15,000
1836[d]	1,660/1,000	ca. $3,000
1837[d]	103/62	ca. $309
1839[d]	383/	ca. $1,149
1841[d]	365/	

[a] *Almost all from central and northern New Mexico and southern Colorado.*

[b] *An average beaver pelt weighed about 1.66 pounds, a pack of beaver fur averaged about 31 pelts or 52 pounds.*

[c] *The 1823–33 mountain price averaged $3.00 per pound.*

[d] *From only one trader.*

Source: Weber 1971

15). All of these mammals were reported to be common in the northern parts of the Sandia Mountains. These population numbers probably held until the 1860 or even into the 1870s.

By 1832 the illegal exchange of alcohol for furs had become a problem for Native Americans on the plains. Father Martinez of Taos complained to government officials that this trade was resulting in "these Indian nations [becoming] extremely demoralized and were prompted to greater destruction of buffaloes in order to satisfy their appetites for strong drink . . ." (Lavender 1954: 229–230). Increasing demands back east for robes dictated a rise in price, which exacerbated the alcohol trade and decimation of buffalo herds (Lavender 1954: 13; Carroll and Haggard 1942: 102). Most of the robes collected were shipped east over the Santa Fe Trail or south down the Chihuahua Trail, formerly called the Camino Real (Weber 1971: 217). Based on his observations in the early 1830s, Josiah Gregg (1966, II: 149, 212) warned that the buffalo might become extinct.

In late 1846–47, at the time of the arrival of the U.S. military and the first Anglo settlers, wildlife populations, excluding the buffalo, were still relatively high away from the region's settlements. Travelers commonly reported seeing black bears and grizzly bears, deer, elk, pronghorn, wolves, coyotes, prairie dogs, rabbits, and wild horses. Raccoons, mountain lions, bobcats, weasels, bighorn sheep, and beaver, which were still being trapped, were also recorded in army reports and diaries of civilians (Abert 1962: 18, 22–23, 29, 31, 33–35, 116–118, 138–139, 144–145; Bailey 1971: 310, 357, 364; Brown 1983: 15; Cooke 1952: 54; Hannum 1930: 221–222; Ligon 1961: 8; Marcy 1988: 244, 252; Ruxton 1973: 178; Weber 1971: 224; Wislizenus 1969: 33).

By the 1850s the Anglo instigated robe trade and hunting had severely reduced buffalo populations. No buffalo were reported in New Mexico, and hunters from the Rio Grande were having to travel at least 250 miles to find them. This situation existed until the late 1870s-early 1880s, when a few stragglers from the almost extinct Southern Plains herd wandered into the eastern part of the territory. Because of this scarcity, many Hispanic families increased the size of their sheep and goat herds (Bailey 1971: 14; Batchen 1972: 64–65; Weber 1982: 98). The Territorial Legislature had passed an act in 1880 to protect the buffalo, but it was too late and the last buffalo was seen in New Mexico in 1889 (Bailey 1971: 13–14; Gard 1960: 216).

Populations of other mammals were also subjected to increased hunting, as well as to loss of forage due to growing livestock herds and loss of habitat as a result of the growth of old settlements and the establishment of new ones in the 1860s and 1870s. Nevertheless, elk, bighorn sheep, pronghorn, and grizzly bear remained relatively common in isolated areas. In other locales there were reports of reduced populations, especially of deer and elk (Bailey 1971: 15–17; Barker 1953: 88; Batchen 1972: 49–50, 64, 66, 68; Henderson and Harrington 1914: 2, 16; Lange 1959: 130; Lange and Riley 1966: 167, 170–172).

At the time of the coming of the first railroads to the territory, 1879–81, several local extinctions of mammals occurred. For example, native elk were extirpated in the Jemez Mountains, primarily due to commercial hunting for railroad construction workers (Scurlock 1981: 31). Also, bighorn sheep disappeared from the Jemez Mountains and Merriam's elk from the southern Sangre de Cristo Mountains, primarily due to hunting pressure (Barker 1953: 88; Hewett and Dutton 1945: 105; Lange and Riley 1966: 94). By 1890 market hunters had killed the last Merriam's elk in northern New Mexico. Hunting pressure also severely reduced the pronghorn in a number of grassland locations (Barker 1976: 107; Tyler 1975: 32, 42, 55–56).

Overgrazing began to adversely impact wildlife as well, and livestock raisers also hunted and trapped such predators as the gray wolf, and Mexican wolf, and grizzly bear. These animals were increasingly preying on livestock as a result of the reduction of their prey species (Brown 1983: 31). Grizzlies were more heavily impacted than wolves by stock overgrazing, as they depended partly on grasses, forbs, and shrubs for food (Brown 1985: 100).

Federal involvement in predator control was initiated in 1885, when the Department of Agriculture began to study the use of poison on these animals (Dunlap 1984: 143). Also, a new steel leghold trap for grizzly bears was first used in the region at this time (Brown 1985: 114). By the 1890s bounties were offered on wolves and other predators, and professional trappers, known as "wolfers," began working in the region (Brown 1983: 43; Burbank 1990: 98). Wolves numbered several thousand over the entire territory at this time (Bennett 1994: 200).

The Territorial Legislature also passed the first game laws to regulate hunting of meat and hide animals during the 1890s (Findley et al. 1975: 329), but populations continued to decline. Bighorn sheep were exterminated in the Sandia Mountains by the end of the century, and beaver had been exterminated in virtually all of the region's mountain ranges by fur trappers and meat hunters by this time (Bailey 1971: 215; Findley 1987: 86; Pickens 1980: 83). Pronghorn and deer populations continued to decline in the study region and were reduced further due to ever-increasing hunting pressure.

In 1905 the U.S. Forest Service began to hire trappers to take wolves on federal forest lands, and 3 years later a bounty of $20 for black bears and up to $50 for grizzly hides was paid. The Territorial Legislature enacted a $15 bounty for wolves in 1909 (Barker 1953: 153; Burbank 1990: 98; Dunlap 1984: 143). These species, as well as mountain lions, bobcats, and coyotes, were hunted and trapped in increasing numbers, especially on forest lands (Brown 1985: 123–124). Perhaps the last grizzly was exterminated in the Sandia Mountains in 1906, and the species was reduced to small numbers in other more isolated ranges (Bailey 1971: 365; Barker 1953: 33; Cooper 1989). A total of 510 coyotes were killed on national forest lands in 1907, and some 271 bobcats were trapped or shot on these same public lands (Bailey 1971: 293, 212; Table 52).

In 1900, Congress passed the Lacey Act, which prohibited market hunting and illegal importation of exotic wildlife (Borland 1975: 122). The New Mexico Game and Fish Department was created by the Territorial Legislature in 1904 (Barker 1970: 185). Black bears and wolves remained relatively common, but bighorn sheep were extirpated in several mountain ranges (Bailey 1971: 17, 309, 349–368; Barker 1953: 88; deBuys 1985: 280).

Northern Rocky Mountain elk were introduced to Vermejo Park by its owner in 1908, and within a few years to the Pecos District of the Santa Fe National Forest (Barker 1953: 93–95; Ligon 1927: 71). Pronghorn, reduced to a couple of thousand animals statewide, were removed from the legally hunted game list (Barker 1970: 1982; Matthieson 1959: 283). However, the pronghorn population in the state dropped to a low of 1,200 to 1,700 in 1915–16. This contrasts with an estimated population of 100,000 animals around 1850 (Barker 1970: 192; Findley et al. 1975: 334). Competition with cattle, sheep, and goats, as well as intensive hunting, caused this decrease (Table 52).

Mountain lion and black bear populations were holding their own in the Jemez and Carson National forests, but gray wolves and grizzly bears were becoming rare in the period 1910–20 (Bailey 1971: 286; Henderson and Harrington 1914: 29; Rothman 1992: 140). Increased trapping and poisoning was spurred by congressional action in 1914 mandating the U.S. Biological Survey to take wolves and other livestock predators on public lands. Aldo Leopold of the Forest Service and J. Stokely Ligon with the New Mexico Game and Fish Department were in charge of the program to eradicate wolves in the state. Some 300 trappers and hunters were employed by this program in 1914–15 (Brown 1983: 52, 126–127). Fifty-seven gray wolves and Mexican wolves were killed on national forest lands in 1915, and over 100 were killed in 1916. Mountain lions, coyotes, grizzly bears, and black bears, and bobcats also were taken in relatively large numbers during these 2 years. Loss of some 24,350 cattle, 165,000 sheep, and 850 horses, valued at almost 3 million dollars, was attributed to wolves, mountain lions, grizzly bears, coyotes, bobcats, and "wild dogs" in 1916 (Brown 1983: 57). These livestock figures, which were probably inflated, were used to justify increased hunting, trapping, and poisoning of predators (Brown 1983: 54–57, 1985: 127–133).

Table 52—Mammal populations, 1900–1935.

Species	1900	1905	1910	1915	1920	1925	1930	1935
Merriam elk	VR	E	R[a]	R	R	U	U	U
Grizzly bear	U	U	R	VR	VR	VR	E	E
Black bear	C	C	C	C	U	U	U	U
Gray/Mex. wolf	U	U	R	VR	VR	VR	VR	E
Coyote	C	C	C	C	C	U	U	U
Mountain lion	C	C	U	R	R	R	R	R
Pronghorn	U	R	R	R	R	R	U	U
Bighorn sheep	R	R	VR	VR	VR	VR	VR	R
Beaver	R	R	R	R	R	R	R	R
Bobcat	C	C	U	U	U	U	U	U
Pine marten	U	U	R	R	R	R	R	R

A = abundant, C = common, U = uncommon, R = rare, VR = very rare, E = extinct.

[a] Reintroduced.

Sources: Bailey 1971; Barker 1970; Brown 1983, 1985; Findley et al. 1975; Ligon 1927

The grizzly bear population declined to only 48 animals by 1917. Predator control intensified this year and the next to help produce more beef for U.S. soldiers fighting in Europe in World War I. An estimated 33 black bears, 84 mountain lions, and 103 wolves were killed in 1917, and 123 wolves were trapped in 1918. Poisoning of grizzly bears was initiated by the U.S. Biological Survey in 1918; 28 animals were killed (Bailey 1971: 272, 287, 307, 311, 313, 353; Brown 1983: 57–58; Table 52).

Government trapping-poisoning and private trapping-poisoning, motivated in part by bounties, continued at an intensive pace into the 1920s (Bailey 1971: 307; Brown 1983: 58, 64, 67, 137, 272; Burbank 1990: 106). The grizzly bear, Mexican wolf, and gray wolf were near extinction in the region. Trapping and hunting had also severely reduced the deer, pronghorn, beaver, pine marten, mountain lion, bobcat, coyote, and prairie dog populations (Bailey 1971: 29, 215, 296; Findley 1987: 86; Ligon 1927: 15). By the early part of the 1930s the grizzly bear was probably extinct in the study region, and the gray wolf was extirpated in central and northern New Mexico. The last grizzly in the state may have been killed in 1931 (Barker 1953: 189–190; Brown 1983: 25, 1985: 155–156; 1985: 150, 160–161; deBuys 1985: 280; Ligon 1927: 15; Scurlock 1981a: 148).

Small numbers of pronghorn were reported near Santa Clara Pueblo and about 10 miles south of Santa Fe in the early 1940s (Hewett and Dutton 1945: 108; Hill 1982: 52). A few mink were observed in the Middle Rio Grande Valley in 1947, the same year that the bullfrog, which was probably introduced in the 1930s, was commonly reported in the area (Pillow and DeVaney 1947: 16–17; Sargeant and Davis 1986: 41).

The New Mexico Game and Fish Commission had been given full regulatory powers to manage the wildlife of the state, including establishing hunting seasons and bag limits (Barker 1970: 188; Findley et al. 1975: 29; Flader 1978: 105). Black bears were given protection by the state in 1927, and in 1933 bighorn sheep from Banff National Park were released into the Sangre de Cristo Mountains. Six years later the Federal Aid to Wildlife Act was passed by Congress, and the state acquired some 30,000 acres of wildlife habitat with available funds (Barker 1970: 100–101). Thirty-seven elk from Yellowstone National Park were released in the Sangre de Cristos, and other elk from Oklahoma were released on Mount Taylor in 1940–42 (Barker 1970: 109–110; deBuys 1985:356). La Joya State Waterfowl Refuge was also established during this period (Barker 1976: 104).

Federal and state programs to control or eradicate predators in parts of the region continued into recent decades. With the wolf and grizzly bear eliminated, the focus was primarily on the coyote, which preyed on game species and livestock. The bobcat and mountain lion were also targeted in the 1950s and 1960s. In 1949 the federal Predatory Animal Control introduced the compound 1080, a highly lethal rodenticide, for control of predators and rodents. In 1954 the Federal Government outlawed the indiscriminate use of poison to kill livestock predators. Some sheep raisers began using the "coyote getta," a tube that was stuck in the ground and baited on the end, such that when a coyote, fox, or bobcat bit the bait, a cyanide pellet was propelled by a charge into the animal's mouth. A number of other nontarget mammals, such as badgers, skunks, domestic dogs, and cats, were killed by this apparatus (Brown 1983: 103; Schaefer 1975: xxiii-xxiv).

Trapping, poisoning, and hunting by personnel from various public agencies continued as well. For example, in 1963 over 6,300 coyotes were killed, but notably, there was no decrease in the statewide population. Larger "problem" animals such as black bears or mountain lions were trapped or tracked down and shot by government hunters (Findley et al. 1975: 281–282; McDonald 1985: 12; Moyer 1979: 71).

Birds

Uses of birds by Native Americans were discussed in Chapter 3. Twenty-nine species have been identified in late prehistoric kiva murals; they are listed in Tables 49 and 50. The close relationship between the Pueblo and birds was discussed by Henderson and Harrington (1914) and Tyler (1979).

As with mammals, early Spanish explorers only commented generally on species that occurred in large numbers, such as sandhill cranes, geese, turkeys (domesticated and wild), crows, and starlings (blackbird sp. ?). Spanish hunting of birds was limited; turkeys were usually acquired through trade with the Pueblos. Hunting of "quail, partridges . . . grouse" is mentioned in documents, but apparently this activity was limited (Carroll and Haggard 1942: 99). Numbers of species such as wild turkey, prairie chicken, and "partridges" (probably grouse) appear to have been greater than in more recent history, and their ranges were more extensive (Bolton 1946: 353; Hodge 1956: 353–354; Kinnaird 1967: 95).

Early Anglo American accounts, such as that by Gregg (1966, I: 195) in the 1830s, refer to large numbers of sandhill cranes, Canada and snow geese, and various ducks. Gregg may have been the first Anglo to record roadrunners in the region. In October 1841 Texan George Kendall (1935) wrote the following about birds in the Middle Valley: "Among the stubble, on either side of the road, we noticed immense flocks of blue and white herons and wild geese, so exceedingly tame that we could approach within a few yards of them. The Mexicans seldom kill them, and hence their tameness." Five years later another traveler down the river noted "an abundance of geese, ducks, and pelicans . . ." (Wislizenus 1965: 34).

In 1846 Lt. William Emory (Calvin 1968: 79, 83) recorded "myriads of sand crane, geese, and brant" between Albuquerque and Padillas, and "immense flights of sand cranes and geese" up and down the valley from Padillas to La Joya.

Of the early American observers, Lt. James Abert was the most keen and comprehensive in respect to collecting and describing animal species, recording a number of mammals and 26 species of birds along the Middle Rio Grande (Abert 1962: 65–142; Table 53).

Sandhill cranes remained common throughout the valley over the remainder of the century, and Merriam's turkeys were found in virtually every isolated riparian reach in the study region (Henderson and Harrington 1914: 33, 35). In addition to the above species, army personnel in the 1850s also recorded a single whooping crane, swans, pelicans, blue herons, bitterns, quail, doves, blackbirds, meadowlarks, cardinals (*Pyrrhuloxia* ?), robins, bluebirds, and "snow-birds" (?) (U.S. Surgeon-General's Office 1857: 250–251).

Perhaps the earliest trained naturalist to collect and report on mammals and birds of the region was Samuel Washington Woodhouse, Assistant Surgeon, U.S. Army. He accompanied an army expedition in 1850–51 that

Table 53—Birds recorded by Abert (Alameda to south of Socorro), fall 1846.

Loon sp.	Red-winged flicker (common)
Swan (*C. americanus*)	Sapsucker (yellow-bellied?)
Brant	Gold-winged woodpecker (?)
Goose-snow	Steller's Jay
Teal sp.	Raven
Mallard	Creeper (brown)
Duck	Robin
Merganser	Mexican blue bird (western? mountain?)
Bald eagle	Butcher bird (loggerhead shrike?)
Sparrow-hawk (kestrel)	Blackbird
Wild turkey	Meadowlark (western)
Quail (scaled or Gambel)	
Blue crane (great blue heron?)	

Source: Abert 1962: 71–99, 117–125

marched up the Rio Grande from El Paso to Santa Fe (Ligon 1961: 7). Another army doctor, T. Charlton Henry (1856), recorded 170 species of birds while stationed at forts Thorn, Fillmore, and Webster in 1853–54. His lists include comments on range and seasonal occurrences.

In 1853 U.S. Army surgeon Caleb Burwell Kennerly followed the same route as Woodhouse but only upriver to Albuquerque. Leaving the Ives expedition at this point, he joined the Whipple railroad survey party that marched west to El Morro and Zuni Pueblo via Laguna and Ojo del Gallo. He, too, observed and collected birds in the region (Ligon 1961: 8).

The best known ornithologist of the historic period who worked in New Mexico was Florence Merriam Bailey. She reported trumpeter swans as a rare migrant to New Mexico; whistling swans, once a rare migrant, apparently were extinct by the time she published her *Birds of New Mexico*. She recorded goshawk as an uncommon nester, golden eagles as common residents in the mountains, and ferruginous hawks as a common summer resident on the St. Augustine Plains. Bald eagles were common in western Socorro County. Sage grouse were recorded as common about 1900–08 but soon were extirpated. Band-tailed pigeons, according to Bailey, were fairly common in the higher ranges of the regions, and loggerhead shrike were common nesters in lower elevations (Bailey 1928: 103, 104, 156, 172, 177, 180–181, 211, 297, 597).

By the late 1800s hunting, poisoning, and development had reduced many bird populations and contributed to the extirpation of others, such as the whooping crane, sage grouse, trumpeter swan, and whistling swan. Some locales still supported relatively large numbers of ducks, geese, blue grouse, and turkeys until the early part of this century (Henderson and Harrington 1914: 34–35, 37, 45; McDonald 1985: 22; Nims 1980: 126). A relatively comprehensive list of birds of the region was compiled by Fannie Ford at this time (1911); she reported 314 species and subspecies.

J. Stokely Ligon (1927), who with Aldo Leopold directed the predator control program, headed up a wild game survey of the state in 1926–27. Birds covered included golden eagles, which Ligon viewed as “a serious enemy of certain species of game,” as well as the young of cattle, goats, and sheep. He noted the “slaughter” of hawks, which he considered both beneficial and harmful, had severely reduced their populations. He called for legislation that would protect all birds of prey because of their controlling rodents through predation. Magpies were considered “enemies” of quail, pheasants, and turkeys, and Ligon recommended that federal and state wildlife personnel initiate control programs for magpies (Ligon 1927: 31, 49–52, 55, 58–59, 114–119, 134).

Ligon (1961) later published his *New Mexico Birds and Where to Find Them*, which included historical data on 399 bird species in the study region. Included with species descriptions are notes on former ranges and status of rare, endangered, or threatened species. Ligon (1961: 3, 6–13) also discussed earlier ornithologists and their works (Chapter 6).

Fish

The indigenous fish fauna of the Upper and Middle Rio Grande in the late prehistoric and early historic periods was much more diverse than that of today. The native fish fauna of the two basins at the beginning of the historic period numbered about 27 species (Sublette et al. 1990: 2). Six large species, now extinct, are evidenced by bone or scale remains in prehistoric Anasazi sites or identified from early Spanish records. At least five other species were extirpated later in the historic period (see Chapter 5, Table 62) by morphological and hydrological changes in the basin’s drainages, high siltation, overfishing, introduction of aggressive exotic fishes, construction of dams and reservoirs, climatic changes, and probably introduced pollutants (Gehlbach and Miller 1961; Miller 1961: 365, 394–398; Sublette et al. 1990: 2, 9–11).

The late prehistoric-historic Pueblo harvested fish from the Upper and Middle Rio Grande drainages, probably in limited numbers (Hewett and Dutton 1945: 132, 136). Early Spanish reports are replete with superlative adjectives for the size of native fish populations, such as “abound,” “large quantities,” “teemed,” and “great abundance” (Ayer 1965: 37; Espinosa 1936: 34; Kinnaird 1967: 94). Some members of these early expeditions, as well as later colonial travelers and settlers, caught and ate fish, including eels, from the Rio Grande and tributary streams (Adams and Chavez 1956: 40, 58–59; Espinosa 1936: 34; Galvin 1972: 55, 57). Thirteen species have been identified from early Spanish records (Table 54).

Trout, unidentified as to species, were “abundant” in the Santa Fe River according to Dominguez (Adams and Chavez 1956: 40) in 1776 and Gregg (1966, I: 142) in the 1830s. In 1782 Fray Morfi described the Rio del Norte (Grande) as “crystalline” above the mouth of the Chama River. On fish in the river, he wrote

> It is stocked with fish that are quite good, some of them more than three quarters of a vara [= 33.3 inches] long, having a small mouth placed where other fish have the gill, very few bones and being very appetizing. Matalote, species of barbel larger by a third [of a vara] is a delicious fish, very bony; bagre, a rock fish like sea-brim and of its large size, without more bones than those serving as ribs. It is most pleasing. Cat-fish does not have scales nor bones but in place of these a long nerve from the head to the mouth, ending in a pyramidal point like three fingers. The largest will be about a third of a vara in length (Thomas 1932: 112).

During this period trout were reported to be abundant in various locales in the region, a condition that continued into the 19th century.

Six large species of fish were extirpated in the early territorial period (1846–1912). The shovelnose sturgeon was last taken from the Rio Grande near San Ildefonso in 1874 by members of the Wheeler Geographical and Geological Exploration Survey. They also noted the occurrence of American eel near Santa Fe. Some 14 years later an unidentified species of catfish, weighing from 75 to 100 pounds, probably now extinct, was being caught in the Rio Grande near Rincon (Clark 1987: 32; Schissel et al. 1989: 159).

After the early influx of Anglo settlers (1846–79) into central and northern New Mexico, which placed new pressures on water and fish populations, the Territorial Legislature passed a law in 1880 making it a misdemeanor to use drugs, explosives, or artificial obstructions in taking fish. Trout could be taken only by hook and line. Additionally, operators of mills or factories could not legally discharge harmful waste into trout waters. Another act, passed 9 years later, authorized fish wardens for every county to assist sheriffs and commissioners in enforcing fish laws, including a closed season for fishing, except for members of needy families. This legislation also directed that a sluice for the passage of fish had to be maintained at all dams (Clark 1987: 32).

In spite of the new laws passed in the late 19th and early 20th centuries, native trout and other game fish populations began to decrease in various locations. The exotic and competitive rainbow trout and brook trout were introduced into many rivers and creeks in the region in 1907–08 and 1928. Other species were introduced by the Game and Fish Department in later years (Barker 1953: 54–56; Kuykendahl 1994: 3; Sublette et al. 1990: 67, 77, 166, 331). Still other exotic species, used as bait, were introduced accidentally by fishermen in this century.

Table 54—Fish identified from Spanish records.[a]

bagre—channel catfish (*Ictalurus furcatus*), yellow cat (*Ameiurus natalis*)
corbina—"sea trout" (?)
matalota—"suckers," bony-tail chub (humpback?) (*Gila robusta, G. elegans*)
casona, cazon—gar-pike (*Lepisosteus platystomus*)
sardina—"shiner," "silvery" chub (*Notropis dilectus*)
mojarra—"sardine" (?)
trucha—trout (*Salmo spilurus*)
anguila—eel (*Anguilla chrysypa*)
boquinete—sucker (*Moxostoma congestum*)
aguja—long gar pike or shovelnose sturgeon (*Scaphirhynchus platyrhynchus*)
pescadito—Rio Grande chub (*Leuciseus nigrescens*)
corcobado—"hunchback" buffalo fish
gaspregou—sheepshead (*Aplodinotus granniensa*)

[a] *Scientific name identifications were made by Dr. David Star Jordan pre 1916.*

Sources: Ayer 1965: 37, 261–262; Espinosa 1936: 34, 38; Hodge and Lummis 1916

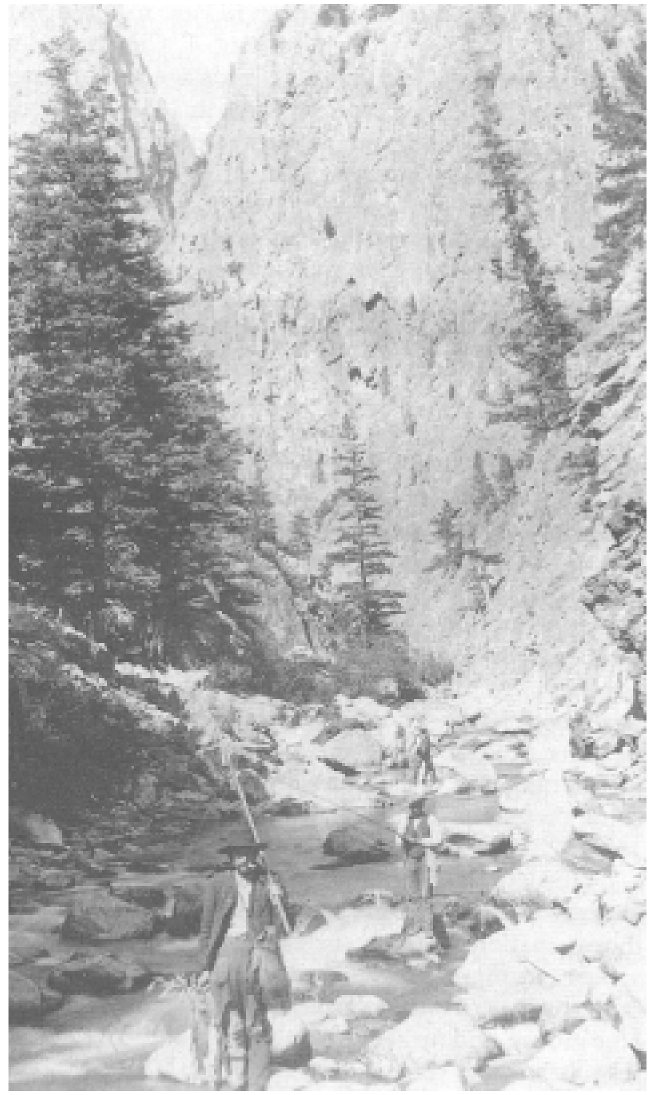

Figure 56—Fishermen on Brazos River, Rio Arriba County. Photo courtesy Museum of New Mexico Archives, Santa Fe (negative no. 72377).

Between the early 1900s and the 1940s native trout populations were decimated, or even extirpated, in many locales in the study region due to overfishing, diminishment of stream flows, increasing sedimentation, pollution, and introduction of aggressive exotic species (Hewett et al. 1913: 35; Pillow and DeVaney 1947; Sublette et al. 1990: 49–74; Fig. 56).

Only limited scientific collections were conducted in the early part of this period, until the work of William J. Koster at the University of New Mexico began in 1939. Koster published an overview of his work in 1957 (Crawford et al. 1993: 37). In recent years the U.S. Fish and Wildlife Service and the New Mexico Game and Fish Department have worked to control exotic species and have reintroduced some native fishes, especially trout, to several streams in the region.

Insects

Except for mosquitoes, insects are mentioned infrequently in the Spanish colonial, Mexican, and territorial periods (1540 to 1912) in New Mexico. Chinch bugs and grasshoppers (or locusts) were the most common insects alluded to by observers. In 1846 George Ruxton recorded 75 varieties of grasshoppers and locusts (Hafen 1950: 150). "Worms," moths, honey bees, "lantern bugs," beetles, lice, tarantulas, mosquitoes, and flies were less commonly mentioned. Mosquitoes were a nuisance, and moths, on at least one occasion, destroyed a large amount of wool in a warehouse in Albuquerque (Simmons 1982: 115). Apparently, the common house fly was introduced to New Mexico between 1840 and 1915 (Gregg 1966, I: 195).

SUMMARY

The Middle Rio Grande Basin, as well as the inseparable Upper Basin, had sustained millennia of human use by the time of first European contact in 1540. Environmental forces such as droughts, floods, and erosion were the primary determinants of the physical and biological conditions over time.

Pueblo, Navajo, Apache, and Southern Ute Indians had modified the landscape, as they, or their predecessors, had for centuries hunted, gathered, farmed, burned, and done other activities. Changes were minimal, temporally and spatially, compared with later modifications generated by the coming Spanish and Anglo Americans due to world view, small populations, and limited technology of these Native Americans. These indigenous peoples were, in fact, as they viewed themselves, entities interrelated with other environmental components of the region. This was reflected in their rituals, songs, languages, and other ecocultural traits. Also, changing environmental conditions significantly shaped the behavior and activities of these indigenous human populations.

Following the later arrival and settlement of two dominant Euro-American groups, historical conditions began to change more dramatically. The Spanish and Anglo views of the environment, their introduced infectious diseases, metal weapons and tools, new cultigens, and exotic plants, and their rapidly expanding populations (after 1750) brought new and extensive impacts to the study region. These impacts resulted in even more complex changes, sometimes extreme, not only for the physical landscape and associated biological components but also for the indigenous peoples as well. Attempts to regulate and manage the forces at work began in the late 1800s, but effective efforts of new laws, agencies, and programs were not able to reverse some processes such as species extinction. More recently, management and preservation of environmental conditions have been more successful, owing to changing environmental views of the private sector, as well as those of government agencies. Clearly, the historical conditions of 1540, or 1750, or even 1920 will never be replicated.

CHRONOLOGY

1400s–1600s	Based on archeological evidence, 54 species of birds were used at Las Humanas and Pueblo del Encierro for meat, feathers, and personal adornment (Snow 1981: 364).
1540	Alvarado, one of Coronado's chroniclers, wrote this description of the Tiguex Province (Isleta to near San Felipe): "This river of Nuestra Senora flows through a broad valley planted with fields of maize and dotted with cottonwood groves. There are twelve pueblos, whose houses are built of mud and are two stories high. They have a food supply of maize, beans, melons and turkeys in great abundance" (Bolton 1969: 184). He also described the Rio Grande as "a large, mighty river" (Hodge 1946: 352).
1540	From first European contact and throughout the historic period, the main items traded by the Pueblos to other Native American groups were corn flour, pollen, and husks; pinyon nuts; turquoise; salt; feathers of eagles, hawks, turkeys, and a number of small birds; and woven baskets and pottery (Sando 1989: 29–30, 38).
1540	The Rio Grande floodplain was 35 to 40 feet lower than the 1962 levels (Titus 1963: 11).
1540	The Pueblos gathered large quantities of herbs . . ." for food (Hammond and Rey 1940: 256).
1540	The Tiguex Pueblo kept poisonous snakes (probably rattlesnakes) in their villages. Poison was extracted from the snakes and placed on arrow-points to facilitate killing of prey animals (Bandelier and Hewett 1937: 169).
1540–41	The Pueblos collected pine nuts, and some were stored for later consumption (Hodge 1946: 350).
1540–94	Spanish explorers noted the abundance, utility, and trade value of furs and skins (Weber 1971: 14).
1541	(fall) Castaneda reported a large number of cranes (probably sandhill), wild geese, crows, and "starlings" (probably a species of black-

bird) in the Tiguex Province. He also noted that there were a "great many native fowl in these provinces, and cocks with great hanging chins [wild turkey]" (Hodge 1946: 353–354).

1541 Alvarado, with the Coronado expedition, reported "There are large numbers of bears in this province, and lions, wildcats, deer, and otter [beaver ?]" (Hodge 1946: 350).

1581 (late September) At the Galisteo pueblos, Chamuscado and Rodriguez were told of Plains Apaches to the east who subsisted on buffalo meat in winter and harvested prickly pear and yucca fruit in summer. They lived in buffalo hide tipis and also traded hides, meat, and deerskins for corn and blankets at the Pueblo villages. The buffalo, they said, were "as numerous as the grains of sand in their hands, and there were many rivers, water holes, and marshes where the buffalo ranged." Residents of the San Marcos Pueblo told members of the expedition that "during certain seasons of the year the buffalo came within eight leagues of the settlement" (Hammond and Rey 1966: 86–87).

1581 The Chamuscado-Rodriguez expedition called the lower Galisteo valley "Valle Vicioso because of its fertility . . ." (Hammond and Rey 1966: 59).

1583 (February 1) At the Piro village of San Felipe the Espejo expedition recorded its inhabitants as wearing cotton cloth and tanned deerskin clothing, buffalo hide moccasins, cotton blankets, and turkey feather robes (Hammond and Rey 1966: 172).

1583 (February 10–12) The Salinas Pueblos had "abundant corn, turkeys, and other supplies" and wore clothes made from buffalo hides, cotton blankets, and "chamois skins." Their villages were located on the west edge of the buffalo range (Hammond and Rey 1966: 222).

1583 (February) A member of the Espejo expedition described the Jemez River near Zia Pueblo as "a fine river with a good volume of water, though it was not so large as the Del Norte" (Hammond and Rey 1966: 180).

1583 (February) Espejo reported "many cottonwood groves and some patches of white poplars four leagues wide" and "quantities of grapevines and Castilian walnut trees" as he traveled up the Rio Grande from the San Marcial area to the Keres pueblos (Hammond and Rey 1966: 219).

1583 (late February) Espejo noted a magpie in a cage at a Keres pueblo (Hammond and Rey 1966: 223).

1583 (late February) Near Cochiti Pueblo the Espejo expedition gave inhabitants of the area sleigh (hawk?) bells and "iron articles" for buffalo hides (Hammond and Rey 1966: 179).

1583 (early) In the San Marcial area Espejo noted "... along the river banks there were many cottonwood groves and some patches of white poplars four leagues wide" (Hammond and Rey 1966: 219).

1583 (March 5–6) At Acoma, Espejo was given "blankets, tanned deerskins, turkeys, and a quantity of corn" (Hammond and Rey 1966: 182).

1583 (March 7) Antonio de Espejo wrote this about Acoma, "These people have their fields two leagues distant from the pueblo, near a medium-sized river, and irrigate their farms by little streams of water diverted from a marsh near the river" (Hammond and Rey 1966: 182, 224).

1583 (June) Cottonwoods were growing near Kuaua Pueblo (Riley 1987: 228).

1583 Diego Perez de Luxan, with the Espejo expedition, wrote "This province ... has many forests of pine and juniper trees...." On the way to Pecos, he noted their travel "through a forest of pines, mostly juniper and white pines. The pine trees were all laden with cones the size of unshelled walnuts. Each cone contains at the most about thirteen or fourteen good-sized kernels" (Hammond and Rey 1966: 176, 206). From about San Marcial to Socorro, Espejo himself noted "mesquite groves and cactus fields, and over mountains wooded with pine forests producing pinon nuts like those of Castile, as well as with savins and junipers" (Hammond and Rey 1966: 219).

1583 Espejo's expedition exchanged iron and small bells for corn, tortillas, turkeys, pinoles, and buffalo robes at Cochiti (Riley 1987: 238).

1591 (January 8) Castano de Sosa may have been the first European to reach the Santa Fe River. He described the event: "It was bitterly cold and snowing. When we emerged from the sierra we came to a river, frozen so hard that the horses crossed on the ice without breaking through" (Hammond and Rey 1966: 280).

1591 (late January) South of Pecos Pueblo, in the Galisteo area, Sosa's expedition traveled "through thick pine forests, then camped "for the night at a ravine with many juniper trees" (Hammond and Rey 1966: 287).

1591 (early) Wood-burning "ovens" were noted by Castano de Sosa at San Ildefonso (Riley 1987: 235).

1591 Explorer Sosa referred to the Rio Grande at San Juan Pueblo as a "deep river," and later as "the river with much water" (Schroeder and Matson 1965: 129, 144).

1598 (late May) North of the Jornada del Muerto, the Juan de Onate expedition procured corn from the Piro Pueblo of Qualacu, which helped alleviate the food shortage for the Onate expedition. Travel continued to be arduous due to the soft, deep sand. The wheels of the supply carts sank to their hubs. As the expedition moved northward, a rainstorm provided needed water, as well as substantially decreasing air and ground temperatures (Simmons 1991: 105–106).

1598 (spring) Onate found "many pueblos and planted fields on both sides of the Rio Grande" from Casa Colorado to north of Albuquerque (Moorhead 1958: 24–25).

1598–99 Onate's colonists complained about living in Pueblo rooms, which they found poorly ventilated and infested with bedbugs and other biting insects (Ellis 1987: 19).

1598–1602 Onate recorded wild turkeys in the province and listed the following mammals for the region: "buffalo, goats with hideous horns [bighorn sheep], lions, bears, wolves, tigers [jaguars ?], penicas, ferrets, porcupines, and other animals" (Bolton 1946: 353).

1598–1630 With the construction of more irrigation systems and the introduction of livestock by the Spanish, the demand for surface water increased significantly (Meyer 1984: 50).

1598–1630 By growing winter wheat brought by the Spanish, the Pueblos extended the farming season, and by adopting livestock, they had to hunt less for meat and hides. The use of cow dung for firing pottery and heating homes may have begun during this period (Schroeder 1975: 53).

1598–1680 New Mexico's governors dominated the export trade in furs and skins, such as those of buffalo, antelope, elk, and deer (Weber 1971: 18–19).

1598 (post) A grass native to Eurasia, sheep fescue (*Festuca ovina*), may have been introduced to New Mexico via the fleece and droppings of domestic sheep brought by Onate (deBuys 1985: 225).

1599 (early) Onate moved his headquarters and capital to the west side of the Rio Grande to San Gabriel Pueblo. Most of the Pueblo inhabitants left, but some remained to haul water and fuelwood for the Spaniards (Simmons 1991a: 1458–149).

1599 (late October) Juan de Onate described the Rio Puerco-of-the-East in the Cabezon Peak area as having many cottonwoods and fairly deep water where he crossed the stream. He named the river "La Torriente de los Alamos" and described the valley as "lush, rich, and fertile" (Lopez 1980: 71, 77).

1599 Hunters with Onate shot a large number of ducks and geese (Espinosa 1936: 34).

1500s (late) Obregon wrote that the Rio Grande was "swift and beautiful, surrounded by numerous meadows and farms..." (Hammond and Rey 1927: 291).

1600 (post) The area along the east side of the Rio Grande between Alameda Pueblo lands and the Mexia "swamps" was called "Bosque Grande" (Adams and Chavez 1956: 145).

1600–34 Spanish livestock herds nearly doubled every 15 months (Gutierrez 1991: 57).

1600–50 The Spanish conquistadores and military officers brought mastiffs and large greyhounds to New Mexico. These "war dogs" were used in combat, which terrorized Native Americans. They were also used in hunting, especially the greyhound (Simmons 1991b: 36).

1604 Spanish carpenters trained Pecos Pueblo men in wood-working skills. The accessibility and diversity of woodlands and forests in the area provided the basis for a vigorous craft over the next 150 years. Carved corbels and vigas, doors, window frames, and furniture were crafted to meet local and regional demands (Kessell 1975: 132–133).

1610 Villagra, who accompanied Onate's 1598 expedition, wrote "The rivers abound with fish, turtles, eels, trout and sardines. These exist in such quantities that a single Spaniard with a large bare hook was able to catch six arrobas [240 pounds] weight" (Espinosa 1936: 34).

1600s (early) Under the encomienda system, Spaniards took Pueblo lands for grazing of livestock. Localized overgrazing and soil erosion resulted. Water was also diverted to Spanish fields, causing a shortage for Pueblo crops (Sando 1989: 53).

1600s (early) (to 1680) Pueblo residents were forced to collect firewood, salt, and pinyon nuts in large quantities, to prepare hides, and to manufacture cotton blankets, causing stress among the villagers (Snow 1981: 368).

1600s (early) (to 1680) Items exported south from New Mexico included sheep, raw wool, hides (buffalo, deer, and antelope), pinyon nuts, salt, Indian blankets, and El Paso brandy (Moorhead 1958: 49).

1610 (post) According to Aldo Leopold, mountain meadows and foothills were overgrazed by Hispanic livestock (Brown and Carmony 1995: 230).

1626 (pre) Fray Alonso de Benavides recorded that the Tewa were experiencing famine due to insufficient irrigation water (Hodge, Hammond, and Rey 1945: 39, 69).

1620s (to early 1700s) An extensive stand of cottonwoods was found along the Rio Grande in the Albuquerque area. It was known as the Bosque Grande de San Francisco Xavier. South of this woodland was the open wetlands called Esteros de Mejia (Simmons 1982: 40).

1630 Fray Benavides (Ayer 1965: 36–37) described the regional rivers as having "... fish in great abundance; and great sloughs [esteros], and particularly the Rio del Norte. This, when it carries least water, and we can ford it, comes up to the saddle; and when it goes swollen, it is of rapid and great current, with the water it receives from the melted snows alone."

1630 As an endurance test, a candidate for membership in one of the secret Pueblo societies or orders had to sit naked all day on a large ant hill and endure stinging bites without making a sound (Ayer 1965: 31–32).

1630 Fray Benavides wrote "The abundance of game appears infinite." He noted that foxes, wolves, mountain lions, wildcats, jackrabbits, and cottontail rabbits were numerous. Bighorn sheep was a common species in the uplands (Ayer 1965: 37).

1630 Fray Benavides listed the following fish found in the Rio Grande Basin: bagre (blue catfish, *Ictalurus furcatus*), trucha (trout, *Salmo* spp.), yellow bullhead, *Ictalurus natalis*), anguila (eel, *Anguilla rostrata*), boqeinete (sucker, *Moxostoma* sp.), sardina (chub, *Notropis* sp.), aguja (gar shovel-nose sturgeon, *Scaphirhynchus playtyrhynchus*), cazon (longnose gar, *Lepisosteus osseus*), and matalote (Gila chub, *Gila intermedia*) (Ayer 1965: 37, 261–262).

1630s (early) Grasshoppers and rabbits destroyed crops at various Rio Grande pueblos (Schroeder 1972: 5).

1635–37 Governor Francisco Martinez de Baeza forced converted Indians to collect and pack large quantities of pinyon nuts for shipment down the Camino Real (Kessell 1979: 155–156).

1639 Governor Rosas shipped 122 painted buffalo hides and 198 "chamois" skins south on the mission supply caravan (Weber 1971: 20).

1600s (mid) Prairie chickens were found in the Salinas Province (Schroeder 1968: 102).

1600s (mid to late) The market for buffalo hides in Mexico sharply increased demand. Spanish traders by-passed the Pueblo middlemen and dealt directly with Plains Indians for the hides. Colonists and government agents exerted pressure on the Pueblo to procure even more hides, causing more stress among the villages (Snow 1981: 367–368).

1659 Some priests traded with various Indian groups for pronghorn skins (Weber 1971: 19).

1660 Governor Mendizabal received a shipment of 23 fanegas of pinyon nuts from Pecos Pueblo (Kessell 1979: 156).

1660 Governor Lopez de Mendizabal shipped 1,350 deer skins and a number of buffalo hides to Parral to market. He sent two other large shipments of skins there during his term. Some 1,200 pronghorn skins and four bundles of elk skins were later found at his property in Santa Fe (Weber 1971: 20–21).

1661 Some 60 Pueblo laborers from Quarai were conscripted by the Spanish to harvest and transport loads of pinyon nuts. Nineteen Indians from Abo worked for 6 days carrying maize from Tabira and Las Humanas pueblos to the house of Captain Nicolas de Aguilar in the Salinas District (Scholes 1937: 394–395).

1661 Also, some 40 Indians of Jemez Pueblo were forced by the Spanish to transport pinyon nuts to "depots" at Santa Fe, Cochiti, and San Felipe (Scholes 1937: 394–395).

1661 Pueblo Indians from Tabira collected salt at a nearby salt marsh and transported it to the Las Barrancas estancia of Sargento Mayor Francisco Gomez (Scholes 1937: 395).

1661 The mission livestock were moved from Las Humanas to Abo because the Pueblos exhausted themselves hauling water for the stock from deep wells to the west of the village (Scholes 1937: 401).

1661 An organ for the church at Abo was purchased with money made by selling pinyon nuts (Toulouse 1949: 4).

1662 At Tome, the Rio Grande channel was located east of its present location (Kessell and Hendricks 1992: 480).

1662 Encomienda system payments made by Indians at Pecos Pueblo included 66 pronghorn skins, 21 white buckskins, 16 large buckskins, and 18 buffalo hides (Weber 1971: 18).

1667 Locusts devastated crops, especially at Santo Domingo Pueblo (Kessell 1979: 218).

1675–1706 No fires appear to have occurred on the west-central slopes of the Sandia Mountains during this period (Baisan 1994: 2).

1675–1710 The pueblo and later land grant of Alameda was located on the west side of the Rio Grande. Sometime after this, and before 1769, the river shifted westward, leaving the village of Alameda on the west side of the Rio Grande (Sargeant 1987: 38–40).

1680 (August) Revolting Pueblo Indians forced Spanish Governor Otermin to abandon his defense of Santa Fe by cutting off the settlement's water supply from the Santa Fe River (Sando 1989: 55).

1681 (December 11) The Spanish army found little firewood in the vicinity of Alameda Pueblo (Hackett and Shelby 1942: 224).

1681 At Puaray Pueblo, near the Rio Grande, there were meadows on either side of the river. They provided "good pasturage and stubble, and there is an abundance of firewood on the other side" (Hackett and Shelby 1942: 220–221).

1692 (pre) Blue catfish occurred in the Rio Grande in the Espanola-Santa Fe area. It is now only found south of Albuquerque, and populations are dwindling (Sublette et al. 1990: 238).

1692 (late August) The condition of the Camino Real was degraded following 12 years of little or no traffic. In many places grasses, forbs, and shrubs had grown up in the road bed. Vargas sent the sheep, cattle, and horses ahead to trample the vegetation, providing a clearer and smoother road for the wagons and settlers in the caravan. In some places, the road was gullied due to water runoff, and Vargas had men ready to repair the road (Hendricks 1993: 81).

1692 (September 4) The Spanish army of the reconquest rested at the abandoned rancho of Felipe Romero near the abandoned Sevilletta Pueblo. This site was selected for its excellent grasses and adequate water (Espinosa and Chavez n.d.: 22).

1692 (September 6) General Vargas led his army up the Camino Real over a "very sandy" road and camped within sight of the hacienda of Tome Dominguez, which then was on the west bank of the Rio Grande. The condition of the road prompted the commander to send the pack animals back for cargo on the laboring wagons so there would be provisions in his camp (Kessell and Hendricks 1992: 375–376, 480).

1692 (late October) Diego de Vargas, who crossed the Rio Puerco west of the later site of Albuquerque with his command, noted that the water was so deep that the soldiers had to carry provisions and equipment on their shoulders (Lopez 1980: 71; Twitchell 1963, I: 381).

1692 (late) Vargas reported that "the river has ruined the fields" of Senecu Pueblo (Kessell et al. 1995: 114).

1692 (late) Vargas described the environment of Zia Pueblo as having "alkaline soil, bad water, no firewood, and is infertile . . ." (Kessell et al. 1995: 113).

1692 (late) Vargas described the environment of La Cienega Pueblo and the El Alamo hacienda as "the terrain and soil are of dry, fine gravel, are well drained, and where the sun shines from the time it comes up . . ." (Kessell et al. 1995: 111).

1692–93 The Esteros de Mejia, which extended along the east side of the Rio Grande from the present Central Bridge to the Barelas Bridge, was the site of a "hacienda" on the Camino Real. Made up of charcos (small lakes) and cienegas (marshes), which supported lush grasses, sedges, and other forage plants, these wetlands were utilized by legal and trespass livestock ranchers. This led to a near fatal altercation among several individuals (Simmons 1982: 10, 40, 87, 112).

1693 (late summer-early fall) The pueblos of San Felipe, Santa Ana, and Zia lost their potential crop harvest due to "worms and the many locusts" (Kessell et al. 1995: 408).

1693 (November 10) Vargas found a "good" campsite at a ford opposite the abandoned hacienda of Ignacio Baca on the Rio del Norte (Kessell et al. 1995: 403).

1693 (November 15) Spanish soldiers and settlers were camped in an "ancon opposite Isleta Pueblo" (Kessell et al. 1995: 407.

1693 (November 19) Vargas ordered his troops and Spanish settlers to the outpost he designated "Plaza de Armas," at the abandoned hacienda of Cristobal de Anaya. This site was north of present Bernalillo and had "abundant firewood and pasture, near the Rio del Norte..." (Kessell et al. 1995: 421).

1693 (December 10) Vargas (Espinosa 1942: 148) described a watering place at San Marcos Pueblo in the Galisteo basin as ". . . where the bountiful water hole and crystal clear stream were certainly a blessing."

1693 There was no late summer-fall harvest due to worms and grasshoppers at Santa Ana, San Felipe, and Zia pueblos (Bailey 1940: 95–98).

1694 (January) Vargas described Jemez Pueblo as on "a height" and "in a good location" with "the necessary conveniences of pasture, water, and firewood" (Kessell et al. 1995: 558).

1694 (May) Plains Apaches visited Governor Vargas at Pecos Pueblo and presented him three buffalo hides and an elk-hide camp tent as gifts. They promised to bring buffalo, elk, and deer hides to trade in the fall (Weber 1971: 22).

1694 (July) Vargas found bison between the Rio Grande and Rio Chama (Bailey 1940: 152–154; Bailey 1971: 152–156).

1695 (summer) An infestation of worms ate most of the crops, which contributed to a famine in the following year (Twitchell 1963, I: 409).

1696 A famine impacted the Pueblo and Hispanic settlements. Various wild animals and plants, in the valleys and the mountains, were commonly harvested and eaten (Twitchell 1963, v. 1: 409).

1600s Bones of the smallmouth buffalo (fish) were found in archeological sites dating to this period along the northern Rio Grande drainage (Sublette et al. 1990: 222).

1600s The Jicarilla Apache believed that the bighorn sheep were driven from their valley habitat into the mountains by the guns of the Spaniards (Tiller 1992: 22).

1600s (late) Rafts were used to cross the Rio Grande to reach the pueblo of San Felipe located on the west bank of the Rio Grande (Strong 1979: 392).

1600s–1706 A bosque extended south from the Alameda Pueblo, along the Rio Grande, to the swamps or marshes of Mexia on the south side of Albuquerque (Adams and Chavez 1956: 145).

1700–1800 About 27,000 new acres were put into cultivation by the Spanish in the Middle and Upper Rio Grande valleys (Hedke 1925: 23).

1701 The Rio Grande channel was several hundred yards east of its late 19th century position in the Bernalillo area (Bowen and Sacca 1971: 51).

1705 The Rio Grande was located east of present Bernalillo, and at times, the river flowed along the east side of the valley from Angostura to below Albuquerque (Chavez 1957: 3).

1706 April The site of Albuquerque was chosen for the availability of good water, tillable land, good grazing grasses, and fuelwood. This location was also selected due to its being on slightly elevated ground, on the Camino Real, and having a good, close ford over the Rio Grande (Simmons 1982: 81–82).

1706 The east bank of the Rio Grande was heavily wooded from modern Ranchos de Albuquerque to below Central Avenue (Simmons 1980: 202). The area settled by the new residents of Albuquerque was known as the Bosque Grande de San Francisco Xavier. The Esteros de Mexia, located just south of Old Town, was avoided by the settlers (Oppenheimer 1962: 15).

1709 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1709–39 The channel of the Rio Grande between Algodones and Bernalillo shifted westward. The church and several homes at colonial Bernalillo (near present Llanito) were washed away in 1735 or 1736 (Snow 1976: 172–175).

1709–63 Santa Ana Pueblo purchased lands from Spanish settlers at Ranchitos, located on the east side of the Rio Grande, along the north boundary of the Bernalillo Grant. Some of the land was used for irrigation farming and the remainder for livestock grazing. The latter area was covered with cottonwood trees (White 1942: 27).

1710 (January 27) The Alameda land grant was given to Captain Francisco Montes Vigil. At this time the village and grant land was located on the west side of the Rio Grande (Adams and Chavez 1956: 152).

1710 (post) The Rio Grande, then located east of Alameda, began shifting westward. By 1768 the channel had moved to its present location, placing the village of Alameda on the west side of the river (Sargeant 1987: 38–39).

1700s (early) The Rio Grande shifted its channel and at times ran east of Bernalillo, Alameda, and Albuquerque (Chavez 1957: 3).

1700s (early) Due to continuing flood damage to their agricultural fields, Santa Ana Pueblos began buying land along the Rio Grande, to the east, where they established ranchos. They moved to these new settlements from spring planting to fall harvest and then returned to the old pueblo for the winter. Later, in the next century, these Keresans established permanent residence at the Ranchos de Santa Ana and returned to their Jemez River pueblo only for ceremonies (Kessell 1980: 168).

1700s (early) Residents of Agua Fria reported to geologist Oscar Loew (1875) that the Santa Fe River had run "full" and that cottonwood and willow species grew along its banks.

1700s (early) Overgrazing had become a problem around the older plazas such as Atrisco, Albuquerque, and Corrales (Baxter 1987: 24).

1700s (early) Sedge grasses and other wetland vegetation were abundant in a cienega located in the eastern part of Santa Fe. This was a special-use property where these plants were "mowed" and fed to the horses of the presidial troops, who escorted town residents to the mountains, where they collected fuelwood or timber (Ebright 1994: 90).

1700s (early to mid) As the flow of the river diminished, which Loew attributed to the disappearance of extensive forests at the river's headwaters and a decrease in precipitation over the area mountains, the trees diminished (Hewett and Dutton 1945: 147).

1713 A lagoon (estero) was located near Bernalillo (Mayer et al. 1994: 80).

1714–17 At least one crop failure due to drought occurred (Simmons 1982: 111).

1715–16 Wildfires were common and widespread during these years (Baisan 1994: 3; Swetnam and Betancourt 1990: 1019).

1722 Captain Antonio Cobian Busto reported "From the city of San Felipe el Real [Chihuahua] to Santa Fe in New Mexico... there are innumerable valleys, streams, and plains, very rich and suitable for breeding cattle and sheep, and sowing wheat, corn, and other foodstuffs..." (Baxter 1987: 19).

1724–25 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1726 Pedro de Rivera visited the Valencia area noting spacious, fertile valley land with extensive cottonwood bosques. He passed several ruined ranches in the Valencia area still uninhabited following the Pueblo revolt (Rivera 1946: 51).

1729 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1736 (early) Five Albuquerque farmers requested that the alcalde allow them to move their livestock back to the Isleta area where better grazing conditions existed (Baxter 1987: 24).

1739 (July 30) The alcalde of Albuquerque, who presented the governor's decree on the Tome land grant, noted that the location was "very damp and in danger of being inundated again" (Ellis 1955: 91–93).

1739 Some residents of Albuquerque, who were experiencing scarcity of wood, insufficient pasture for livestock, a scarcity of irrigation water, and encroachment of footpaths on their land, requested and received the Tome land grant (Ellis 1955: 91; Oppenheimer 1962: 16).

1739 (ca.) The Rio Grande shifted westward in the Angostura area, which resulted in a later boundary dispute between Santa Ana and San Felipe (Bayer et al. 1994: 90).

1730s (late) (to early 1742) Pedro Sanchez claimed that wolves attacked and bit his sheepherders on the Ramon Vigil grant and caused him to remove his sheep (Ebright 1994: 229).

1740 (November 15) The governor granted land to Hispanic settlers who founded Belen, Jarales, and other area communities. Ditches from the Rio Grande to fields were dug with palas de palo (wooden shovels). The uplands along the Rio Puerco-of-the-East and the Manzano Mountains were common lands for grazing livestock, collecting fuelwood, and hunting (Espinosa and Chavez n.d.: 75–78).

1744 The Santa Fe River was described as a flowing stream with crystalline waters and abundant trout within the capitol (Hackett 1937: 27, 34, 399).

1744 Valley cottonwoods extended more than 10 miles along the Rio Grande around Alameda (Galvin 1972: 58).

1744 Albuquerque experienced an infestation of moths, which were eating large stores of raw wool. Fortunately, a buyer from Mexico City arrived and purchased the wool before the insects destroyed very much (Simmons 1982: 114–115).

1748 The frequency of wildfires was substantially above normal (Swetnam and Betancourt 1990: 1019).

1748–1846 Sandia Pueblo lost a significant portion of its lands to Hispanics because of its fertility and available water (Clark 1987: 22).

1749 Belen residents were in a legal dispute with Nicolas Duran y Chavez, whose cattle, they claimed, were damaging and fouling the acequia madre. He said that finding pasture for his cattle and sheep was difficult (Horvath 1980: 111).

1700s (mid) Intensive livestock grazing and fuelwood cutting led to denudation and soil erosion along Abiquiu Creek. Water from the stream tasted and smelled like cattle manure (McDonald 1985: 120).

1700s (mid) The Rio Puerco Valley at this time was rich in grasses, bosques, springs, and lakes. There were "belly-high grasses, vast bosques, and wooded thickets." The floodplain was broad and flat, and flood waters overflowed the low banks and spread out over the valley. Many lakes dotted the valley, and springs were numerous (Lopez 1980: 71).

1750 Santa Fe had evolved to a rancheria of houses and fields distributed along three leagues of the Santa Fe River valley. Residents wanted to be near their fields for convenience and to protect their crops against thieves and foraging animals (Simmons 1974: 61).

1750 By this year Albuquerque and nearby communities were experiencing some pressures of overpopulation. Suitable agricultural land was taken, and livestock overgrazed some pastures and outlying range lands. By this year, the bajada between Albuquerque and the Sandia-Manzano mountains was virtually denuded of grass by livestock. Outmigration to "new" lands, such as the Rio Puerco-of-the-East, began (Simmons 1982: 106–107, 1988: 7).

1751 Timber for use as vigas in the Sandia Pueblo church then under construction was cut in the Sandia Mountains. Since the pueblo had no oxen to pull the logs down from the mountains to the village, residents of the five Keres pueblos to the north and Spaniards from Bernalillo were recruited to do this. In about 20 years, the roof of this new church collapsed due to poor engineering or shoddy construction (Kessell 1980: 136).

1752 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1753 (October 21) Several Albuquerque families, seeking adeuate grazing for their livestock, petitioned the governor for a grazing grant on the Rio Puerco (Simmons 1982: 106–107).

1754 A priest described the Rio Grande as "a beautiful image of the celebrated Nile" (Timmons 1990: 39).

1750s As the Navajos were forced south by Utes, conflict over resource competition in the Rio Puerco basin with Hispanos accelerated (Lopez 1980: 72).

1750s (late) (to 1760) Major Spanish settlement of lands along the Middle and Upper Rio Puerco and on the south and west sides of Mount Taylor occurred (Wozniak 1987).

1760 Bishop Tamaron noted that the Santa Fe River was dry during the summer months prior to harvest, and the Rio Grande had ice during the severely cold winters (Adams 1954: 47, 65, 105).

1763 July 7 Representatives of Santa Ana Pueblo exchanged over 200 head of livestock and several items for a tract of land south of Angostura and extending from the Rio Grande to the foot of the Sandia Mountains (Bayer et al. 1994: 80–81).

1763 By this time, an "upper" and a "lower" Bernalillo were recognized. Soon, however, the upper settlement was forced upriver to Algodones, a location of higher elevation, by floods (Snow 1976: 175).

1763 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1765 Eight residents of the Los Quelites grant on the nos Puerco and San Jose requested Governor Capuchin's permission to withdraw from the grant, claiming that there was insufficient and salty water in the two streams. Water from springs and a cistern were used for watering their corn, chile, and cotton (Ebright 1994: 10).

1765 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1766 (August 12–13) Nicolas de Lafora passed the Senecu and San Pasqual pueblo ruins, and found "plenty of pasture" in the area. From here to the Vueltos de Acomilla, he passed through "swampy ground with a great deal of coarse grass and reeds," which included the Bosque del Apache (Kinnaird 1967: 88).

1766 (August 14) Opposite the ruins of Sevilleta Pueblo, Lafora wrote about the mouth of the Rio Puerco "whose waters always flow muddy and turgid" (Kinnaird 1967: 89).

1766 (August 15–16) Lafora continued to travel north up the east bank of the Rio Grande. His expedition reached Las Nutrias, then Tome, passing over a "good level road." The population of Tome was given at 70 Spanish residents. Lafora noted that "all kinds of grain abound, as well as sheep, and there is plenty of good pasture everywhere in the vicinity. On the next day he traveled 10 leagues north over "a plain extensively forested with poplar trees along the river's edge" (Kinnaird 1967: 89–90).

1766 Lafora (Kinnaird 1967: 95) wrote "There is a great variety of birds. Partridges are abundant and are caught by hand after their first flight."

1766 Lafora noted "large quantities" of fish in New Mexico's rivers (Kinnaird 1967: 94).

1766 Lafora reported for central and northern New Mexico that "There is more than enough pasture, which is grama grass for the most part" and "There are several rivers containing a large quantity of fish, particularly the Rio Grande del Norte" (Kinnaird 1967: 94–95).

1766 Lafora listed buffalo, bear, wolf, coyote, bighorn sheep, elk, deer, and "partridges" (grouse ?) as game animals. He noted that the fur-bearing beaver, ermine, and marten, which were abundant, were ignored by Hispanic residents (Kinnaird 1967: 95).

1767 A severe flood on the Santa Fe River impacted Santa Fe. The river channel shifted into the Rio Chiquito, which is now covered by Water Street (Twitchell 1963, I: 447).

1768 (April) Residents of Atrisco received a grant of grazing lands to the west, along the Ceja de Puerco (Wozniak 1987).

1769 Dominguez related a report "... in the year '69 of this century the river flooded (turning east) the greater part of Tome, to the total destruction of houses and lands. It follows this course to this day [1776], and as a joke (let us put it so) it left its old bed free for farmland for the citizens of Belen, opposite Tome (and they still have it, and Father Claramonte, from whom I heard this tory, has seen it planted)" (Adams and Chavez 1956: 8).

1760s The lower Rio Puerco began entrenchment, a process that continues today (Love and Young 1983).

1771–75 The annual crop harvests at San Ildefonso Pueblo were diminished due to infestations of "locusts" (Adams and Chavez 1956: 71).

1771–76 Locusts caused losses in crop production (Adams and Chavez 1956: 71).

1770s (early) To prevent depletion of provincial resources, New Mexico governors banned exports of wool and livestock. Sheep flocks increased, and officials allowed sale of woolen products and wethers. Late in the century, sheep numbers increased until export of the animals increased dramatically. Ranchers brought their animals to la Joya de Sevilleta in August to begin the drive south down El Camino. As this was the rainy season, the flocks and men would have adequate water on their journey (Baxter 1993: 109).

1773 A New Mexican of the Rio Abajo commented on a positive aspect of Rio Grande floods: "The water brings with it a thick mud which serves as manure for the land, leaving on top of the irrigated earth a glutinous scum resembling lard" (Simmons 1982: 96).

1774 Spaniards at San Juan de los Caballeros, Rancho del Embudo, and Picuris Pueblo were taking trout and eels for food (Galvin 1972: 57).

1774 O'Crouley recorded trout, eels, ahujas, and besugos as food fish caught by residents (Galvin 1972: 55, 57).

1774 Don Pedro Alonso O'Crouley described the Alameda area as "a plain that for a distance of four leagues is covered with poplars [cottonwoods] (hence its name), which beautify the country. The Rio Grande crosses its central region, making it fertile. On its banks is a settlement of a few families under the spiritual care of a friar attached to the mission of Albuquerque, three leagues away" (Galvin 1972: 58).

1774 Poor harvests in previous years, due to the drought, and Navajo raids, forced Hispanos to abandon the Rio Puerco from San Luis to Casa Salazar. The Rio Puerco was reported to be so named because "its water is as dirty as the gutters of the streets, since its bed is of black clay and its bottom very treacherous with mire" (Adams and Chavez 1956: 254).

1775 (May 13) A party of Taos Pueblos left their village "to round up some wolves," but a battle with Comanches diverted them (Thomas 1940: 181).

1776 (pre) The flow of the lower Rio Nambe had been reduced to a trickle due to upstream use (Adams and Chavez 1956: 71) and probably the drought.

1776 (pre) At the village of Canada de Cochiti, composed of scattered ranchos along the canyon floor, crop harvests were small due to the intermittent flow of the Rio Chiquito (Adams and Chavez 1956: 159).

1776 (pre) Zia Pueblo depended primarily on upland dry farming in raising crops; there were irrigated plots along the Jemez River, but water was only available following intense rains (Adams and Chavez 1956: 98).

1776 (pre) The farmlands of Zia Pueblo were located "in several small canadas of the hills to the south and for two leagues along the Jemez River. The alkaline river water and sandy soil was relatively unproductive, especially in drier years (Adams and Chavez 1956: 175).

1776 (pre) Jemez Pueblo farmlands along the Jemez River were relatively rich and produced good crops. The river water was less alklaine than at Zia and Santa Ana pueblos. A large number of fruit trees also were productive (Adams and Chavez 1956: 181).

1776 (pre) Groves of cottonwoods grew along the Rio Grande at Santo Domingo, and agricultural fields were located along both banks of the river above and below the pueblo. These fields were irrigated by Rio Grande water. Other fields along the Camino Real from the river to Santa Fe were dry farmed. Good harvests of various crops, including melons and watermelons, were common, as were "very tasty peaches and apricots" (Adams and Chavez 1956: 137).

1776 (pre) A stone embankment had been built on the Santa Fe River to prevent flood damage to property in the villa (Adams and Chavez 1956: 40).

1776 (pre) The Chama River at Abiquiu had "very fine meadows on both banks, with corresponding groves of beautiful poplars" (cottonwoods). The farmlands were "extremely fertile," including those at a small plaza near the shrine of St. Rose of Lima. Fields were irrigated with water from the Chama River. At the foot of the hill, where the Genizaro occupants of the pueblo were located, there were "two little springs of very good water, and since it was good, it is used for drinking" (Adams and Chavez 1956: 126).

1776 (pre) Plagues of "locusts" periodically adversely impacted crop harvests (Adams and Chavez 1956: 30).

1776 (late October or early November) A trade fair was held during this and previous years at Abiquiu. Utes brought deerskins to trade for horses; 15 to 20 good deerskins would get a horse. They also brought deer or buffalo meat, which they exchanged for corn or corn flour. Sometimes they brought young captives from other nomadic groups to trade with the Spanish (Adams and Chavez 1956: 252–253).

1776 Residents of Jemez Pueblo were using charcoal for heating (Adams and Chavez 1956: 179).

1776 An extensive cienega was located a short distance west of Taos Pueblo. Cattle were pastured there to graze the lush plants, and some sedge and grasses were cut as "hay" for other livestock. This marsh vegetation was burned each spring to foster vigorous growth of new plants (Adams and Chavez 1956: 111).

1776 Fray Dominguez reported that farmlands around Quemado and Cieneguilla were "fertilized" by overbank floodwaters of the Santa Fe River (Adams and Chavez 1956: 41).

1776 Fray Dominguez described the Rio del Norte, or Rio Grande: "From the places where the headwaters on this river are to be seen, one observes a great abundance of water. As it declines toward the south it acquires more and more water from the many rivers (large and small) that keep joining it from the east and west from above Taos to below El Paso, where it joins still others" (Adams and Chavez 1956: 7).

1776 Fray Dominguez (Adams and Chavez 1956: 40–41, 43) described the Santa Fe River: "... although it carries enough water to be called a river,it is not overabundant. Indeed, it is usually insufficient, and at the best season for irrigating the farms, because there are many of them, it does not reach the lowest ones ... only in a very rainy year is there enough for all." Springs in the Cienega area produced a flow in the river, most years, all the way to its confluence with the Rio Grande near Cochiti.

1776 The priest at San Felipe de Neri in Albuquerque pastured his horse in a marsh "back of the convent on the Rio del Norte" (Adams and Chavez 1956: 150).

1776 Fray Dominguez (Adams and Chavez 1956: 170), at Santa Ana Pueblo, reported: "They are really dependent on the rains, because in addition to the inadequacy of the river, which sometimes helps irrigation when there is heavy rain, the uneven site, now uphill, now off at a distance, does not permit the formation of pools to quicken and fertilize the plants. This results in completely unfavorable crops."

1776 Dominguez described the location of Isleta Pueblo: "The little rise on which the pueblo stands is as small as I said in the beginning, and it lies on the very meadow of the Rio del Norte, which sometimes overflows its bed up above the pueblo when it is very high and forms a very wide branch at a distance from it. This cuts off the settled part as if it were an island, which is doubtless the reason why it was named Isleta. This place stands, as has been said, on the very meadow, open to the plain which slopes down from those hills I mentioned at Atlixco of Albuquerque" (Adams and Chavez 1956: 207).

1776 Father A. Dominguez referred to the lake, four-tenths of a mile from Laguna Pueblo, as "almost round and very large" and estimated it to be over 100 feet deep, with bulrushes on one shore (Adams and Chavez 1956: 187).

1776 The skins of buffalo, mountain lions, wolves, and sheep were used as floor coverings, sleeping pads, and covers at Nambe Pueblo (Adams and Chavez 1956: 50).

1776 There were trout in the river at Quemado, near Santa Cruz, at Picuris, and Pecos, which Spanish residents caught and ate (Adams and Chavez 1956: 83, 91, 213).

1779 The meadows south of Cochiti Pueblo were severely damaged by overgrazing of livestock (Lange 1959: 37).

1770s Albuquerque residents resorted to the use of horse manure as a fuel because of the scarcity of wood in the area. Threat of attacks by Comanches or Navajos may have precluded their venturing from the village to collect firewood (Moorhead 1958: 24; Thomas 1932: 101).

1781 Teodoro de Croix, commander general of the interior provinces of New Spain, wrote "The species of deer, antelope, and bison there

[New Mexico] are inexhaustible" (Thomas 1941: 112–113).

1782 Taos Pueblo was described by Fray Morfi as having extensive, fertile fields watered by more than 300 springs and 4 streams. Timber for use in construction and as fuelwood was close by (Thomas 1932: 96).

1782 Near Taos was a large pond, located at "a little more than a musket shot north of Taos Pueblo, where are estimated more than three hundred springs of good water which irrigating the lands nearby produce the best pastures of the Kingdom. The timber for construction and fuel is close to the pueblo and in abundance" (Thomas 1932: 96).

1782 About 8 miles south of Taos Pueblo there was a Spanish ranch "with abundance of arable lands even more fertile than those of the pueblo.... There is a free-flowing spring of hot water" (Thomas 1932: 97).

1782 Fray Morfi described the Santa Fe in relation to its river of the same name: "It occupies a plain on the western skirt of a sierra and is distant about a league and a half (!) from its summit where there is a pool which provides the source for a river, meager in truth, the waters of which in years of little rain are dissipated before reaching the Rio Grande del Norte. However, it provides abundantly the Villa..." (Thomas 1932: 91). Further on, he reported "... the river is poor and can only fertilize some fields. It has besides excellent trout..." (Thomas 1932: 92).

1782 The banks of the Rio del Norte were described as "shady" (Thomas 1932: 90).

1782 Sandia Pueblo was described as located on "a plain upon the meadow" that had "sufficient cultivated lands with ordered and abundant pastures" (Thomas 1932: 101).

1782 Around the ruins of Tonque Pueblo were "fine lands and three springs for its use" (Thomas 1932: 97).

1782 There were several hot springs between Sandia Pueblo and the Espiritu Santo spring along the Rio Salado (Thomas 1932: 111–112).

1782 At the site of a former Spanish ranch, known as Encinal, Navajos were cultivating land. They also used good grazing lands to the south (Thomas 1932: 106).

1782 Fray Morfi recorded beaver, otter, and "water-dogs" in the region (Thomas 1932: 112).

1782 King Charles III of Spain requested that eight elk be captured in New Spain and shipped to the royal zoo in Madrid. This task fell on Governor Juan Bautista de Anza in Santa Fe, and the elk were captured in nearby mountains and brought to pens behind the Governor's Palace, then sent south with the fall caravan to Mexico City. All but one of the eight animals reached Madrid safely (Simmons 1969: 41–44).

1782 Fray Morfi recorded the following fish in the region: matalote (humpback chub), barbel (?), and bagre (catfish) (Thomas 1932: 112).

1782 "Excellent trout" were present in the Santa Fe River (Thomas 1932: 92).

1785 Regional fires were common and widespread (Swetnam and Betancourt 1990: 1019).

1780s (late) Hispanic authorities encouraged Navajos to bring pelts to settlements to trade (Weber 1971: 28).

1791 Grass for livestock around Belen was scarce (Espinosa and Chavez n.d.: 177).

1797 Based on tree-ring evidence, a forest fire occurred on the Pajarito Plateau (Robinson 1990: 142).

1799–1800 The Montoya family on the La Majada grant protested to the governor that the large cattle herds and sheep flocks of Miguel and Manuel Ortiz had destroyed a spring that the Montoyas had tapped to irrigate their fields. Paulo Montoya, part owner of the La Majada grant, filed suit against the two men (Snow 1979; 228; Wozniak 1987).

1700s (late) Decimation of grasslands and fuelwood, and total appropriation of water in the Santa Fe area, caused the governor to recommend moving the capital to the confluence of the Santa Fe River and the Rio Grande (MacCameron 1994: 35).

1700s (late) (to early 1800s) Pedro Baptista Pino ran "a large-scale livestock operation in the Galisteo Basin ..." (Bustamante and Simmons 1995: xiii).

1800 By this year residents of Abiquiu were traveling up to 20 miles to gather fuelwood (McDonald 1985: 121).

1800–46 Raids by nomadic Indians forced ranchers to keep their stock close to settlements, and grasslands were soon overgrazed as a result (Kelly 1955: 395).

1801 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1803 Governor Chacon described the Rio del Norte: "... it does not carry much water upon crossing it as is believed" (Simmons 1991: 164).

1803 Elk, deer, bighorn sheep, buffalo, bears, mountain lions, wolves, foxes, and coyotes were reported as common in the region (Simmons 1991: 168).

1805 (ca.) The channel of the Rio Grande, which ran past the pueblo ruins of Alameda, changed its location (Lange and Riley 1970: 176).

1805 (ca.) (to 1824) The Rio Grande's channel was located at the present site of Bernalillo. At this time the old village was situated upstream, some 2 miles to the west. The river began a shift to the northwest. Two groups of Bernalillo citizens living on the west bank of the Rio Grande north of Kuaua were forced from their homes by a westward shift in the flow of the Rio Grande. Landless, they petitioned for tracts of land on the new east bank of the river at the north edge of Sandia Pueblo land. Overgrazing of the area on the west side of the Rio Grande during the colonial period may have been a factor in their move as well (Bowen and Sacca 1971: 60). Some 20 Hispanos, displaced by a westward shifting Rio Grande, moved onto a tract of land "loaned" to them by Sandia Pueblo. This land was south of the present, old church of Nuestra Senora de Dolores in Bernalillo on the east side of the new Rio Grande channel. This cluster of residences was called "Los Cocinitas" (Bowen and Sacca 1971: 48–49).

1806 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1807 (March 2) Zebulon Pike (Coues 1987, II: 602–603) reported that Father Baptiste Lalande at San Juan Pueblo was "a great naturalist, or rather florist; he had large collections of flowers, plants, etc., and several works of his favorite studies, the margins and bottoms of which were filled with his notes in the Castilian language."

1807 (March 5) There was a ford across the Rio Grande at Santo Domingo Pueblo. At normal flow the river was 3 to 4 feet deep and about 300 yards (feet?) wide (Coues 1987, II: 615).

1807 (March 7) Pike described the Rio Grande at the Barelas ford as "400 yards wide, but not more than three feet deep and excellent fording" (Coues 1987, II: 621).

1807 (March) Pike described the Rio Grande in general: "It cannot ... be termed a navigable stream, owing to the sand-bars," and "In the mountains above Santa Fe it afforded amply sufficient water for canoe navigation, and even more than appeared to be flowing in its bed in the plains. This must be attributed to numerous canals and the dry sandy soil through which the river courses, where much of the water which flows from the mountains must be absorbed and lost" (Coues 1987, II: 729–730).

1807 According to Pike, the Rio Grande was called the Rio del Norte above El Paso and Rio Bravo, or Rio Grande, below (Coues 1987, II: 641).

1807 Elk were reported as common by Pike (Coues 1987, II: 597).

1800s (early) Some 20 Hispanos, displaced by a westward shifting Rio Grande, moved onto a tract of land "loaned" to them by Sandia Pueblo. This land was south of the present, old church of Nuestra Senora de Dolores in Bernalillo; this cluster of residences was called "Los Cocinitas" (Bowen and Saca 1971: 48–49).

1800s (early) Rancho de las Golondrinas, located south of Santa Fe on the Chihuahua Trail, was known throughout the province for its productive agricultural fields and always dependable springs (Baxter 1987: 74–75).

1800s (early) A shortage of lead for ammunition continued, and the governor ordered the residents at San Jose de las Huertas to extract the ore from the north end of the Sandia Mountains and in the Cerrillos area (Schroeder 1977: 24).

1800s (early) Pinyon nuts gathered in the Ojo Caliente area were shipped down the Camino Real in large quantities (Swadesh 1974: 61).

1800s (early) Animal skins, hides, and furs were probably the main export items to Mexico (Weber 1971: 30–31).

1800s (early) A Tewa Pueblo Indian reportedly killed two buffalo near Santo Domingo Pueblo (Bailey 1971: 13).

1800s (early to mid) An elderly San Ildefonso man claimed to have hunted pronghorns near Rio Grande Canyon on the Pajarito Plateau (Henderson and Harrington 1914: 15).

1811 Hispanics were hunting elk, pronghorn antelope, mule deer, buffalo, rabbits, jackrabbits, quail, and "partridges" (Bustamante and Simmons 1995: 12–13).

1812 Pino recorded buffalo, elk, deer, bighorn sheep, jackrabbit, wild turkey, grouse (blue? sage?), and quail as common game animals (Carroll and Haggard 1942: 99–100).

1811 "Trout, eels, catfish, stickleback, cardume, land turtle, and water tortoise" were found in New Mexico's rivers (Bustamante and Simmons 1995: 13).

1812 Wild horses, or mustangs, were reported "in great abundance" in the province (Carroll and Haggard 1942: 100).

1813 (pre) Santa Ana's governor charged San Felipe Pueblo with destruction of timber on some of its land at Angostura (Bayer et al. 1994: 91).

1813 The alcalde mayor of the Jemez jurisdiction issued a proclamation calling for livestock raisers to keep their animals away from fields from planting to harvest time and off the banks of irrigation ditches. He further stated that an adequately strong bridge must be constructed where livestock must cross (Simmons 1968: 8–9).

1815 (fall) A French trapper wrote that the streams of northern New Mexico "abounded with beaver" (Weber 1971: 46).

1815 Three Anglo Americans were trapping in the Sangre de Cristo Mountains in southern Colorado (Connor and Skaggs 1977: 30).

1817–30s Adequate water was a problem at Carnue at the west end of Tijeras Canyon. As a result, the population shifted to higher settlements in the Sandias (Quintana and Kayser 1980: 48).

1817–80s Wood cutting was a common activity of Tijeras Canyon Hispanic settlers (Quintana and Kayser 1980: 48).

1819 Wildfires were common and widespread (Baisan 1994: 3; Swetnam and Baisan 1995: 18).

1820–40 There were few or no fires over much of the region during this period. This may have been due to generally wetter conditions and intensification of sheep grazing, which reduced fuel (Swetnam 1990: 10).

1821 Most rangelands around settlements in the Rio Grande basin had become overgrazed by this year. Some livestock owners sent their flocks to the llano east of the Pecos River (Rebolledo 1987: 100).

1821 The ruins of the Felipe Romero house were located south of Belen and about 200 yards east of the Rio Grande. By early 1897 the river shifted eastward, to within 5 yards of the ruins (Wilson 1977: 14).

1821 With independence from Spain, the Mexican government viewed Pueblo Indians as citizens, and therefore they had the right to sell land either as individuals or as a tribe (Carlson 1975: 100).

1821 Three parties of Anglo traders came over the Santa Fe Trail, and members of these groups trapped beaver and other fur-bearing animals on the Rio Grande from below Santa Fe and north into the San Luis Valley (Hafen and Hafen 1993: 93).

1822 (January-June) A party of some 22 Anglo trappers took fur-bearing animals around Taos (Connor and Skaggs 1977: 32–33).

1822 Wildfires were common and widespread in the region (Baisan 1994: 3).

1822 Based on tree-ring data, a forest fire occurred on the Pajarito Plateau (Robinson 1990: 142).

1822–23 James Baird came back to Mexico and within 3 years was operating a distillery near Taos. In 1826 he moved to El Paso and began to trap beaver. Subsequently, he complained about Anglo trappers wiping out the beaver populations, taking pelts worth $100,000 over a year-and-a-half period of trapping (Sonnichsen 1968: 102).

1822–24 The first area to be intensively trapped was the southern Sangre de Cristo Mountains between Santa Fe and Taos (deBuys 1985: 93).

1822–26 Taos trappers virtually took all of the beaver in the Sangre de Cristo and Jemez mountains (Flores 1992: 8).

1824 (December 3) In the Rio Grande valley, below Socorro, James O. Pattie (1966: 52) saw "great numbers of bears, deer, and turkeys." One bear, which charged one of the members of his trapping party, was killed.

1824 Two groups of Bernalillo citizens living on the west bank of the Rio Grande north of Kuaua were forced from their homes by a westward shift in the flow of the Rio Grande. Landless, they petitioned for tracts of land on the east bank of the river on the north edge of Sandia Pueblo land. Overgrazing of the area on the west side of the Rio Grande during the colonial period may have been a factor as well (Bowen and Sacca 1971: 60).

1824 Some 2,000 pelts and furs that went back east over the Santa Fe Trail were valued at about $15,000 (deBuys 1985: 97).

1824 Some trappers took 1,500 pounds of beaver pelts from New Mexico (Weber 1971: 84).

1824 Beaver populations in the Rio Grande and Pecos River basins were rapidly decreasing due to Anglo trapping (Weber 1965: 65).

1825 Twelve beaver pelts obtained from the Comanches were sold at Abiquiu (Weber 1971: 163).

1825 (late) (to October 1826) Several groups of trappers illegally took $100,000 worth of furs out of New Mexico (Weber 1971: 118).

1826 James O. Pattie, a trapper, wrote "When the dry season returns, this grass [native bunch] may be said to be cured standing. The cattle feed and fatten upon it, when in its state of verdant tenderness. It afterwards sustains them as substantial hay" (Pattie 1966: 268).

1826 A Santa Fe Trail caravan transported 2,044 pounds of beaver back east (Weber 1971: 100).

1826–41 William Workman operated a still at Taos and may have been involved in smuggling hides and pelts (Weber 1971: 156–157).

1827 (September to February 1828) Two Hispanics and two Frenchmen trapped eight tercios (240 pelts) of beaver fur on the headwaters of the Rio Grande and the Conejos River (Weber 1971: 161).

1827 (November) A French American trader bought an unknown amount of furs at Abiquiu. These had been obtained by Hispanics in an exchange with Ute Indians (Weber 1971: 163).

1827 Anglo and Franco trappers virtually harvested all of the beaver in the Sangre de Cristo Range by this date (Ungnade 1972: 48).

1827 Anglo trappers harvested beaver from wooden rafts while floating down the Rio Grande from Cochiti Pueblo to El Paso. At the latter settlement, they dismantled their rafts and sold the "lumber" and logs to local residents. The trappers then turned eastward to the Anglo frontier, thus avoiding payment of export fees (Weber 1971: 157).

1827 Over 1,100 beaver skins taken by Ewing Young and associated trappers on the upper Pecos and San Juan rivers and confiscated by government officials in Santa Fe were threatened with deterioration when "a great rain" saturated the pelts. To save them, they were sold. This rain also "almost ruined all the houses in town" (Cleland 1963: 217, 220, 224).

1828 Some 1,200 pounds of beaver pelts, valued at over $5,000, were shipped over the Santa Fe Trail (Weber 1971: 173).

1829 A single trapper returned over the Santa Fe Trail with 951 pounds of beaver pelts valued at $4,297 (Weber 1971: 175).

1820s Local farmers began to notice formation of cienegas and esteros in the Middle Rio Grande Valley. These resulted from the dumping of excess water from irrigation ditches (Wozniak 1987).

1820s Trapper George Yount claimed to have seen 50 or 60 grizzly bears in a day. James Ohio Pattie claimed to have observed 220 in a single day (Cleland 1963: 44).

1820s (late) (to early 1830s) Some "foreign" trappers told government authorities that they had purchased furs from Native Americans or Hispanic residents, when in fact they had trapped the animals. Then they sold them to Santa Fe Trail traders, who transported them back to Missouri (Weber 1971: 159).

1830 (late) (to spring 1831) Gervais Nolan led a trapping expedition from Taos to an unidentified area and returned with 50 pounds of beaver fur (Weber 1971: 183).

1831 (summer) William Sublette, a Santa Fe Trail trader, exchanged his merchandise for 55 packs of beaver pelts (1,705) and 800 buffalo robes, which he took back to Missouri (Weber 1971: 147).

1831 About $50,000 worth of beaver pelts and bison robes were shipped east over the Santa Fe Trail. Some $17,500 worth of these were harvested in New Mexico, amounting to 55 to 60 packs of beaver and 200 robes (Weber 1971: 206).

1831–33 Trading and trapping by Anglos and Hispanos resulted in the shipment of a substantial amount of beaver pelts east over the Santa Fe Trail (Weber 1971: 206).

1832 (fall) The Charles Bent and Company returned from Santa Fe with 13,182 pounds of beaver, representing at least 131 packs of pelts. These were taken over the past 2 years. There were also 355 buffalo robes included with this shipment (Weber 1971: 206–207).

1832 About 90 packs, or about 2,790 beaver pelts, went east over the trail from Santa Fe. About one-third of these were trapped in New Mexico (Weber 1971: 206–207).

1833 The city council of Santa Fe issued a proclamation with regulations requiring draining of stagnant pools, cleaning of streets, and removal of garbage. Throwing trash or dead animals into irrigation ditches and streams and burning of rubbish piles were prohibited (Simmons 1992: 224).

1833 An estimated 60 packs of beaver were shipped from Santa Fe (Weber 1971: 207).

1834 The annual caravan from Santa Fe carried $15,000 worth of beaver pelts and 50 packs of buffalo robes (500) east over the trail (Weber 1971: 218).

1830s Fewer beaver were taken as a result of population reduction due to trapping and falling prices. The taking of buffalo robes increased due to demand and rising prices (Weber 1971: 208–210, 215).

1830s (mid) Hat-making technology improved, and techniques to substitute raccoon, rabbit, and nutria for beaver were found back East, resulting in the rapid decrease in beaver pelt prices (Muldoon 1987: 70).

1830s (mid) The popularity of buffalo hides as sleigh lap robes and floor rugs was growing in the eastern United States. As a result, the price of robes increased (Lavender 1987: 13).

1835 Coal mining in the Cerrillos area was begun (Elston 1961: 166).

1836 One merchant transported 1,000 beaver skins and 1,000 buffalo robes over the Santa Fe Trail (Weber 1971: 219).

1837 Another Santa Fe trader carried 200 buffalo robes and 2 packs of beaver pelts to Missouri (Weber 1971: 219).

1837 Regional fires were common and widespread (Swetnam and Betancourt 1990: 1019).

1838 A band of French trappers went into the Sangre de Cristo Mountains above Mora, but owing to prior trapping along the streams, they caught no beaver (deBuys 1985: 159).

1839 Businessman Manual Alvarez shipped 383 pounds of beaver pelts over the Santa Fe Trail to St. Louis (Weber 1971: 219).

1839 No significant trapping apparently occurred in New Mexico (Weber 1971: 225).

1830s Josiah Gregg described the Rio del Norte (Rio Grande) as "so shallow for the most part of the year, that Indian canoes can scarcely float in it" (Gregg 1966, I: 138).

1830s Gregg (Quaife 1967: 133) noted that the Rio Puerco was dry at its mouth part of the year.

1830s Gregg (1966, I: 160–161) wrote the following on the grama species in New Mexico: "... it cures upon the ground and remains excellent hay—equal if not superior to that which is cut and stacked from our western prairies. Although the winters are rigorous, the feeding of stock is almost entirely unknown in New Mexico; nevertheless, the extensive herds of the country, not only of cattle and sheep, but of mules and horses, generally maintain themselves in excellent condition upon the dry pasturage alone through the cold season, and until the rains start up the green grass again the following summer." Gregg (1966, I: 159) also noted that mesquite, pinyon, and cottonwood were the most popular fuelwoods in New Mexico. Pinyon resin was used to make lamp oil. Cottonwood along streams was described as "scantily scattered along their banks." He also commented "Those [banks] of the Rio del Norte are now nearly bare throughout the whole range of the settlements and the inhabitants are forced to resort to the distant mountains for most of their fuel."

1830s Josiah Gregg (1966, II: 202) wrote the following about fire's role in maintaining grasslands: "It is unquestionably the prairie conflagrations that keep down the woody growth upon most of the western uplands. The occasional skirts and fringes which have escaped their rage, have been protected by the streams they border. Yet may not the time come when these vast plains will be covered with timber? ... Indeed, there are parts of the southwest now thickly set with trees of good size, that, within the remembrance of the oldest inhabitants, were as naked as the prairie plains; and the appearance of the timber in many other sections indicates that it has grown up within less than a century. In fact, we are now witnessing the encroachment of timber upon the prairies, wherever the devastating conflagrations have ceased their ravages."

1830s Wolves were reportedly taking cattle, horses, and sheep in the region (Gregg 1966, I: 194).

1830s Gregg (1966, I: 192–195; II: 207–210) noted that black bears and grizzly bears were relatively common in the region and the wolf abundant in northern New Mexico. Elk and deer, according to him, did not occur in large numbers. Gregg also mentioned pronghorn, bighorn sheep, prairie dogs, and wild horses.

1830s Gregg (1966, I: 195–196) observed that geese, ducks, and cranes were the most numerous birds in the territory, and turkey were numerous in some mountain ranges. Partridges and quail were scarce.

1830s Trout were reported as abundant in the Santa Fe River (Gregg 1966, I: 142).

1830s–40s Hispanic settlers, who were descendants of residents of San Jose de las Huertas, came from the Rio Grande to start a new village in the valley. They found that the old fields were no longer fertile and that the creek flow had decreased (Batchen 1972: 86).

1830s (late) Almost all felt for hats was made from furs like raccoon, which were much cheaper than beaver. With a decreased price in the beaver market, large trapping companies went out of business (Murray 1979: 32).

1840s (pre) The bison may have ranged west to the Rio Grande in northern New Mexico and across the grasslands of north-central and northwestern New Mexico to the San Francisco Peaks-Grand Canyon area (Henderson and Harrington 1914: 13–14).

1840 The Sangre de Cristo Mountains near Taos Pueblo were "well stocked with deer, elk, bear, turkey, grouse, and squirrel" (Bodine 1979: 255).

1841 (early) Santa Fe merchant Stephen L. Lee sold 365 pounds of beaver fur to Charles Bent (Weber 1971: 182).

1841 (October 21) Falconer (1963: 93–95), traveling near Sandia Pueblo observed "The Rio Grande, even at this distance N., is very broad, running over a bed of red sand, but very shallow." A few days later he crossed the river at Parida, where its depth was about 2 feet. He described the Rio Grande above Alameda as "very broad, running over a bed of red sand, but very shallow."

1841 The European honey bee had not yet reached New Mexico (Gregg 1966, I: 195).

1841 Notes and the mineral collection of Thomas Falconer, a member of the Santa Fe expedition and a Fellow of the Geological Society of London, were seized by Mexican officials (Northrop 1961: 85).

1842 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1842 Based on tree-ring data, a forest fire occurred on the Pajarito Plateau (Robinson 1990: 142).

1843 Father Martinez of Taos reported that buffalo, deer, and other game were becoming more scarce due to increased hunting pressure, which in part was fostered by traders on the Southern Plains. He warned that extinction would eventually take place (Keleher 1982: 68–69).

1844 Josiah Gregg (1966, II: 149, 212), based on observations made in the early 1830s, also warned that the buffalo might become extinct in the West and decried their slaughter.

1845 The upper Rio Puerco was a "grassy wilderness" with "swampy vegas and clear water" and "willow-lined banks" (Maes and Fisher 1937: 10).

1845? Lorenzo Labadie established a temporary ranch at Los Ojuelos, 10 miles east of Tome Hill (Simmons 1973: 147).

1840s (mid) As beaver trapping continued to decline, coarse furs again dominated the hide trade in New Mexico (Weber 1971: 227).

1846 (May) Captain Donaciano Vigil stated that Anglo trappers were shipping $200,000 worth of beaver skins annually from Abiquiu and Taos (Cleland 1963: 153).

1846 (July 9) Frederick A. Wislizenus (1969: 29) noted *Artemisia*, or sagebrush, as he traveled south through the Galisteo Basin. Near the "foot of the Placer Mountains" he recorded "dwarfish cedars."

1846 (July 11) Wislizenus (1969: 33) found excellent grass and water 3 miles south of San Antonio on the east side of the Sandias. That night, in his camp, "wolves, deers, and other innocent animals" frightened his picketed horse.

1846 (July 14?) Rain made the valley branch of the Rio Grande, 3 miles above Albuquerque, virtually impassable. Some of the wagon traffic shifted to the upper branch, which ran north-south near present Edith Boulevard, N.E. (Wislizenus 1969: 34).

1846 (July 18) Returning to the main valley road near Albuquerque, Wislizenus (1969: 34) described the landscape: "The Rio del Norte is here about 100 yards wide, and as usual, sandy, shallow, everywhere fordable and nowhere navigable, not even for canoes. In the river we saw an abundance of geese, ducks, and pelicans; the latter bird is very common all along the water. Fishes and shells appear to be very scarce. On the banks of the river, heretofore quite bare of trees, occasionally a few cotton trees are seen."

1846 (July 18) Wislizenus (1969: 34) recorded large numbers of geese, ducks, and pelicans (probably white) on the Rio Grande south of Albuquerque.

1846 (July 19) Wislizenus (1969: 35), traveling down the river, "reached a fine grove of cotton trees, called bosque, or alamos de Pinos ..." on the east bank of the Rio Grande south of Isleta Pueblo.

1846 (July 21) From the Chavez "hacienda" near Pinos, south to 6 miles below Tome, Wislizenus (1969: 35) described the area along the route: "soil and road getting better." He and his party stopped at a pond about a mile from the river.

1846 (July 22–24) About 6 miles south of Valencia, Wislizenus (1969: 35) stopped at a pond at noon. Farther south, below Casas Colaradas, he found "tolerable grass," and below that "good grass."

1846 (July 23) Four miles below Casas Coloradas and one-half mile east of the river, Wislizenus (1965: 35) noted "tolerable grass."

1846 (July 24–26) Near La Joya, Wislizenus (1969: 93–95) collected creosotebush (*Larrea tridentata*), mesquite (*Prosopis juliflora*), and narrow-leaf yucca (*Yucca angustifolia* [*glauca*]).

1846 (July 28) In the mountains west of Socorro, Wislizenus (1969: 37, 39) found a new species of yucca (*Y. baccata*). A week later he discovered a new species of *Echinocactus* along the trail near Dona Ana. This cactus was 4 feet high and more than 6 feet in circumference.

1846 (July 30–31) At Bosque del Apache, Wislizenus (1969: 37) "camped in a fine grove of cotton trees near the river." Below Valverde, he camped in another grove of cottonwoods and on the next day found "many wild turkeys" in the bosque.

1846 (August 1–2) Traveling the Jornada del Muerto, Wislizenus (1969: 38) found no water but "tolerable grass, and an abundance of mezquite and palmillas." The latter two species were collected and used as fuel. En route to the Ojo del Muerto east of the road, "many antelopes" were encountered.

1846 (mid August) The U.S. Army found grass, water, and wood from Las Vegas to Santa Fe. These resources were characterized as "abundant" near the recently abandoned Pecos Pueblo (Clarke 1966: 71–72).

1846 (August) Grass around Santa Fe was scarce; the U.S. Army had to send their horses from 12 to 15 miles to graze (Calvin 1968: 60).

1846 (late August-September) Lt. Abert (1962: 18, 22–23, 29, 31, 33–35) recorded the following mammals in northern and central New Mexico: grizzly bear, gray wolf, black-tailed deer [mule], white-tailed deer, elk, pronghorn, raccoon, cottontail, rabbit, and prairie dog.

1846 (September 2) South of Santa Fe, Emory reached the Galisteo River, "...which, at that time, was barely running. The bed of the creek is sand and pebbles of the primitive rock.... From this place to its mouth there is scarcely the sign of vegetation. At the dry mouth of the Galisteo..." (Calvin 1968: 62–63).

1846 (late August-September) Lt. James Abert (1962: 25, 27, 29–33, 36, 39, 42) recorded the following birds in northern and central New Mexico: duck spp. hawk sp., night heron sp., turkey, "skylark," cowbird sp., yellow-headed blackbird, raven sp., Stellar's jay, and western meadowlark.

1846 (September 6) A contingent of the Army of the West stopped for lunch at "a beautiful cotton-wood grove," Bosque de Pinos, south of Isleta Pueblo. Later, they passed a section of the river where "grass was only moderate—wood scarce" (Connelly 1907: 232).

1846 (September 6–7) From Los Padillas to Peralta to the Chihuahua Trail on the east side of the Rio Grande there was "deep sand, and the country is perfectly barren" (Calvin 1968: 70).

1846 (September 23) Abert (1962: 37–38) noted "very good pasture grounds along the Rio Moro[a]."

1846 (September 26) Soldier Henry Smith Turner (Clarke 1966: 76–77) described the landscape south of Santa Fe: "past the Del Gado Rancho, plenty of water in the creek that crossed the road near it." He found water at the crossing of Galisteo Creek, but it was dry a "few hundred yards below," and no grass on the road today "until camp was made across from San Felipe pueblo."

1846 (September 29) Lt. William Emory crossed the Rio Grande at Albuquerque where "its width was about twenty-five yards, and its deepest part just up to the hubs of the wheels" (Calvin 1968: 79).

1846 (September 29) Between Albuquerque and Los Padillas, Emory recorded "myriads of sand crane, geese, and brant." He also found "a sandy plain, destitute of wood, and with little grass" (Calvin 1968: 79).

1846 (September 29) On the road from Santa Fe to the old Placer mine, Abert (1962: 46) recorded juniper, pinyon, cactus, yucca, and "a scant growth of grass."

1846 (September 30) Emory (Calvin 1968: 81) found hawks building nests in holes in the basalt escarpments west of Isleta. In the valley around Peralta he recorded "a considerable growth of cottonwood; among which are found some signs of beaver."

1846 (September 30) Traveling west from Los Padillas, Emory (Calvin 1968: 80) recorded "a succession of rolling sand hills" with walking stick cholla, sagebrush, and "scrub cedar, about as high as the boot-top."

1846 (September) Near Tome was "a filthy lake hard by [the river] ..." (de la Vega 1976: 39).

1846 (late September-early October) Henry Smith Turner noted a lack of wood for fuel along the Rio Grande from San Felipe Pueblo and south to almost Socorro, although good grass and water were found. Only a few sparse cottonwood groves were seen. These were "preserved with great care." Numerous sandhill cranes, wild geese, and ducks were observed. He found less sand on the road below Barelas along the west side of the river (as opposed to the east side) (Clarke 1966: 76–79).

1846 (October 3) Camped on the Rio Grande, near La Joya de Sevilleta, Emory (Calvin 1968: 82–83) described the river bank as "fringed with large cottonwoods growing at intervals." Flocks of geese and sandhill cranes, ducks, plovers, doves, and meadowlarks were observed. Several "large cat-fish and soft-shell turtles were caught" in the river.

1846 (October 4) In the La Joya area, Emory (Calvin 1968: 85) recorded cholla, mesquite, romeria, a composite, stickleaf, and chamisa. Below the village, and on either side of the Rio Grande, the grass was described as "excellent." Cottonwood along the river became more common as he moved downstream.

1846 (October 5) Emory (Calvin 1968: 86) encountered creosotebush and "a little stunted acacia near Socorro, and cane grass [*Phragmites*] and salt grass in the river valley."

1846 (October 6) About 11 miles below Socorro, Turner's army contingent encamped "where grass and wood were abundant on the bank of the Del Norte" (Clarke 1966: 79).

1846 (October 7) Abert (1962: 59–60) was told that snow fell every month in the Taos area. Wheat, corn, beans, pumpkins, melons, and chiles were the main crops. Surrounding hills were "covered with very good grass, which furnishes subsistence to herds of cattle and horses, as well as to fine flocks of sheep and goats."

1846 (October 7–8) Traveling down the Rio Grande, north of the Fray Cristobal Range, Emory (Calvin 1968: 88–90) noted that the cottonwood was larger and denser and the grama grass adjacent to the floodplain taller. He shot two or three quail (scaled ?), a small hawk (merlin ?), and a deer. A "few black tailed rabbits" were seen as well. He commented on the scarcity of game in the territory.

1846 (October 8) Along the road from Santa Fe to Agua Fria, Lt. Abert (1962: 65) noted threadleaf groundsel, sagebrush, and several species of cactus. He had to purchase "fodder and wood" for his camp near Agua Fria.

1846 (October 9) Emory (Calvin 1968: 91), west of the Fray Cristobal Range and north of San Diego, surveyed the Rio Grande; its width was 118 feet, with a mean depth of 14 inches.

1846 (October 9) Abert (1962: 65) left camp at Agua Fria and passed through Cienega, which he referred to as "well settled" and a "well watered place . . . the neighboring hills are full of springs." He recorded cranes and wild geese in the area.

1846 (October 10) Abert (1962: 65) recorded narrow-leaf yucca as abundant along the road from Galisteo Creek to San Felipe Pueblo. The Rio Grande at this point was "three to four feet deep," and "large flocks of geese and blue cranes; also some teal" were seen.

1846 (early October) Below Socorro, Captain Turner noted that trees were much more abundant than upriver, and the grass remained good (Clarke 1966: 80–81).

1846 (October 12) Magoffin's caravan experienced slow travel through sand just north of Isleta Pueblo (Drumm 1962: 152).

1846 (October 12) Moving up the Jemez River from Ranchitos, Abert (1962: 71) described the valley as "very sandy; the bed of the stream three-quarters of a mile in width, contains, in many places, no water. . . ."

1846 (October 12) Lt. Abert (1962: 71) found Santa Ana Pueblo virtually abandoned; most of the residents were gathering corn from fields at the confluence of the Jemez River and the Rio Grande. The military contingent camped near the pueblo, where they found little firewood or forage for their mules. No grass was found in the vicinity of the camp.

1846 (October 13) Back at Ranchitos on the Rio del Norte, Abert (1962: 71 72) wrote that the river "was full of wild geese," and at Bernalillo, he saw "large flocks of blue cranes; they kept up a great whooping."

1846 (October 14–15) Ponds along the road from Bernalillo to Albuquerque "were filled with ducks, geese, and cranes" (Abert 1962: 72).

1846 (October 16–17) West of Atrisco, Abert (1962: 74) and his men followed the Rio Puerco upstream over a sandy road. He initially described the valley as "wide, flat, overgrown with varieties of artemisias and coarse grass, fit only for sheep and goats." The river banks were "stiff loam; they are 10 or 12 feet high, and stand vertically." He described the surrounding landscape as "broken with sand hills, that are overgrown with cedar trees, the only kind of timber to be seen, except a few cotton-wood trees that are found in the bed of the river." Abert moved his men and wagons slowly up the river through deep sand and, in some places, dense stands of sagebrush. They encountered a corn field or forked-pole hogan and archeological ruins. The height of the river banks where they crossed was 30 feet; this was near the abandoned town of "Poblazon."

1846 (October 18–19) Having crossed the Puerco, Abert (1962: 77–78) found no water in a tributary of the river as he moved west, and the valley around seemed "destitute of grass." Lacking wood for fuel, the men used "dry branches of the artemisia to build a cooking fire." On the second day Abert reached Moquino, a Laguna Pueblo village. Here, his mules ran off in search of grass and water.

1846 (October 20) Abert (1962: 81–82) moved on to Paguate Pueblo, where he "saw several large flocks of sheep and goats." Following the Rio Paguate south, he passed through corn and pumpkin fields where "large flocks of cranes were whooping." At Laguna, the lake to the west of the pueblo held only a small pool of water. Along the Rio San Jose were large flocks of snow geese. To the northwest was the village of Cubero, which Abert was told had good grass and water. At the pueblo

Abert noticed turkeys, chickens, and "tame macaws."

1846 (October 22) A contingent of the U.S. Army reached the Galisteo River and found water for themselves and their animals (Cooke 1964: 94).

1846 (October 22–23) Abert (1962: 92) moved northeast from Acoma, toward El Rito, and found travel to be difficult in the deep sand. Light rain fell on their camp on a sandy knoll, and there was no grass for the animals. On the next day the ruins of El Rito were reached; the village was abandoned some years before when residents had their irrigation water diverted upstream. Camping near the ruins, Abert found "plenty of wood and of water" and "the pasturage was good."

1846 (October 24) Susan Magoffin put on rubber boots and waded into the Rio Grande near Bosquecito. She wrote of this experience: "... I found myself standing on a sand-bar and the wide Rio Grande curling its dark waters around me. There is something wildly sublime in the deep murmur of a mighty river, as it rolls by us with stately pride, its course pending to the fearful Ocean" (Drumm 1962: 161–162).

1846 (October 24) Abert (1962: 92–93) traveled east-southeast, down the Rio de San Jose to its confluence with the Rio Puerco. Two to 3 miles down the Puerco "some water, that was quite thick with mud" was found.

1846 (October 25) Abert's (1962: 95) command awoke to a "heavy frost and a skim of ice on the water." Moving toward the Rio Grande, they "collected enough wood to last a couple of days." Atrisco was reached, and a camp was made.

1846 (October 25) Abert (1962: 96) wrote ". . . no wood is to be obtained within less than 9 or 10 miles of Albuquerque. . . ."

1846 (October 27–28) A rain and windstorm struck Abert's (1962: 99) party camped at Pajarito, and the temperature dropped. In the morning and early afternoon, Canada and snow geese were "very abundant" and incessantly "honking."

1846 (October 30) Moving west from Isleta Pueblo into the Manzano Mountains via Infierno Canyon, Abert (1962: 100) described the road as "fine" and "compact." In the foothills were "several species of yucca and cacti." The Manzanos were "covered with snow, and the temperature dropped." A "stream of cold water" flowed through the canyon, and "cottonwood trees and grape vines" grew along its banks. Juniper and pinyon were noted on canyon slopes.

1846 (October 31) A "terrible storm," accompanied by "rain, hail, snow, and great gusts of wind" struck Abert's (1962: 103–104) camp. He recorded "holly" [agarita or *Mahonia*?], juniper, fir, and "some stunted oaks" along the trail, as well as "numerous signs of bear." As the party left the canyon and the Manzanos, and took the road south toward the "salt lakes," the strong, cold winds forced Abert to make camp in the "densest grove of pine trees" and to build a huge fire of "pitch pine" (pinyon?). "A number of Mexicans, with eleven carretas loaded with corn, stopped and encamped" nearby.

1846 (October) Near La Joya, Emory (Calvin 1968: 83) saw "immense flights of sand cranes and geese," which were feeding near houses and villages, not only here, but up and down the Rio Grande.

1846 (late October-early November) Captain P. St. George Cooke (1952: 54) noted that beaver, bear, and deer were present in and along the Rio Grande from just below Socorro to San Diego.

1846 (November 1) Abert (1962: 104–105) moved south over "an extended plain" on the road to Chilili, which in recent years had moved up the drainage from an earlier village site in order to find a more reliable water supply. Around the community were "flocks of sheep containing several thousand [animals]." The rangelands here afforded "excellent pasturage." At Tajique, the party camped above the village near a stream.

1846 (November 2–3) Col. P. St. George Cooke (1952:) and his U.S. troops camped in an "open grove of the river bottom" with "plenty of fuel" south of San Marcial. On the second day, camp was on "a high plain, covered with grama grass." For the last 40 miles of travel south along the valley he noted "the flat river bottom is perhaps two miles in width" and with "forests covering perhaps one-fourth of the bottoms, and the mountains also covered with cedar very near." He also observed mesquite and cactus (?) 10 feet high along the route.

1846 (November 5–6) After visiting the Abo ruins, Abert (1962: 116–118) followed the road west, through Abo Pass, and on to Casa Colorado on the Rio Grande. On the bajada he saw a "large band of antelope dash across the road. Farther along the route, cattle were found grazing near "several little ponds of water," where the party camped. North of the village were several large ponds whose "surfaces were covered with ducks and geese, and long-legged cranes" and a number of vineyards.

1846 (November 7–8) From Casa Colorado, Abert (1962: 118–119) turned south, down the east side of the Rio Grande for about 12 miles, where camp was made "on a salt plain, by the side of the river, close by some cotton-wood trees." There were "some pools of beautifully clear water," which was "perfectly saturated with salt." A windy weather front struck, bringing colder temperatures. Abert stopped at La Joya, where corn was purchased for the mules and horses. He continued downriver and made camp in "a large grove of cottonwood trees in the vicinity of an acequia." During the day's march, "great quantities of mezquit" and creosotebush were seen.

1846 (November 9) From La Joya south, Abert (1962: 119–120) noted that the river banks were "heavily timbered with cotton wood, and the weather was warmer." Along the road were scattered mesquite and four kinds of cactus." Many flocks of sheep that the pastores had driven in from the mountains" were observed. Below Sabino there were goats, in addition to sheep. Below Parida the route became more sandy and traversed some steep hills.

1846 (November 10) Lt. Abert (1962: 120–121) noted "cockle burs" (*Xanthium strumarium* var. *canadense*) and "sand burs" (*Cenchrus* sp.) in New Mexico. These were nuisances, as they stuck to clothing, blankets, the manes of horses, and the tails of mules. The screw-bean mesquite was also recorded.

1846 (November 15–19) While hunting near Valverde, Abert (1962: 125–126) and a few men killed several merganser ducks, and a bald eagle was sighted on a sand bar in the middle of the Rio Grande.

1846 (November 19–28) The livestock of Ruxton's party suffered from a lack of grass and severe cold as they traveled from El Paso to Valverde (Hafen 1950: 167).

1846 (November 20–27) The river at the Valverde camps was "full of sand bars," and the river level was low. Carrizo grass, or *Phragmites*, grew along the banks. As the weather turned colder, Abert (1962: 126–28) moved camp to "a more sheltered position" with "plenty of cotton wood trees. Construction of houses was begun, and adobes for the chimneys from the ruins of Valverde" were collected.

1846 (November 28) At Valverde large cotton-woods extended a half-mile back from the Rio Grande "without any undergrowth of bushes" (Hafen 1950: 167).

1846 (November) A U.S. soldier reported that many of the horses from his unit were perhaps becoming ill from browsing cottonwoods. He also noted that the "cotton-wood trees here are so thickly clad with mistletoe, that they present a green appearance" (Stanley 1950: 62).

1846 (late November) George Ruxton (1973: 179) and two hunting companions saw about 30 turkeys in the bosque at Valverde.

1846 (November-December) The large number of U.S. troops and Santa Fe Trail traders camped at Valverde almost exhausted the fuelwood, grass, and game in the area (Moorhead 1958: 167–168).

1846 (December 1–9) A hunting party at Valverde "saw many deer and wild turkeys," but were able to kill none. Several coveys of quail in the area were hunted (Abert 1962: 129–130).

1846 (December 14) Ruxton (1973: 183) crossed the river to the west bank at the Valverde ford and described the village of San Antonio: "Crossing Del Norte, we proceeded on its right bank ten or twelve miles, encamping in the bottom near the new settlement of San Antonio, a little hamlet of ten or twelve log-huts, inhabited by pastores and vaqueros—shepherds and cattle-herders. The river is but thinly timbered here, the soil being arid and sterile; on the bluffs, however, the grass is very good, being the gramma or feather-grass, and numerous flocks of sheep are sent hither to pasture from the settlements higher up the stream."

1846 (December 14–19) Three different contingents of the invading U.S. Army, under Colonel Doniphan, marched south, staggered over these 6 days so there would be adequate forage for their animals (McGaw 1972: 158).

1846 (December 16–19) Abert (1962: 135–137) and his command continued north through Socorro and on to Lemitar, where some residents had mules for sale. He bought two of the animals. At the Jose Chavez "hacienda" Abert bought hay for his animals. At Belen, he obtained specimens of selenite, which was used locally for covering windows.

1846 (December 19) A physician in Albuquerque related that many Hispanic children had died from measles and whooping cough (Abert 1962: 135–137).

1846 (fall) The U.S. military could find no cattle feed within 50 miles of Santa Fe, owing partly to recent fires set by Indians (Frazer 1983: 11; Sunseri 1979: 75).

1846 (fall) (to summer 1847) Augustus Fendler, a Prussian botanist, collected 1,026 plant specimens along the Santa Fe River and the Rio Grande Valley to the west. Two genera in the saxifrage family were named for him, *Fendlera* and *Fendlerella* (Dickerman 1985: 168–169).

1846 (December 21) Camped above Galisteo Creek, George F. Ruxton (1973: 187) noted there was no grass or "timber" at this site.

1846 (December 21–23) About a mile north of San Felipe, Abert (1962: 138–139) and his command camped in an "old cultivated field, which afforded grazing for our animals." On the road the next day, near Santo Domingo, they shot at four coyotes. At Galisteo Creek there was "plenty of water," and the command camped there. Near Cieneguilla, Abert's mule became mired in marsh mud, but the animal was extricated with some effort. Santa Fe was reached around noon of the 23rd.

1846 (December 22–23) Abert (1962: 138–139) reached the Galisteo River, where "we found plenty of water, which, although covered with ice, yet that could be easily broken." The next day was cold, and the ground was covered with snow.

1846 (December) Ruxton (1973: 178) reported deer, pronghorn, hares, and rabbits as abundant in the Valverde area. He also killed a mountain lion in this locale.

1846 Santa Fe-Chihuahua trails trader James Josiah Webb noted that the area roads were so bad that they made only 2 to 10 miles a day (Bieber 1931: 188–189).

1846 Abert described the Tierra Amarilla grant as having "prime stock range" (Swadesh 1974: 62).

1846 Ruxton recorded 75 varieties of grasshoppers and locusts, "lantern bug," an "endless variety" of beetles, and tarantulas (Hafen 1950: 150).

1846 Three years after cura Antonio Jose Martinez warned that the Anglo-spurred market for buffalo hides would severely reduce, if not exterminate, this animal, New Mexico hunters had to travel over 250 miles east to find only small herds. He also warned that Plains Indians would increase their raiding on New Mexico as their food base, the buffalo, dwindled (Weber 1982: 98).

1846 Governor Charles Bent reported that Jicarilla Apache were stealing livestock for their meat because there was little game in the region (Worcester 1979: 44).

1846 (post) Several plants collected and described by Frederick Wislizenus were named in his honor: *Ferocactus wislizeni*, valley cottonwood (*Populus deltoides* ssp. *wislizeni*), and spectacle pod (*Dithryea wislizeni*) (Dickerman 1985: 166).

1847 (January 2–3) After crossing the Rio Gallinas, Abert (1962: 144–145) saw "large herds of antelopes, apparently from two to three hundred animals in each herd. . . ."

1847 (January 29) General Sterling Price found the old camino militar near Embudo impassable for his wagons and artillery. Opposing rebels had deployed among the junipers, pinyons, and boulders, making an attack on them difficult (Twitchell 1963, II: 240).

1847 (March 18) An Anglo trading party, below El Paso, burned the tall grass around their camp so fire would not sweep across them while asleep (Drumm 1962: 224).

1847 (April 26) G. Gibson and his companions traveled north from Valverde on the Chihuahua Trail to camp, 1 mile above the ford of the road to Socorro. Here, they found water, wood, and grass at their camp in cottonwoods. The Rio Grande was running high, precluding their crossing the river to Socorro to procure needed items (Frazer 1981: 33).

1847 (April 27) Ducks and geese were plentiful along the Rio Grande from the Socorro ford to north of Bosquecito (Frazer 1981: 33).

1847 (April 29) From north of Bosquecito to above La Joya de Sevilleta, George Rutledge Gibson's unit found no grass for their animals or wood for fuel (Frazer 1981: 35).

1847 (May 1) From 3 miles south of Tome to near Isleta Pueblo, Gibson reported there was no wood or water and little grass (Frazer 1981: 36).

1847 Regional fires were common and widespread (Swetnam and Betancourt 1990: 1019).

1847–61 The army set up a number of sawmills across the region. Some lumber was contracted from private sources, but soldiers cut and sawed most of the lumber used in construction (Frazer 1983: 187).

1848 (August 27-September 1) A party of trappers found no grass for their horses and mules from Santa Fe to Abiquiu. They did find "fine grass" on the Chama River above Abiquiu (Hafen and Hafen 1993: 344–345).

1849 (June 13–19) Anglo travelers found "very poor grazing" and "no grass" from Cerrillos to San

Antonio, on the east side of the Sandia Mountains (Bloom 1945: 146).

1849 (June 20) Emigrant William H. Chamberlin also observed that there was no fuelwood "in the neighborhood of the place," and that gathered at some distance from Albuquerque sold for $30 per cord. Traveling south from Albuquerque on the next day, Chamberlin wrote "For the most part of the time we traveled through very heavy sand beds and hills, which was drifting, and almost suffocated us at times" (Bloom 1945: 146–147).

1849 (June 20) William Chamberlin (Bloom 1945: 146) described the Rio Grande at Albuquerque as a "noble river, so celebrated in history of late years, is nearly a mile wide at this point. Its waters have been higher this season than ever known before, and although considerably abated, is still very much swollen, and more than bank full in many places. . . . The current is very swift, the water cold, and of a muddy or turbid nature."

1849 (June 21) Following the old Camino Real south from Albuquerque, Chamberlin's party encountered "heavy sand beds and hills, which was drifting," and "as far as the eye can reach nothing but a bleak, barren continuation of sand hills is visible" (Bloom 1945: 148).

1849 (June 22) Chamberlin described the Rio Grande environment in the Valencia-Tome area: "The channel of the river frequently narrows to 150 yards, where it runs very rapid, boiling, foaming and roaring, as its turbulent waters rush along. The sand hills frequently extend into the river, obliging us to cross them, and at times we cannot find the bank of the Rio Grande, where we had pretty good grazing for our stock, but were very much annoyed by mosquitoes, which swarm along the river in myriads ..." (Bloom 1945: 148–149).

1849 (June 22) South of Peralta, Chamberlin and his compan-ions camped on the bank of the Rio Grande, where they found "pretty good grazing" for their livestock. Swarms of mosquitoes were a nuisance (Bloom 1945: 149).

1849 (June 25) At, or near, Parida, Chamberlin and his com-panions crossed the Rio Grande in a "large dug out" operated by a "ferryman." The river apparently still flowing above normal was "about 250 yards wide..." (Bloom 1945: 150).

1849 June 28 Camped south of San Antonio, Chamberlin recorded "good grass, lots of mosquitoes . . ." (Bloom 1945: 151).

1849 (June 30) In the San Marcial area, Chamberlin wrote "The bottom land along the river becomes narrower as we travel down," and "the growth of cottonwood on its banks becomes more extensive," and at camp "we had plenty of grass" (Bloom 1945: 152).

1849 (June 30) South of San Marcial, Chamberlin described the vegetation on the uplands, adjacent to the river, as short, dry grass ". . . which affords good pasture for sheep. The hills and plains are covered with a great variety of mezquite and other bushes, plants and flowers peculiar to the country . . ." (Bloom 1945: 152).

1849 (summer) The Abo ruins were "inhabited by owls and coyotes" (Hannum 1930: 222).

1849 (August 16) Colonel John M. Washington's troops found "good grass and water" and "sufficient fuel" at Agua Fria on the Santa Fe River (McNitt 1964: 7).

1849 (August 17) From the mouth of the Santa Fe River to the east bank of the Rio Grande, across from Cochiti, Lt. James H. Simpson recorded grassland with no trees (McNitt 1964: 8).

1849 (August 20) Lt. Simpson saw a small, gray wolf close to Canoncito on the Rio Guadalupe (McNitt 1964: 15).

1849 (August 22) Lt. Simpson camped near San Ysidro, where there was "good water, tolerable pasturage, and wood in the vicinity" (McNitt 1964: 24).

1849 (August 24) Lt. Simpson described the Rio Puerco, above San Luis, as about 100 feet wide at the bottom of its channel. The vertical banks were 20 to 30 feet high; they were graded down by the contingent so that the artillery and pack animals could cross the river. The river was "slightly fringed with cottonwood" and with "water only here and there, in pools —the fluid being a greenish, sickening color, and brackish to the taste." (McNitt 1964: 29).

1849 (August 24) Another member of the Simpson-Washington contingent, Richard Kern, wrote in his journal "The Puerco was a miserable, dirty and little stream of brackish water lined with high cut soil banks and cotton woods" (McNitt 1964: 29).

1849 (August 24) The 15-mile march north from the Rio Puerco passed through "pine and cedar of a dwarf growth, very thinly scattered; and the artemisia [sagebrush] has been seen everywhere" (McNitt 1964: 30–31).

1849 (August 24–25) After passing over grasslands and scattered juniper and pinyon pine, Lt. Simpson camped on the Torreon Arroyo. A few cottonwoods along the arroyo were noted (McNitt 1964: 32).

1849 (summer) Wild horses were seen north of San Pedro. Near this settlement, "grass was scarce." Wolves were common along the road east of the Sandias (Hannum 1930: 221–222).

1849 (late summer) Fuelwood, grass, and water were found at La Joya (Hannum 1930: 223).

1849 (late summer) About 15 miles south of San Antonio, on the Chihuahua Trail, "there was good grass . . ." Opposite Valverde, there was a "patch of timber . . ." (Hannum 1930: 226).

1849 (late summer) Near La Joyita the Rio Grande was over 6 feet deep. The nearest "timber" was 3 miles away, and local residents gathered "brushwood" there for fuel (Hannum 1930: 223–224).

1849 (September 20) The Rio Grande, at the Barelas crossing, was described as "probably three hundred yards wide, the stream rapid, its depth four feet, and its bottom of a quicksand character" (McNitt 1964: 153).

1849 (September 21–22) Lt. Simpson reported that residents of Albuquerque had to travel 25 miles to find fuelwood. There were scattered trees sparsely distributed along the Rio Grande (McNitt 1964: 152, 154).

1849 (late September) Lt. Simpson wrote in his journal "The valley of the Rio Grande for a number of miles above Albuquerque presents the finest agricultural and pastoral country I have yet seen in New Mexico. The breadth of the valley under cultivation is, probably, not quite a mile." Farther north, he wrote "The face of the country today has presented, with some trifling exceptions—along the Rio Grande, at Delgado's, and between Agua Fria and Santa Fe—one extended barren waste of uncultivable soil" (McNitt 1964: 154, 158).

1849 Rangelands around Santa Fe, perhaps for up to 20 miles, had been denuded of grass by livestock of wagon trains. At nearby Galisteo, erosion, which began at this time, had been cut by deep arroyos, and the Galisteo Creek has eroded to a depth of 12 feet. The channel today is about 200 feet wide; in 1849 a plank spanned the creek (deBuys 1985: 216–217).

1849 A military officer who had been stationed at Socorro recommended the Canadian River-Gila River route to southern California as best because the Santa Fe area had little grass to support emigrant caravans (Bearss and Gibson 1979: 207).

1849 Several cattle died from eating poisonous plants in the Abo area (Hannum 1930: 222–223).

1849 A wolf with rabies reportedly attacked a party of men and bit six of them; one later died (Cox 1925: 135–136).

1849–50s A U.S. military officer noted "Horses and mules turned out to graze always prefer the grass (grama and other bunch grass) upon the mountain sides to grass of the valleys" (Marcy 1988: 113).

1849–50s In some valleys in and near the southern Rocky Mountains, "immense herds of pronghorn antelope" congregated. Mounted Native Americans in the region surrounded the herds, then ran the animals until they tired. Large numbers of the exhausted animals were then approached and killed (Marcy 1988: 244).

1840s Corn was a popular exchange item in the fur trade with Native Americans (Muldoon 1987: 71).

1840s Most beaver pelts going over the Santa Fe Trail were obtained in New Mexico through trading rather than trapping (Weber 1971: 224).

1840s–60s (falls) Parties of men from the Placitas area went east onto the Southern Plains to hunt buffalo. These hunters carried ground corn, dried peas, beans, onions, and raisins as provisions. Buffalo hides were used in making clothing, moccasins, rugs, and balls used in a game. The meat was dried while on the plains and transported back to the home villages. As the buffalo became increasingly scarce, families increased the size of their goat and sheep herds (Batchen 1972: 64–65).

1840s–70s Bears in the Sandia Mountains were reportedly common and were considered a menace to the goat and sheep herds and their herders. Attacks on these livestock occurred, and a few herders were mauled or killed. Wildlife such as deer, wild turkey, and grouse were abundant in the northern reaches of the Sandia Mountains. Pronghorns were common on the Bajada de Sandia. They were hunted with guns, bows and arrows, and box traps by Placitas area Hispanics (Batchen 1972: 49–50, 64).

1850 About 100,000 acres were in irrigated cultivation in the Middle Rio Grande Valley. "Native hay" was a major crop (Hedke 1925: 5).

1850 Colonel McCall (1851: 5) wrote the following about New Mexico livestock: "There are in New Mexico grazing lands of great extent, where countless flocks and herds may be reared at a very trifling expense. They require neither stabling nor forage during the winter; the numerous 'gramma,' a species of grass found on the mountain sides and the adjoining uplands, affording abundant sustenance during that season."

1850–51 The U.S. Assistant Surgeon accompanied Lt. Lorenzo Sitgreaves on his expedition from El Paso to Santa Fe, then west to El Morro and the Zuni area. He was the first scientist to collect birds and mammals in the region. He collected and described, for the first time, grey-headed junco (now lumped with two former species into one), black-capped vireo, Cassin's sparrow, Abert's squirrel, Ord's kangaroo rat, and the coyote (Hume 1942: 497–503).

1850–1911 Sandhill cranes were common along the Rio Grande during migration (and probably late fall-winter) (Henderson and Harrington 1914: 33).

1851 (April 19–20) About 30 miles north of El Paso the dominant vegetation on the uplands bordering the Rio Grande was mesquite chaparral, creosotebush, sagebrush, two species of yucca, and patches of grama grass. On the floodplain were cottonwood trees. About 50 miles north of the same town, the river valley supported "fine groves of large cottonwood, with occasional mezquit" (Bartlett 1965, I: 199–200).

1851 (April 27) Bartlett's (1965, I: 215–216) party crossed "the old fording place" at San Diego. He described the crossing: "In fording the river, one of the wagons, in consequence of diverging a little from the proper course, got into a quicksand, and was near being lost."

1851 (April 27) Part of the boundary survey contingent crossed the Rio Grande at the old ford site at San Diego. The entire valley in this area was described as being "more or less wooded ..." with "excellent grass." The party camped at Santa Barbara, above San Diego, near a mile-long lake that was probably a former channel of the Rio Grande (Bartlett 1965, I: 216–217).

1851 (August 17) Galisteo Creek, east of present I–25, "was barely running." From here to its confluence with the Rio Grande there was "scarcely the sign of vegetation" (Dillon 1970: 53).

1851 Regional fires were common and widespread (Swetnam and Betancourt 1990: 1019).

1851 J. R. Bartlett noted that wolves were abundant on the plains and valleys of southern New Mexico (Brown 1983: 15).

1851–52 The Territorial Legislature declared that the acequia alignments in use at the time should not be disturbed and should remain public, and their use for irrigation should take precedence over all other uses, such as grist mills (Wozniak 1987).

1851–60 Based on tree-ring evidence, precipitation was below 20th century means (Fritts 1991: 155).

1852 At Albuquerque, Franz Huning described the water used for domestic activities as "always more or less oily and in winter hard to get at" (Browne 1973: 57).

1852 Merriam's turkey was found on every wooded riparian reach in the territory (Henderson and Harrington 1914: 35).

1852 Grizzly bears were reported common in the valleys of southwest New Mexico and the Rio Grande in the south-central part of the state (Bailey 1971: 357).

1852 Naturalist S.W. Woodhouse reported that wolves were common across New Mexico (Bailey 1971: 310).

1852 (ca.) The El Tajo ditch was constructed to "relieve the high water overflows at Albuquerque." The de los Padillas acequia, on the other side of the river, was primarily used for flood control (Wozniak 1987).

1852–55 Army doctor Thomas Charlton Henry described New Mexico's wildlife: "The plains swarm with antelopes; the hills with deer and 'grizzlies'; the rivers with swans, ducks, and wild geese; while among the timber generally, are to be found many curious birds, peculiar to the country, some specimens of which are undescribed. There is a great profusion of lizards, salamanders, and chameleons; I should say more than thirty species..." (Hume 1942: 210).

1852–55 Army surgeon Henry wrote "This is a curious and unique country—New Mexico, full of ... lizards, tarantulas, and flies in profusion (Hume 1942: 209–210).

1850s (early) A U.S. Army surgeon described the Rio Grande in the Socorro area as 200 to 600 yards wide, depending on runoff amounts from the basin above. High water occurred from the first of May to late July, and more severe floods destroyed "hundreds of acres" of agricultural fields. Change in the channel reportedly took place every year (Hammond 1966: 24–25).

1850s (early) The Rio Puerco channel at La Ventana was about 8 feet deep (Dortignac 1962: 588).

1853 (May 2) A military contingent crossed the Rio Grande at Cieneguilla, located about 18 miles southwest of Taos. The men dismounted and swam the horses across the river (Bennett 1948: 36).

1853 (October 3) Lt. A.W. Whipple (Foreman 1941: 109) described the Rio Galisteo: "The channel is sandy, and several hundred feet wide, evidently bearing much water at certain seasons. The flowing stream is only a few feet in width."

1853 (November 7) Lt. Whipple (Foreman 1941: 116) described the Rio Grande at Pajarito: "... the river bottom is wide and low as at Albuquerque." And further south at Isleta "The bed of the river is sandy, and the depth of water three to four feet. The usual ford is about one hundred yards below. Few trees occur in the valley, except at Bosque de los Pinos, five miles below Isleta, where the wide bottom lands are covered with quite a forest of mesquites and cotton-woods."

1853 (November 7) Between Albuquerque and Bosque de los Pinos, Lt. Whipple noted that there were few trees in the valley. At the latter location, 5 miles below Isleta, he noted ". . . the wide bottom lands are covered with quite a forest of mesquites and cotton-woods" (Foreman 1941: 116).

1853 (November 10) At the Barelas ford, just south of Albuquerque, Lt. Whipple described the Rio Grande: "The bed of the stream is about 500 yards wide, with a channel upon each side from three to four feet deep, and a temporary island of sand and clay in the centre, occupying about one third of the width. In one or two places there were quicksands sufficient to make the passage laborious. The current of the stream is rapid. . . . Our own observations made the fall five feet per mile at this place" (Foreman 1941: 119).

1853 (November 12) Leaving the Rio Grande and moving westward, Lt. Whipple (Foreman 1941: 120) reached Sheep Springs, also known as El Alamo, 17 miles east of the Rio Puerco and on the road to Laguna Pueblo. He wrote, "The water seems to issue from beneath a stone ledge, but is neither palatable nor abundant."

1853 (November 12–16) Lt. Whipple (Foreman 1941: 120–129) and his men reached the Rio San Jose, which he described as a "... fine wide valley ... the stream that now flows by the foot of the hill is narrow, and, a short distance below, shows strong symptoms of sinking below the surface. The banks are covered with a rich soil, which, in some places, is white with efflorescent salts. Ascending the narrow valley, the stream became larger . . . forming lagunas, and fertilizing some very broad bottoms." Farther west, he refers to the San Jose as ". . . a pretty brook . . ." and beyond, at the "Hay Camp," probably near modern McCarty, wrote "The valley spreads out into a wide vega, covered with an abundance of grama, which is occasionally cut to supply hay to the military posts." The Ojo del Gallo was reached on the next day.

1853 Zoologist C.B.R. Kennerly observed that black bears and grizzly bears were common in the foothills from Mount Taylor to the Zuni Mountains. He also reported that both species, when food shortages occurred in the mountains, came down to the valley and frightened away sheepherders and attacked their flocks (Bailey 1971: 364).

1853 Indian Agent E.A. Graves of Dona Ana reported that the buffalo population was still decreasing due to Plains Indian-trader activities (Keleher 1982: 89).

1853–54 Indian agent Steck reported that game was scarce due to Anglo-American hunting and other activities. Older Gila Apaches recalled the time when buffalo were near (Cole 1988: 80–81).

1853–54 Lt. Col. Henry (1856) recorded 170 species of birds while stationed at forts Thorn, Fillmore, and Webster (Ligon 1961: 7–8).

1854 (spring) The only large tract of cottonwoods found along the Middle or Upper Rio Grande Valley was located below Isleta Pueblo on the east side of the river according to W.W.H. Davis (1982: 356). He wrote "Wood is exceedingly scarce all over the country. The valleys are generally bare of it."

1854 (April 28) Bartlett (1965, I: 217–218) and his party camped at Santa Barbara, on the west bank of the Rio Grande, near a "pond or laguna, extending a mile or more." He commented ". . . I think it must have been formerly the channel of the Rio Grande . . . it is continually changing its bed, where great bends occur. The laguna is now supplied by overflows from the river."

1854 W.W.H. Davis (1982: 353) described Albuquerque "As a place of residence it is far less pleasant than Santa Fe. At some seasons of the year high winds prevail, when the sun is almost obscured by the clouds of fine dust that is whirled through the air, and which finds an entrance into the houses through every nook and cranny. Then there are flies and mosquitoes, which swarm in and out of doors in untold millions, which neither day nor night allow man or beast to live in peace. The weather is oppressively warm in the summer season. The water used for all purposes comes from the river, and is so muddy that you can not see the face in it until it shall have settled several hours."

1854 Perhaps the last whooping crane in New Mexico, prior to its reintroduction in 1975, was recorded by Henry near Fort Thorn in the Rio Grande Valley (Ligon 1961: 106).

1854 On a river cut-off at Santa Barbara, Bartlett 1965, I: 218) noted "many wild fowl. . . ."

1855 (July) A bosque was present in the Rio Grande Valley near Algodones (Davis 1982: 389).

1855 On the Rio Puerco, south of the Santa Fe Rail line, the channel was 20 feet deep (Bryan 1928: 276).

1857 Santa Fe was described as "pleasantly situated on an extensive plateau" and produced "good crops of wheat, corn, beans, red pepper, and many of the vegetables . . ." and "apples and the smaller fruits. . . ." The area around "for miles" was destitute of trees. The "large growth" was reportedly "cut away, at an early date in the history of the place, for fuel and for better security against hostile Indians . . ." but "stunted cedars are very common." Pinyon was "the almost sole supply of fire-wood," which was "brought for miles on the backs of donkeys and sold by the load, in the plaza, at from twenty-five cents to one dollar...." The "river-water is very extensively used for drinking purposes, and is excellent." Potable water was found by digging wells 10 to 40 feet deep (U.S. Surgeon-General's Office 1857).

1857 Lieutenant E.F. Beale (1858) described the vegetation along the Rio Grande near Ft. Craig: "The grass on the river bottoms is not good, and we therefore camped on the nearest hills to the river, where we found excellent gramma."

1857 Near Fort Craig were black bear, grizzly bear, gray wolf, mountain lion, bobcat, and weasel. Birds included "swans, pelicans, wild geese, brant, and almost every species of duck . . . as well as sand-hill cranes, blue herons, bitterns, and several species of snipe." Away from the post in the foothills and mountains there were "turkey, quail, blackbird, meadowlark, robins, doves, sparrows, bluebird, cardinal bird, snow-bird, and many others. The Rio Grande abounded in "catfish, buffalo, and white fish," and "beavers and muskrats" were "found in great numbers within a mile of the post." Drinking water was collected from the Rio Grande (U.S. Surgeon-General's Office 1857: 250–251).

1857 Fort Wingate was situated in an "open and grassy" valley "with some pine timber and scrubby oak scattered through it, and has well-wooded hills back of it." The fauna was composed of "antelope, black-tailed deer, black bear, large gray wolf, coyote, wild cat, fox, beaver." Birds included various species of ducks, ravens, blackbirds, "Canada" jay, "speckled" woodpecker, northern flicker, kestrel, several species of hawks and owls, mourning dove, a flycatcher, western meadowlark, magpie, mountain and western bluebird, and a swallow. There was "very little game in the neighborhood of the post, it having been thinned out of late years by the Navajo Indians" (U.S. Surgeon-General's Office 1857: 311).

1858 The first Hispanic families began to settle Ojo de la Casa east of Placitas, where there was fertile soil and water from Las Huertas Creek (Batchen 1972: 6).

1859 (summer) At Isleta Pueblo, Samuel W. Cozzens (1988: 274–275) noted "acequias nicely kept, and the vineyards yielding abundantly." He and his two companions forded the river, which was 3 to 4 feet deep, about 300 feet wide, and muddy. They camped for the night on the bank of the river at the pueblo. On awakening the next morning, the Rio Grande was flowing between the men and Isleta, a half mile away. Part of a vineyard and a corn field were destroyed during the movement of the river. Cozzens (1988: 275) described the ford at Isleta: "Its bottom is nothing less than a mass of quicksand; and as we had been informed that the ford here is hazardous and very uncertain it was with no enviable feeling that we looked at the muddy, turbid water, and realized the difficulties we might encounter in getting our mules and heavily-laden wagon safely across the stream and up the steep bank on the opposite side."

1859 On the road from Isleta to Laguna Pueblo, Cozzens (1988: 279) described the landscape as "quite destitute of vegetation, and presenting altogether a most barren and cheerless aspect." Reaching the Rio Puerco he noted that "the valley is quite extensive and very flat, and is covered with a species of coarse grass, valuable for sheep and goats, thousands of which were seen grazing on every side." Shepherds and their dogs were with each flock.

1859 Near the ruins of Valverde, Cozzens (1988: 77) observed that "cottonwood trees ... line[d] the banks of the Rio Grande" and he camped at a location "where there was a prospect of our poor animals obtaining a supply of grass."

1859 Captain Randolph Marcy (1988: 252) wrote this about bighorn sheep meat: "The flesh of the bighorn, when fat, is more tender, juicy, and delicious than that of any other animal...."

1859 The imposition of duties on imported goods ended the annual trade caravans of Pueblo Indians to Sonora. They took serapes, buffalo hides, and other items to exchange for rebozos, oranges, and so forth (Lange and Riley 1966: 237).

1859–76 No buffalo were observed in New Mexico (Bailey 1971: 14).

1850s Santa Fe experienced critical water shortages, and a search for a new source was initiated. A dam was constructed at the headwaters of the Santa Fe River in 1866, but the resulting reservoir did not supply all of the needed water (Clark 1987: 33).

1850s (late) Manuel Chaves moved his family to the Ojuelos Ranch, east of Tome Hill. An upper and lower spring provided water, and their livestock fed on abundant grass. The ranch was located on an old trail connecting Tome and Comanche Canyon on the west side of the Manzano Mountains (Simmons 1973: 147–149).

1860 The Rio Grande shifted to a new channel, which left La Mesilla and Las Cruces on the same side of the river (Cozzens 1988: 277).

1860 (ca.) Floodwater runoff in the upper Rio Puerco drainage was "lost" in marshy meadows at the lower end of the Cuba Valley in the Cabezon-Casa Salazar area (Maes and Fisher 1937: 1–4).

1861 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1862 (February 25) There was a river ford east of Lemitar (Hall 1960: 193).

1862 (March 5) Confederate soldier A.B. Peticolas found wood to be "very scarce near Judge Spruce Baird's in Albuquerque's South Valley." "Dry cow chips" were used instead for fuel (Alberts 1993: 59).

1862 (March 5) In the Padillas area there was a road on the floodplain along the west side of the Rio Grande; this road was "very sandy." Paralleling this road was an upland road, located along the edge of the floodplain. This was "a much better road for wagons" (Alberts 1993: 59).

1862 (March 8–9) Sergeant Peticolas' unit camped at "Soda Spring" in Tijeras Canyon, where the men burned dead wood and green "cedar" (juniper). The weather "was bitter cold and disagreeable" and "windy, with frequent showers of snow . . ." (Alberts 1993: 67).

1862 (March 11) Sergeant Peticolas described the route north, along the east side of the Sandia Mountains, as "altogether the best road I have traveled for many a day. The mountains on either side are covered with a dense growth of pine and cedar..." (Alberts 1993: 68).

1862 (late March) Some 11,000 sheep were taken from Chavez's Ojuelos Ranch by Navajo raiders (Simmons 1973: 186).

1862 (April 12) Sergeant Peticolas' unit crossed the Rio Grande at the Barelas ford on a "flatboat" (Alberts 1993: 101).

1862 (April 14) The road, wrote Sergeant Peticolas, from the South Valley to Los Lunas, along the west side of the Rio Grande, was "very heavy with sand," and the wagons could not travel very fast" (Alberts 1993: 102).

1862 (April 16) Peticolas' unit found "plenty of wood" at a Hispano rancho near Belen. The severe dust storm continued all day (Alberts 1993: 107).

1862 (April 17) At Magdalena the "pines were plentiful all along the road." The men camped at Ojo del Pueblo, where three bears were flushed but not shot (Alberts 1993: 110–113).

1862 (April 19) A Confederate contingent reached the Saracino Spring near the confluence of the Rio Salado and the La Jencia Creek. The Salado Valley was "very boggy where the salt creek seeps, or crawls sluggishly along down the valley." Continuing northwestward, the contingent shot three pronghorns and a bear (Alberts 1993: 110–111).

1862 May) The Los Pinos rancho, owned by Governor Henry Connelly, was leased by the U.S. Army for use as a supply depot. The army had rights to cut and use shrubs and trees on the property (Miller 1989: 214).

1862 (spring) The cottonwood bosque in the Peralta area provided protection for the Confederate troops being assaulted by Union forces (Cook 1993: 6).

1862 There was a ford on the Rio Grande at Mesilla (Horgan 1954, II: 831).

1862–90 Sheep herds in the upper Rio Puerco basin produced intensive grazing pressure, and erosion was accelerated (Maes and Fisher 1937: 10–15).

1863 June Captain Rafael Chacon and a military contingent camped at Cebolleta, where they found "wood, water, and grass in abundance." Moving southwest the next day, they found water in arroyos and holes, abundant grass, but no wood (Meketa 1986: 227).

1863 (summer) Camping at Gallinas Spring in the Gallinas Mountains, military personnel found an abundance of trout, some of which they caught and ate (Meketa 1986: 235).

1864 A father and son from Ojo de la Casa were herding goats and sheep in a "grassy canyon above La Madera." Late in the afternoon, as they were setting up camp, they discovered a flock of turkeys roosting in a pine tree. They started a grass fire below the tree, and the smoke caused the turkeys to panic and become disoriented. As a result, the two herders managed to capture over a dozen of the birds (Batchen 1972: 68–69).

1865 The military experimented with using mesquite beans as livestock feed (Miller 1989: 95).

1866 (July 12) James F. Meline (1966: 101) saw four large flocks of sheep near Ocate. A gray wolf was seen later in the day.

1866 (late July) Meline (1966: 118). described the plant environment south of Santa Fe: "... we found ourselves, at the end of four miles, out on the sandy plain covered with cactus, scattered and stunted cedars, and liberally intersected by arroyos...." Fourteen miles farther south, he noted "little grass" and still farther, crossing Galisteo Creek, "we see but little water."

1866 (late fall) The new settlers of San Francisco Xavier on the Rio Puerco used cottonwood along the stream to construct their houses and outbuildings. This new town was located at a spring, El Ojito del Rio Puerco (Lopez 1988: 72–76).

1866 The Santa Fe River was dry 5 miles below the town of Santa Fe (Meline 1966: 151–152).

1866 A new road from Santa Fe to El Paso, which was periodically covered by blowing sand, was constructed, "replacing the old road" (Bayer et al. 1994: 171).

1866 James F. Meline (1866: 151–152) noted that the Santa Fe River had "a wide pebbly bed, showing capacity for frequent mountain torrents," and "in ordinary seasons its waters are lost in the granite sands, some five miles below town."

1867 (April 3) Bell (1965: 241–242), traveling below Albuquerque, observed "The greater part of the valley is here almost entirely destitute of trees. This may be partly accounted for by the fact that the banks of the river are of a sandy, friable nature, and that the bed of the stream is always changing its position, sometimes to one, sometimes to the other; thus destroying fields of corn, irrigating canals, and villages...."

1868 Just below Albuquerque, the Middle Rio Grande changed its course, moving westward, close to Atrisco. The river only ran here for a few weeks, and when it shifted back, a remnant channel was left (U.S. Surveyor-General and Court of Private Land Claims 1894).

1869 The 40-stamp mill at the Ortiz mine in the Old Placers district was operating (Elston 1961: 155).

1869–77 There were two charcos, or small lakes, near Tome. One of these, on Father Ralliere's land, was drained in 1877 (Ellis and Baca 1957: 25–27).

1860s An estimated 18,000 acres of new irrigated land was developed in the Middle Valley (Wozniak 1987).

1860s Constructing successful irrigation facilities on the upper Rio Puerco, in the Cabezon area, was easy because the stream channel was relatively shallow (Maes and Fisher 1937: 12).

1860s The influx of Anglo traders, trappers, military hunters, and miners reduced populations of various game animals on which the Jicarilla Apache depended for food. They turned more to raiding as a means of subsistence (Tiller 1992: 64–66).

1860s (late) Elk herds of more than 100 animals were seen in the Rociada Valley. Hunting pressure subsequently reduced these herds dramatically (Barker 1953: 87).

1860s–70s A relatively large influx of new Spanish settlers to the upper Rio Puerco valley led to overgrazing and scarcity of irrigated cropland (Carlson 1979: 34).

1860s–70s The women of Placitas harvested a "tall, brown, tender grass and tied it into neat bundles and exchanged it for whatever they could get in Bernalillo" (Batchen 1972: 43).

1860s–70s Malarial fevers, diarrhea, dysentery, and venereal diseases were common illnesses among the military (Miller 1989: 43).

1860s–1912 The river bed at San Marcial aggraded between 12 and 14 feet due to the reduction of the Rio Grande's historic flow, which had, before, scoured out the stream channel (Clark 1987: 205).

1870 By this year, silt and sand from arroyo runoff were adversely impacting irrigable lands on the end of the Galvan-Sanchez-Sandoval grant near San Ysidro. Some members of these families were forced to move due to the loss of these arable lands. The silt deposits probably resulted from intensive grazing of sheep and goats and resulting erosion on surrounding uplands (Swadesh 1978: 46–47).

1870 Wildfires were common and widespread (Swetnam and Baisan 1995: 18).

1870 Based on tree-ring evidence, a forest fire occurred on the Pajarito Plateau (Robinson 1990: 142).

1870 Jose L. Perea and Mariano Otero grazed over 24,000 sheep in the Cabezon-Bernalillo area (Maes and Fisher 1937: 11).

1871 (July) "Chinch" bugs were damaging cabbage plots in the Albuquerque area. A priest suggested sprinkling lime water on the infested plants, which apparently was successful (Steele 1983: 84).

1871 Mice were causing so much damage to food and clothing at military posts that the Quartermaster General issued orders to keep rat terriers and cats around storage areas (Miller 1989: 231).

1872 (August 19) The Santa Fe River flooded near Santa Fe with a flow that probably exceeded 1,000 cfs (US Geological Society 1994).

1872 J.H. Beadle (1973: 486, 488) described the mesa above San Felipe Pueblo as "treeless" and grassless." He compared the Middle Rio Grande Valley to the Nile.

1873 Bighorn sheep were common in the Sangre de Cristo Mountains northeast and east of Santa Fe and Taos (Bailey 1971: 16–17; Barker 1953: 88).

1874 (pre) Informants stated that there had been two varieties of buffalo in New Mexico; one lived on the plains, and the other inhabited the mountains (Bailey 1971: 15).

1874 The Rio Puerco channel at La Ventana was about 8 feet deep (Dortignac 1963: 507).

1874 Elk were reported on a high plateau near Tierra Amarilla (Henderson and Harrington 1914: 16).

1874 A shovelnose sturgeon (*Scaphirhynchus platorynchus*) was taken from the Rio Grande near Albuquerque. No other specimens have been reported since (Koster 1957: 23).

1874–75 Severe arroyo cutting had begun by these years as a result of overgrazing and droughts (Harris et al. 1967: 11).

1874–98 Prairie dog and jack rabbit populations generally increased on regional rangelands due in part to the widespread killing of wolves and coyotes by ranchers, homesteaders, and government trappers. As rangelands were overgrazed, prairie dog and rabbit populations were forced to move onto previously unoccupied areas and compete with livestock for the grass there. Less desirable range plants, such as cactus and thorny shrubs, spread due to the overgrazing and drought (Smith 1899: 14–15).

1875 (March 3) The Right of Way Act provided for a 200-foot right-of-way for railroads and 20 acres for station grounds every 10 miles across public domain (Westphall 1965: 93–94).

1875 Joseph Rothrock, south of Gallup reported the following: "Gaining the summit a thousand feet above Fort Wingate, we were at an altitude of about 8000 feet above the sea, a fine, open, park-like region with a large growth of yellow pine (*Pinus ponderosa*) and fir covering the hillsides. A diversified herbaceous vegetation was out in the most brilliant colors, beautifying alike the woods and open grounds.... Good forage was abundant" (Cooper 1960: 130).

1875 The Rio Puerco channel at San Luis was shallow; a low irrigation dam of "brush and poles" easily diverted water from the stream (Tuan 1966: 588–589).

1875 Bears, probably both black and grizzly, were reported as common in the Sandias. Placitas area herders and their goats and sheep were sometimes attacked by bears, but being poorly armed, the herders usually let one or two of their animals be taken (Batchen 1972: 49–50).

1875 (ca.) Most bajadas were still covered by grassland, but intensive livestock grazing, followed by soil erosion, and later fire suppression, resulted in three changes—reduced grass cover, the invasion of juniper from the adjacent woodlands, and the proliferation of desert shrubs (Dick-Peddie 1993: 29).

1875–85 The volume of silt in the Middle Rio Grande Valley peaked (Hedke 1925: 28).

1876 (to ca. 1880) The Rio Puerco channel near Cabezon was shallow, and a road crossing was marked with large logs laid parallel (Bryan 1928a: 273).

1877 The Rio Puerco near San Luis was described as having "high banks marked by recent caveins and falling trees." An older stream channel was situated to the east (Bryan 1928: 268).

1877 The Rio Puerco near Guadalupe was between 26 and 29 feet wide (Bryan 1928a: 275).

1877 A military officer with the U.S. Geographical Exploration and Survey reported that elk, once plentiful in the Jemez and Ortiz mountains, were rarely seen (Henderson and Harrington 1914: 2).

1877–78 (summers) Grasshopper infestations destroyed most of the wheat in the Taos Valley (Miller 1988: 157).

1878 Based on tree-ring data, a forest fire occurred on the Pajarito Plateau (Robinson 1990: 142).

1878 J.W. Powell issued his *Report on the Lands of the Arid Region of the United States,* in which he observed that there was more potentially irrigable lands than the water necessary to irrigate them (Worster 1985: 133).

1878 A young bear was killed by a sheep herder on the north end of the Sandias while attempting to eat the herder's cheese (Batchen 1972: 67).

1878–79 Native Americans (Pueblo?, Jicarilla Apache?) were burning forests and woodlands in northern New Mexico to drive deer down into canyons where they could be more easily hunted (Cooper 1960: 138).

1879 (summer) The Rio Grande ceased flowing from Albuquerque to El Paso due to diversion from the river by farmers in southern Colorado (Miller 1989: 69).

1879 John Wesley Powell believed the sole major problem inhibiting maximum timber production in the western forests was fire (Cooper 1960: 137).

1879 Regional fires were common and widespread (Swetnam and Betancourt 1990: 1019).

1879 A resident of Laguna stated that extensive cutting of timber for railroad ties or locomotive fuel had occurred in the area. He also noted that those forests in the Santa Fe area had been "destroyed" (U.S. Lands Commission 1880: 455–458).

1879 Commercial mining of the lead-zinc veins in the Cerrillos district began (Elston 1961: 155).

1870s As El Paso's population increased significantly, using more and more water, the level of the Rio Grande began to fall. The major cause, discovered later, however, was the diversion of the river's waters by numerous new settlers in southern Colorado, who had been lured to the area by the Denver and Rio Grande Railroad (Sonnichsen 1968: 382).

1870s Bear, deer, blue grouse, and turkey were plentiful in the Sandia Mountains. Pronghorn antelope were common on the foothill and bajada grasslands. Increase in the number of hunters and the availability of better weapons, resulted in the depletion of these game animals by the end of the decade (Batchen 1972: 64, 66).

1870s Bears were relatively common in Canon de Agua, at the north end of the Sandia Mountains (Batchen 1972: 67–68).

1870s The Rio Puerco was described as "without a deep channel" and having "large groves of cottonwood trees, high grass, and weeds." A small bridge spanned the river near Cabezon, and a diversion dam of cottonwood logs, limbs, and poles was constructed for irrigation at San Luis (Bryan 1928a: 273).

1870s (late) Mariano Otero brought 25,000 to 30,000 pounds of corn annually at Cabezon (Maes and Fisher 1937: 14).

1870s (late) Intensive hunting of deer in the north end of the Sandias forced the last of these animals to take refuge around Osha Springs (Batchen 1972: 66).

1870s–80s Hispanic farmers, would-be colonists, and Anglo miners from Pena Blanca and La Jara moved onto the Espiritu Santo land grant, hoping to use water from the Rio Puerco to irrigate their crops (Bayer et al 1994: 158–159).

1870s (to about 1900) Good harvests of wheat, corn, and beans were realized along the Rio Puerco, and "natural hay" was cut for local use or sold in Albuquerque (Bryan 1928a: 278).

1870s (to early 1900s) Fires on Anglo rangelands were suppressed by a "beef drag," slaughtering the nearest steer, splitting it, attaching forelegs to one saddle horn and the hind legs to another, then dragging the carcass, with loose skin flopping behind, along the edge of the fire. Back fires were begun by dragging a rope soaked in kerosene and ignited, especially along cow trails. Fuel breaks, or "fire guards," were sometimes made by plowing two or three strips about 100 feet apart (Pyne 1982: 93–94).

1880 (pre) The flow of the Rio Grande was sufficient to scour sediment from its channel. After this year, the stream bed began to aggrade due to continued decreasing flow and increasing silt load (Harper et al. 1943: 49).

1880 (pre) Las Vegas residents got their water from the Gallinas River, but with the formation of the Agua Pura Co., water was piped from a small reservoir on the river. This water soon became "dirty" compared with the clear, clean water from the free-flowing river (Perrigo 1982:28).

1880 (pre) Deer, bighorn sheep, and turkeys were common in Frijoles Canyon (Lange and Riley 1966: 167).

1880 (pre) Cochiti Pueblos hunted buffalo in the Estancia Valley. Hunters from this village also "trapped" pronghorn and deer in a tributary canyon of the Rio Grande above present Cochiti Dam (Lange 1959: 130).

1880 (spring-summer) There were some 10,000 acres under irrigation in the upper Rio Puerco valley (Cuba to Casa Salazar) (deBuys 1985: 217).

1880 (April 15) The Territorial Bureau of Immigration was organized. "Valuable mines of gold and silver" and ranges "capable of producing sheep for the million" were extolled (Bureau of Immigration 1881: 7–8, 53).

1880 (October 14) Adolph Bandelier noted that the vegetation below, or south of, the La Majada Mesa was more "destitute" than that on the mesa (Lange and Riley 1966: 145).

1880 (October 25) Bandelier encountered some Cochiti Pueblo men who had been gathering zacate, or popote, grass (*Stipa* sp.) on the Potrero de las Vacas for making into brooms. This area was also utilized for pinyon nut gathering (Lange and Riley 1966: 170–172).

1880 (October 25) Bandelier observed that most game, including bears, was "abundant" in the Jemez Mountains (Lange and Riley 1966: 170–172).

1880 By this date, the flow of the Rio Grande had been so reduced by upstream use that irrigation systems and hundreds of acres in the Mesilla Valley-Las Cruces area were abandoned (Wozniak 1987).

1880 The flow of the Santa Fe River had become insufficient for the needs of Santa Fe residents. Reservoirs had to be constructed and wells drilled in this century to meet community needs (Thomas et al. 1963: D–10).

1880 Cottonwoods (common?) were found in and around Pena Blanca (Lange and Riley 1966: 91).

1880 A major flood occurred along the Rio Puerco (US Geological Survey 1994).

1880 Some 64,034 acres of forests burned regionally (Ensign 1888: 82).

1880 By this year bighorn sheep were extinct in the Jemez Mountains (Hewett and Dutton 1945: 105). This species was an important source of meat and figured in ritual ceremonies and mythology (Tyler 1975: 118–131).

1880 A resident of Santo Domingo Pueblo related that bighorn sheep "were driven out of the Sierra del Valle, etc., by the Apache" (Lange and Riley 1966: 94).

1880 The New Mexico Territorial Assembly passed an act to protect the buffalo, but this species was virtually exterminated by this date, and enforcement of the statute was impossible (Gard 1960: 26).

1880 The Santa Fe railroad line was constructed a few miles east of the Rio Grande because company officials thought the land in the valley north of Albuquerque was too soft to adequately support the tracks (McDonald 1992: 12).

1880 White wine and hand-cut hay was being sold at Cabezon (Rittenhouse 1965: 64).

1880 Los Lunas residents Louis and Henry Huning and Solomon and Tranquilina Luna ran 60,000 to 70,000 sheep and over 150,000 cattle, respectively (Roberts 1963: 9).

1880 A fish and game law was passed by the Territorial Legislature that made it a misdemeanor to take fish by use of drugs, explosives, or artificial obstructions. Trout could be taken only by hook and line. Operators of mills or factories could not discharge any waste harmful to trout. Commercial sale of fish was also limited (Clark 1987: 32).

1880 Commercial mining of sandstone copper deposits began in the Nacimiento Mountains (Elston 1961: 155).

1880 Mining of the fluorspar-barite-galena veins in the Placitas district occurred (Elston 1961: 160).

1880 (ca.) Jose Antonio Padilla and his family moved from Belen to Rito Quemado, located west of Magdalena. The creek was so-named either because of the sagebrush and rabbitbrush had been burned off by Indians or because of the volcanic landscape in the area (Pearce 1965: 128).

1880–85 Bandelier (1892: 150) reported that black bears climbed into the top of pinyon trees in search of nuts in the Jemez region.

1880–87 EuroAmerican settlers moved onto the public lands that became the Jicarilla Apache Reservation in 1887. Overgrazing decimated much of the rangeland. All of the arable lands and surface water were claimed as well (Tiller 1992: 87–97).

1880–91 Several trading posts and a general store were operating in Cabezon, serving local residents, travelers on the Star Line Route, Navajos, and area Pueblos. Calico, other fabrics, "fancy" metal buttons, perfume, tobacco, tools, candy, cookies, coffee, sugar, and flour were sold or traded. Navajos brought weavings, jewelry, and sheep to trade for these goods. Two Hispanic residents owned herds of 16,000 and 10,000 sheep. The first also owned 2,000 cattle. By 1891 the village residents owned enough sheep to fill 17 freight wagons with wool (Rittenhouse 1965: 16–17, 31, 33, 36–39, 64–67, 70, 79).

1880–91 Trout were common in Frijoles Creek, which was described as a "gushing brook, enlivened by trout." The stream also had "many pools . . .," which were nonexistent by 1910 (Henderson and Harrington 1914: 54).

1880–98 Poor drainage and alkaline build-up caused abandonment of farmlands in lower areas. There were about 75,000 acres of arable lands between Albuquerque and the mouth of the Rio Puerco, but only about one-fourth was in cultivation. Some tracts were abandoned because the farmers went to work for the Santa Fe Railroad (Follett 1898:87–88).

1880–1900 Lateral arroyos to the Rio Grande carried large quantities of silt into the acequia madre at San Pedro. An elevated canal siphon was constructed to correct this problem (Marshall and Walt 1984: 284).

1880–1905 Overgrazing removed the main source of the grizzly bear's diet—herbaceous vegetation. For survival they turned to predation of livestock (Brown 1985: 100).

1880–1910 The combined population of Casa Salazar and Guadalupe averaged 359 persons; about the same number was recorded for Cabezon-San Luis (Garcia 1992: 5).

1880–1924 The Rio Grande river bed aggraded 7 feet at the Isleta bridge, 8 feet near San Antonio, and 9 feet at San Marcial (Sullivan 1924: 7).

1880–1925 Increasing volumes of silt were due to decreasing flows of the Rio Grande and overgrazing and subsequent erosion in the Upper and Middle River basins (Hedke 1925: 11).

1880–1929 The bed of the Rio Grande began to aggrade and subsequently the river bed was 2–3 feet above the level of San Marcial. The construction of Elephant Butte dam and reservoir and dense growth of tamarisk and other riparian vegetation increased the volume of silt deposition from 1915 to the 1920s. The August 1929 flood destroyed the adobe and frame structures and buried the village in silt (Calkins 1937a: 9–10; Marshall and Walt 1984: 283–284).

1880–1940 Livestock grazing, farming, mining, and other land use resulted in deterioration of land, which caused some settlements to be abandoned in the Middle Rio Grande Basin. The carrying capacity of rangelands decreased 50 to 75 percent during this period (Kelly 1955: 308).

1880 (post) Extensive clear-cutting on the Rio Chama drainage, primarily on private lands, removed the ponderosa pine forest (Harper et al. 1943: 55).

1880 (post) The Chili Rail Line, completed south from Colorado to Espanola, carried sheep, cattle, hogs, pinyon nuts, apples, mica, quartzite, lepidolite, and mica from northern New Mexico (Gjevre 1969: 18–19).

1881 Santa Fe completed a piped-water system, which included damming the Santa Fe River above town (Simmons 1992:206).

1881 There were no trees growing along the Santa Cruz River near the town of the same name (Kessell 1980: 87).

1881 The railroad extended rail construction across the Zuni reservation, and contract lumbermen built logging roads and cut "tens of millions of board feet of lumber" on the Zuni River watershed (Hart 1991: II/3).

1881 A "sacred grove" of cottonwood trees, about 2 by 0.5 miles, was located near Taos Pueblo (Nims 1980: 95).

1881 The San Luis Valley had "a profusion of wild geese and ducks" and "swans, also, are found there, and white brant, or snow geese, as well as sand-hill cranes" (Nims 1980: 126).

1881 A. Bandelier reported that beaver were common along the Rio Grande in the Pena Blanca area; much less common here were river otters. However, he noted that both species were more abundant in the Valle Grande (Lange and Riley 1966: 214).

1881–83 The last native elk in the Sangre de Cristo Mountains northeast of Santa Fe were observed or reported (Barker 1953: 88). Elk were extirpated in these mountains by settlers, miners, and market hunters (deBuys 1985: 280).

1881–84 A hunter and specimen collector found beaver dams common near the headwaters of the Pecos River. In the pools formed behind the dams he found the "best trout fishing of any locality I have ever visited in the Rocky Mountains" (Bailey 1971: 214).

1882 (July 13) The Santa Fe River, carrying high water, flooded part of the valley across the Rio Grande from Cochiti (Lange and Riley 1966: 339).

1882 Bandelier noted that the Rio Grande was "treacherous" and divided into five narrow and swift-running branches at Pena Blanca. Also, he observed that the river "changes its bed almost daily" (Lange 1959: 79–80).

1882 There were a "considerable number of bears" in the Manzano Mountains (Lange and Riley 1966: 383).

1882 The General Land Office in Washington, D.C., ruled that "when a mountain was a boundary [of a land grant] the summit was to be taken as the dividing line, unless otherwise indicated" (Ebright 1994: 239).

1882 A. Bandelier recorded the exotic *Ailanthus*, or tree-of-heaven, growing at the plaza of Ojos Calientes, 3 miles from Socorro (Lange and Riley 1966: 318).

1882–1900 Coal production in Santa Fe County increased from 3,600 tons to 252,731 tons (Elston 1961: 155).

1880s (early) The Newhouse, steel leghold no. 6, grizzly bear trap was first used (Brown 1985: 114).

1880s (early) Elk were extirpated in the Jemez Mountains by commercial hunters working for the "Chili" Railroad and local subsistence hunters (Scurlock 1980: 31).

1883 (pre) Taos Pueblo hunters reported there were two kinds of bison—a smaller variety in the mountains and a larger one on the Southern Plains in the past (Bailey 1971: 14–15).

1883 (March) A. Bandelier described the Agua Azul spring near Grants as "A large pool of deep, crystalline water, extensive enough to allow skiffing, and many ducks in it" (Lange and Riley 1970: 64).

1883 (November 1) Bandelier (Lange and Riley 1970: 155) wrote "At Alamillo, cottonwoods cover the river bottom, and thence on they continue to beyond San Marcial, with much more vegetation besides....At San Antonio ... the east bank is exceedingly bleak and denuded."

1883 (December 21) Bandelier described the Rio Grande Valley below Rincon as "... wooded up to four miles from Rincon, 'alamos.'" He also observed open and marshy conditions (Lange and Riley 1970: 181).

1883 Texas cattleman W.C. Bishop concentrated his 3,000 cattle in Pajarito and Water canyons, which had perennial springs, on the Pajarito Plateau (Rothman 1992: 29).

1883 The Franz Huning property, south of the "castle" in Albuquerque, was "open fields with bosques, lagoons, and occasional clumps of cottonwoods dotting it" (Browne 1973: 136).

1884 (May 23-June 3) The Rio Grande shifted and cut a new channel between the Socorro railroad station and the center of town. Residents were able to divert the river back to its original channel (Carter 1953: 21).

1884 (May 31) By this time, the ongoing flood had increased the capacity of the Rio Grande channel through scouring action (Carter 1953: 19).

1884 When the Rio Grande shifted its course to the west between Los Lentes and Los Lunas, the river cut the acequia madre and left it on the east side of the river. Three other ditches "moved" from west of the river to the east side in the area (Wozniak 1987).

1884 Commercial mining of the "contact-metamorphic copper" deposit in the San Pedro Range began (Elston 1961: 155).

1884–1957 Brick and tile were made at the old State Penitentiary near Santa Fe. The raw material used in making bricks was shale mined from a deposit east of Palace Avenue (Elston 1961: 163).

1885 (July) The Rio Grande between Cochiti and Santo Domingo ran in three channels, with "the main channel reaching to above the knee on horseback." And, "The river is constantly encroaching on the right hand side" (Lange et al. 1975: 59).

1885 (August 1) The Rio Grande, south of Santo Domingo, was falling, and crossing was difficult due to "quicksand" (Lange et al. 1975: 75).

1885 (September 26) Adolph Bandelier described the flow of the Santa Fe River through its canyon of the same name as "like a small stream..." (Lange, Riley, and Lange 1975: 107).

1885 The main, still discontinuous, channel of the Rio Puerco had a volume of about 17,000 acre-feet (Dortignac 1960: 47).

1885 Federal involvement in predator control began when the Department of Agriculture began to study ways of poisoning rodents, pest birds, and predators (Dunlap 1984: 143).

1885 Clarence E. Dutton's geological work on the Mount Taylor and Zuni Plateau areas was published (Northrop 1961: 85).

1885–1905 Some competent ranchers and observers considered the grizzly's reputation as a stock killer undeserved, particularly on the larger ranches before overgrazing became widespread (Brown 1985: 101).

1885–1963 An estimated 600,000 to 800,000 acre-feet of sediment washed from the Rio Puerco watershed into the Rio Grande (Hay 1972: 290).

1880s (mid) Intensive hunting severely reduced pronghorn numbers; by the end of the decade they were not found on many grassland locales where they formerly were common. The pronghorn was an important meat source and played a significant role among the western Pueblos and at Hopi (Tyler 1975: 32, 42, 55–56).

1886 (April 18–20) Wind and rainstorms hit central and northern New Mexico. The Santa Fe River flooded on the 20th, and at least one bridge washed out (Lange et al. 1975: 144, 445).

1886 (September) A severe thunderstorm struck

Santa Fe, causing flooding of the Santa Fe River. High winds and hail accompanied the storm (Lange et al. 1975: 175).

1886 The Texas, Santa Fe and Northern Railroad Co. was formed to construct a rail line from Espanola to Santa Fe. A.J. Hager had a sawmill in dense timber above Santa Fe and furnished trestle timber for the line (Chappell 1969: 13–18).

1887 (pre) Residents of Los Ranchos lost their acequia due to a "rise of the river." One individual, Guadalupe Gutierrez, stated that the high water table and wetlands had been caused by "surplus water from the acequias" (Wozniak 1987).

1887 (May-July) The largest recorded fire in the Sangre de Cristo Mountains started in Tesuque Canyon. It burned north to Santa Fe Baldy and east to the Las Vegas Range, where it was stopped by a railroad tie-cutting crew (Ungnade 1972: 73).

1887 The Rio Puerco channel at Guadalupe was about 3 feet deep and 30 feet wide (Bryan 1928a: 274–275).

1887 Some 74 Acoma hunters killed 744 pronghorn antelope in 1 day near Datil (Tyler 1975: 37–38).

1888 About one-fourth to three-eighths of the forest area of Rio Arriba County had burned (Ensign 1888: 145, 148).

1888 An unidentified species of catfish, weighing from 75 to 100 pounds, was being caught in the Rio Grande near Rincon (Schlissel et al. 1989: 159).

1888 The river was dry at Socorro (Hedke 1925: 26).

1888 Citizens from southern New Mexico and El Paso organized a company that advocated the construction of a reservoir on the Rio Grande, above the Palomas Valley. From the reservoir they wanted water to be conveyed to the Mesilla and El Paso valley to relieve their shortages of irrigation water. By this year, irrigated acreage along the Dona Ana ditch decreased form an initial 7,000 acres to about 4,600 (Wozniak 1987).

1888–91 John W. Powell, head of the U.S. Geological Survey, initiated irrigation surveys in river basins of the West. The Rio Grande was studied in 1889–1900, which also included surveys for reservoir sites (Wozniak 1987).

1888–1913 The total capacity of acequias diverting water from the Santa Fe River was 117 cfs. Flow of the river was affected by the 4,000-acre-foot capacity reservoir located above the town. This structure enabled "much of the flood water to be utilized for irrigation which would otherwise flow to the Rio Grande." River flow only reached the Rio Grande during floods (Follansbee and Price 1915: 424).

1889 (January 31) Springs used by the village of Tome were protected by territorial legislation (Clark 1987: 29).

1889 Legislation was passed to create fish wardens in every county to assist county sheriffs and commissioners in enforcing the fish laws, including a closed season of fishing, except fishing by members of needy families. The law also directed that a sluice for passage of fish had to be maintained at all dams or other obstructive facilities constructed for purposes other than irrigation. Also, operators of mills or factories could not discharge waste of any kind, injurious to trout, into any stream (Clark 1987: 32).

1889–1930 A few river otters were recorded near Espanola, Rinconada, and Cieneguilla (Bailey 1971: 324).

1880s Due to overgrazing and logging in the Zuni Mountains, the upper Zuni watershed began to seriously erode (Hart 1991a: II/3).

1880s A large fire burned for weeks in the mountains above Santa Fe until it went out on its own (Tucker and Fitzpatrick 1972: 49).

1880s Trout were reported in Rito de los Frijoles (Hewett and Dutton (1945: 118–119).

1880s With most of the prey animal populations decimated, wolves became dependent on livestock for sustenance (Brown 1983: 31).

1880s Meat from a deer killed near the Ellis Ranch in the upper Las Huertas drainage was sold in Madrid for $13 due to the scarcity of wild meat (Batchen 1972: 66).

1890 (about July 14) Charles Lummis described the feast day dance at Santo Domingo as taking place during a "furious sand-storm" of 2 hours, followed by an intense rainstorm that ended the dancing (Lange 1959: 344).

1890 J.W. Powell (1891: 271) reported "From Albuquerque to San Marcial, drainage of the lower of the Rio Grande Valley is exceedingly poor. Many ponds, some of them 8 or 10 acres in extent, are full of water during the early part of the year, and others show by the alkali coating on their sides and bottoms that the water has but recently left them."

1890 The soil at Santa Ana Pueblo was "sandy and untillable"; the village had been "long since abandoned" and was only used "for autumn and winter residence." There was a single cottonwood tree at the old pueblo. Beyond the

Jemez River, to the south, there were "undulating plains of wind-swept sands, dotted by stunted cedars growing at intervals, and often forming the nucleus of new mounds during wind storms" (Poore 1894: 431–432; White 1942: 29).

1890 From just north of Albuquerque to Los Lunas the valley was "bordered by barren hills of blown sand" (Powell 1891: 271).

1890 Market hunters killed the last elk in northern New Mexico (Barker 1976: 107).

1890 The American Turquoise Company began mining operations in the Cerrillos area (Elston 1961: 155).

1890–91 According to J.W. Powell (1891: 272), a number of houses in the low-lying areas of the valley south of Los Lunas "have fallen in by the sinking of the foundations. A large part of the valley ... is overgrown with cottonwood thickets or bosques, as they are called."

1890–91 On the east side of the river, below Bernalillo and Belen, once productive fields were "alkali flats" caused by a "lack of drainage" (Powell 1891: 270).

1890–91 Powell (1891: 270–271) described the Rio Grande: "The river from Pena Blanca to San Marcial occupies a broad sandy bed, dividing in low stages into a number of narrow and crooked channels, but in flood covering in many places nearly half of the valley."

1890–91 Drainage of the low-lying valley land from Albuquerque to San Marcial was "exceedingly poor." Numerous ponds, 8 to 10 acres in size, were full of water during the early part of the year. Extensive deposits of alkali along the valley between Los Lunas and Belen appeared as "light snow" (Powell 1891: 271).

1890–91 Low-lying ditches in the Tome-Los Lunas area were subject to "frequent overflow" and "being washed out or being filled with silt" (Powell 1891: 271).

1890–95 The Rio Puerco Irrigation Company constructed masonry and earthen dams, canals, acequias, and pipelines from below Cuba, south to the Lagunitas land grant. Before the system was fully operational, flash floods washed out the dams (Dortignac 1962).

1890–1900 The deepening Rio Puerco channel became a problem for irrigation farmers in the Cabezon area (Bryan 1928a: 274).

1890–1900 A trapper took wolverines "in considerable numbers" on the headwaters of the Rio Grande (Warren 1942: 68).

1890–1904 In areas of rugged terrain, homesteaders herded goats, which resulted in the overgrazing of the steepest slopes (Brown 1985: 98).

1890–1906 Deer, rabbits, blue grouse, wild turkeys, eagles (probably golden), and mourning doves were common in the Bosque Peak area of the Manzano Mountains (McDonald 1985: 22).

1890–1915 Most wolves killed during this period were killed because of the widespread use of bounties (Brown 1983: 43).

1891 Some 12 million acres of forest burned in the Sangre de Cristo Mountains (Ungnade 1972: 48).

1892 The Rio Grande flow was depleted as far upstream as Los Lunas (Hedke 1925: 26).

1893 (pre) Santa Ana Pueblo was abandoned in the spring and summer due to poor fertility of farmlands and high winds. Farming was practiced at Ranchitos on the Rio Grande. The village was reoccupied in the fall and winter. Santa Ana cattle grazed on the mesa above, but there was little grass. Duning was caused by lack of vegetative cover and high winds. Coyotes and rattlesnakes were common in this area, which was "dotted by stunted cedars growing at intervals, and often forming the nucleus of new mounds during wind storms" (Poore 1894: 108).

1893 Based on tree-ring data, a forest fire occurred on the Pajarito Plateau (Robinson 1990: 142).

1893 The agricultural fields of Sandia Pueblo were located below the village. The acequia madre began at the Rio Grande, 2 miles above the pueblo. Large cottonwoods grew along most of the length of the ditch. Several large islands, rising about 6 feet above the river level, and covered by "groves of cottonwood and willows," were located below Sandia. The uppermost island was some 700 acres in size (Poore 1894: 111).

1893 By this year the exotic cheat grass had spread across much of the state (Frome 1962: 253).

1893 San Felipe Pueblo had extensive agricultural lands along the Rio Grande. Perhaps the most productive was located a mile south of the village, where the Rio Grande divided. An "island" of loamy soil, 1.5 miles long and about a third of a mile wide, was found at this location (Poore 1894: 110).

1893 A large island "overgrown by cottonwood trees" in the Rio Grande at Santo Domingo served the pueblo as a "park." The valley was 1 to 1.5 miles in width here, and the pueblo lands occupied a 5.5-mile reach. The old church and many houses were destroyed in recent years. Some orchards and "small plots" of corn and vegetables were located on the east bank of the river, but low-lying tracts of land were not being farmed due to threat of flood damage. Santo Domingo had about 1,200 horses, 1,200 cattle, some oxen, and a few goats. The horses ranged on land covered with sagebrush, south of the cultivated lands (Poore 1894: 109–110).

1893 The legislature passed the Territorial Bounty Act, authorizing counties to pay bounties on "predatory wolves, big bears [grizzlies], mountain lions, bobcats and coyotes" (Brown 1983: 43).

1893 The New Mexico Territorial Legislature passed a law allowing counties to raise money for paying "wolfers" and other predator hunters for their services (Burbank 1990: 98).

1894 (October) The first confirmed report of Russian thistle in New Mexico was made (Wooton 1895: 3).

1894 Zia Pueblo lacked adequate potable water owing to the salinity of the Jemez River (White 1962: 54).

1894–96 San Francisco and San Ignacio on the Montano grant in the Rio Puerco basin were abandoned (Bryan 1928a: 276).

1895–1924 The mean flow of the Rio Grande at Buckman was 1,444,000 acre-feet (Hedke 1925: 37).

1895 (pre) Native grasses, watered by overbank flooding of the upper Rio Puerco, were cut and dried for use as hay. Some of this hay was hauled to Albuquerque and sold (Bryan 1928a: 278).

1895 By this year virtually every acre of available grassland in the region was stocked with sheep or cattle. Rangelands that should have been stocked with one cow on every 40 acres were stocked with four animals (Barnes 1926: 7).

1896 Ditches with a capacity of 406 cfs were diverting water from the Rio Grande between Embudo and Buckman (Follansbee and Dean 1915: 120).

1896 The irrigation ditches between Buckman and San Marcial diverted an estimated capacity of 1,779 cfs of water from the Rio Grande (Follansbee and Dear 1915: 141).

1896 There were about 105,000 acres of irrigated acreage in tributary drainages of the Rio Grande (Dortignac 1956: 30).

1896 There were some 14,000 acres under irrigation along the main stem of the river above the Middle Valley (Dortignac 1956: 30).

1896 Drought and increasing use in the San Luis Valley caused a decline in irrigated farmland in the Middle Rio Grande Valley to 32,000 acres (Wozniak 1987).

1896–1910 Irrigated acreage in the Rincon Valley decreased from nearly 10,000 acres to less than 4,500 acres due to shortages of irrigation water (Wozniak 1987).

1897 The Organic Act authorized the sale of timber on forest reserves, granted local residents free use of timber and stone on these lands, set forth broad directions for management of the reserves, and appropriated funds to regulate them (Clary 1986: 2, 29).

1897 Otero gave out 60,000 sheep on a partido basis in the upper Rio Puerco basin (Maes and Fisher 1937: 14–15).

1897 The Santa Rosa de Cubero acequia, located between San Felipe and Santo Domingo pueblos, had disappeared due to a change in the course of the Rio Grande (Wozniak 1987).

1897 The first game laws to regulate hunting of meat animals such as mule deer were passed by the Territorial legislature. Nevertheless, populations continued to decrease to less than 20,000 animals statewide by 1924. Two years later a bag limit of one buck deer was set (Findley et al. 1975: 329; Huey et al. 1967: 42).

1898 About 19 percent of New Mexico was forested according to a USGS study (Baker et al. 1988: 34).

1898 There were an estimated 70,000 wolves in the territory (Bennett 1994: 200).

1899 A surveyor described a "new channel" of the Rio Puerco at Cabezon that was 198 feet wide. Seven years later the channel at the same location was 244 feet wide and 20 feet deep. These changes were attributed, in part, to land use activities by residents of the area (Bryan 1928a: 271–273).

1899 (ca.) Irrigation farming on the Cieneguilla grant ceased (Pratt and Snow 1988, chapter 4: 46).

1890s Widespread forest fires, probably started by railroad operations or ranchers creating meadows, burned in the mountains between the lower Chama River and the Colorado border, west of the Rio Grande (McDonald 1985: 122).

1890s The Newhouse steel trap, with a double-spring and offset jaws, sometimes with teeth, proved to be very effective in catching wolves (Burbank 1990: 99).

1890s (late) Bighorn sheep were exterminated in the Sandia Mountains (Pickens 1980: 83).

1800s (late) The Mexican Government complained to the U.S. Government about shortages of irrigation water at Ciudad Juarez. The Mexicans advocated construction of a reservoir in the narrows of the Rio Grande above El Paso. New Mexicans did not support this site location (Wozniak 1987).

1800s (late) Two grizzly bears charged into a flock of sheep in the Pecos high country, and the herder shot one of the bears and wounded the other. This animal turned and mauled the young man, who was able to kill the bear with a knife (Barker 1953: 193–194).

1800s (late) All five races of southwestern wolves were extant in the state (Brown 1983: 24–25).

1800s (late) (to early 1900s) Florence Merriam and Vernon Bailey conducted research and wrote a number of books on the birds and mammals of New Mexico (Ligon 1961: 11).

1800s (late) (to early 1900s) Brook trout were introduced into the Rio San Jose near Laguna, then into the Rio Grande and drainages in the territory (Sublette et al. 1990: 72).

1800s Mosquitoes caused widespread malaria in the area (Stanley 1966: 13).

1900 (pre) "A good cover" of galleta, blue grama, and alkali sacaton grasses was found over much of the Rio Puerco watershed (Dortignac 1963: 508).

1900 (pre) Fires created extensive stands of aspen, ponderosa pine, and Douglas fir in the upper montane coniferous forest zone, about 8,000–10,000 foot elevation (Dick-Peddie 1993: 58).

1900 (pre) Native trout disappeared from El Rito de los Frijoles on the Pajarito Plateau (Hewett et al. 1913: 35).

1900 (pre) Before the construction of major dams on the Rio Grande, an estimated 75 billion pounds of sediment was carried annually in irrigation systems and floodwaters. This silt was rich in phosphate, potash, and nitrogen (Simmons 1991b: 69, 77).

1900 (pre) An old San Ildefonso man claimed he had hunted antelope on the eastern side of the Pajarito Plateau (Hewett and Dutton 1945: 108).

1900 May The Lacey Act, ending market hunting for pelts, plumage, eggs, meat, and so forth, and outlawing illegal importation of foreign wildlife, was passed by the U.S. Congress (Matthiessen 1964: 172).

1900 May A jaguar was trapped near Grafton in Socorro County (Bailey 1971: 283).

1900 Extensive use of cottonwoods for fuel, construction, and livestock feed in the Middle Rio Grande Valley had subsided by this year (Dick-Peddie 1993: 151).

1900 In precinct 12, "Lower Tome," there were 593 residents. In precinct 29, "Upper Tome," there were 325 residents (U.S. Census Bureau 1900).

1900 The decrease in rangeland productivity due to overstocking and overgrazing over the previous 4 decades began. The number of head of livestock continued to increase to a high of 177,000 animals in 1930. By 1935 the total had dropped to 54,000, but it began to increase again after the 1930s drought (Dortignac 1956: 59–60).

1900 There were 533,000 head of livestock grazing in the Middle and Upper Rio Grande basins (Hay 1972: 290).

1900 By this year residents in the Mesilla Valley were promoting the Elephant Butte site for construction of a dam and reservoir. The Reclamation Service favored this site and began studies (Wozniak 1987).

1900 By this year beaver had been virtually exterminated by trappers and hunters in all of the territory's mountain ranges (Findley 1987: 86). Also by this year, elk became extinct in southern New Mexico, primarily as a result of commercial and sport hunting (Findley et al. 1975: 328).

1900 A huge swarm of grasshoppers descended on Bland Canyon, drowning in the stream and polluting the water. Reportedly, they were piled over a foot deep along the stream's banks, and residents of Bland were forced to dig out springs for their drinking water (Sherman and Sherman 1975: 13).

1900 Thomas A. Edison tried unsuccessfully to work the Old Placers deposits using a dry method of extraction (Elston 1961: 155).

1900–10 Overgrazing and logging on the Zuni River watershed accelerated soil erosion (Hart 1991a: II/3).

1900–10 Black bears were reported as common in most mountain ranges in New Mexico. Grizzlies were less common, but they still inhabited the more remote mountains (Bailey 1971: 349–368).

1900–16 Non-Pueblo grazing and road-building, as well as overgrazing and timber cutting on adjacent lands, damaged Santa Ana Pueblo lands (Bayer 1994: 183–185).

1900–26 Construction of railroads, bridges, and dikes and levees prevented the Rio Grande channel from shifting (Rodey and Burkholder 1927: 15).

1900–41 Only a few records of the river otter were recorded in southern Colorado, where populations were more common in the 19th century (Warren 1942: 72).

1900–50 The ponderosa forests on the east side of the Sandia Mountains disappeared due to logging and fire suppression (Baisan 1994: 2).

1900 (ca.) Fire suppression, which began about this time, resulted in an increased proportion of Engelmann spruce and corkbark fir in the subalpine coniferous forest zone, 9,500 to 12,000 feet elevation (Dick-Peddie 1993: 51, 56).

1900 (post) Pinyon-juniper woodlands spread at lower elevation ecotones onto grasslands during this century as a result of fire suppression, livestock grazing, and other factors (Dick-Peddie 1993: 91–92).

1902 The first Yellowstone cutthroat trout were introduced into northern New Mexico (Sublette et al. 1990: 56).

1902 The last Rocky Mountain bighorn sheep in the Taos Mountains was shot. This subspecies had been reported as abundant a quarter of a century before this event (Bailey 1971: 17).

1903 (summer) Elliott Beatty and two companions caught 438 trout in 6 hours from the Valdez Creek and the Mora River (Barker 1953: 54–56).

1903 By this year Russian olive had been introduced at Mesilla Park (Freehling 1982: 10).

1903 Gray wolves were "fairly common" in the Manzano Mountains (Bailey 1971: 309).

1903 Mountain lions were reported as common on the headwaters of the Pecos River (Bailey 1971: 286).

1903 Black bears were relatively common along the headwaters of the Pecos River (Bailey 1971: 352).

1903 Bighorn sheep were seen for the last time in the Truchas Peak area (Barker 1953: 88).

1903 The last bighorn sheep were extirpated in the Sangre de Cristo Mountains. Competition with domestic sheep for grazing, diseases transmitted from the domesticated to the native sheep, and hunting were the primary causes of their demise (deBuys 1985: 280).

1903–04 Intensive trapping of beaver occurred along the Rio Grande north of Santa Fe (Bailey 1971: 215).

1903–06 Black bears were reported as common in most mountain ranges in New Mexico (Bailey 1971: 350–351).

1903 (and 1905, 1909) The Territorial Legislature passed acts authorizing counties to levy taxes to be used for paying bounty claims on predatory animals (Hagy 1951: 91).

1904 (pre) There was no bosque at Corrales except at one location (Eisenstadt 1980: 13).

1904 (October 11) A peak discharge of 50,000 cfs occurred on the Rio Puerco (Snead and Reynold 1986: 57).

1904 There were 30,000 sheep owned by small operators grazing in the Cabezon-Cuba area. One sheepman in Cuba owned 32,000 animals, and another had 20,000 (Maes and Fisher 1937: 15, 18–19).

1904 The New Mexico Game and Fish Department was created by the Territorial Assembly (Barker 1970: 185).

1904 (ca.) A jaguar was killed on the west slope of the Caballos Mountains (Bailey 1971: 284).

1904–06 The Rio Grande carried an estimated annual sediment load of 14,580 acre-feet. A USGS employee observed "The deposition of sand and silt in the erosion basins causes frequent changes in the course of the river, so that bayous, sloughs, and oxbow lakes are common in the bottom lands" (Lee 1907: 24).

1904–06 Turquoise mining in the Cerrillos district "declined sharply" (Elston 1961: 160–161).

1905 (spring) At the north end of the Mesilla Valley, floods caused the river to move about a mile to a new channel (Lee 1907: 24).

1905 (summer) (to 1908) The Reclamation Service completed work on the Leasburg diversion structure and ditch system, which served Dona Ana, Las Cruces, and Mesilla acequias (Wozniak 1987).

1905 Between Albuquerque and Cabezon several large herds of sheep and goats were seen along the freight road. Prairie dog villages were relatively common along the route, as were associated burrowing owls, rattlesnakes, hawks, and eagles (Schmedding 1974: 90–92).

1905 Exotic trout species were introduced into the Santa Fe River (Kuykendahl 1994: 3).

1905 The Forest Service began to hire trappers to kill wolves on national forest grazing land (Dunlap 1984: 143).

1905 A few resident black bears and grizzly bears were reported in the San Mateo Range near Grants (Bailey 1971: 365).

1905–08 The freight road between Albuquerque and Cabezon traversed sand hills, clay soils, deep arroyos, and quicksands at fords. Some wagon ruts, especially on steeper grades, became arroyos (Schmedding 1974: 78–79, 88–90).

1905–15 U.S. forest rangers trapped or shot grizzly bears, wolves, and mountain lions to help maintain good relations with local ranchers and to collect bounties (Brown 1985: 123–124).

1906 A ford across the Rio Grande was in use at

Las Canas, located on the east bank of the river south of Parida (Marshall and Walt 1984: 276–277).

1906 "Cattle barons" were opposed to statehood because free-grazing on the public domain would be disallowed, and they would be forced to make rental payments to the state fund. "Lumber barons" were opposed because large timber holdings were assessed at less than 10 percent of their value (Larson 1968: 243).

1906 The Rio Puerco channel at San Luis was 20 feet deep (Tuan 1966: 589).

1906 A moderate earthquake caused severe damage to Socorro and the surrounding area (Northrop 1980: 85).

1906 The church of San Antonio de Aquinas was destroyed in an earthquake (Marshall and Walt 1984: 303).

1906 Homesteader Fred Rhea, concerned about fire in the tall grass surrounding his home on Bosque Peak in the Manzano Mountains, moved his sheep onto this vegetation and they "grazed it down" (McDonald 1985: 22).

1906 Perhaps the last grizzly bear in the Sandias was killed by Augie Ellis near the Ellis Ranch (Cooper 1989).

1906–07 A series of earthquakes occurred in the Socorro area (Sanford 1986: 19).

1907 (pre) Local Hispanics grazed cattle and cut the indigenous grasses for hay along Abo Creek (Clark 1987: 329).

1907 (January 16) An agreement between the United States and Mexico was ratified; it gave Mexico the right to divert up to 60,000 acre-feet of water from the Rio Grande for agricultural use (Hay 1972: 299).

1907 W.T. Lee (1907: 31) described the Rio Grande north of El Paso as "mainly a floodwater stream subject to great fluctuations in volume."

1907 This was perhaps the last year that the lower Rio Puerco-of-the-East was perennial (Titus 1963: 81).

1907 The first rainbow trout, an exotic species, were stocked in the Santa Clara Creek and Rio Puerco near Espanola (Kuykendahl 1994: 3).

1907 Five hundred ten coyotes were killed on national forest lands (Bailey 1971: 312).

1907–10 Snakeweed, *Gutierrezia* spp., had invaded the grasslands of the mesa and foothill zones by this time (Watson 1912: 202).

1908 (April 16) The name, Manzano Forest Reserve, was changed to Manzano National Forest (Tucker 1992: 112).

1908 (June) Elliott Barker (1953: 33) killed four grizzly bears on Spring Mountain in the Sangre de Cristo Range.

1908 The Rio Grande was dry just below Cochiti Pueblo (Harrington 1916: 101).

1908 Most of the timberland in the Manzano National Forest had been cut for ties and other railroad construction material (Baker et al. 1988: 78).

1908 Salt cedar, or tamarisk, was "commonly planted" in Albuquerque as an ornamental plant (Watson 1912: 80).

1908 The exotic brook trout was introduced into the Rio Grande at Embudo, Santa Barbara, and Pueblo (Kuykendahl 1994: 3).

1908 A $20 bounty was paid for dead bears, and up to $50 was paid for grizzly bear hides. Some 271 bobcats were killed in the national forests, and many more were harvested by trappers or killed by ranchers statewide (Bailey 1971: 293; Barker 1953: 153).

1908 W.H. Bartlett, owner of the Vermejo Park, reintroduced elk there (Barker 1953: 93).

1909 The New Mexico Territorial Legislature enacted a $15 bounty for wolves (Burbank 1990: 98).

1909 The estimated saw timber volume on national forests in New Mexico was 16,200 million board-feet (Baker et al. 1988: 78).

1909 Pronghorns were removed from the list of legally hunted game animals to afford them protection (Matthiessen 1959: 283).

1909–11 Elliot Barker (1976: 10–11, 14) observed that sheep had damaged "high elevation slopes" in the Sangre de Cristo Mountains. This impact apparently occurred because of "close herding and trailing" and repeated bedding of the sheep at the same location.

1909–11 Botanist J.R. Watson (1912: 202), following his field study of plant communities, wrote this about the adjacent uplands of the Rio Grande: "This was undoubtedly originally a grassland, and is so yet where it has not been too seriously over-grazed. . . . Now thanks to lack of scientific control of grazing, it has been invaded by the composite *Gutierrezia* ... as to merit being called a Gutierrezia formation."

1909–26 The river bed at San Marcial aggraded about 12 feet. The rising river bed caused a widening of the Rio Grande channel and encroachment on farmland from Belen south (Rodey and Burkholder 1927: 15).

1910 (pre) The housefly was introduced to New Mexico (Henderson and Harrington 1914: 59).

1910 (pre) Bighorn sheep were extirpated in the Tewa area (Henderson and Harrington 1914: 3).

1910 (August 19) A pair of bald eagles was observed in Frijoles Canyon (Henderson and Harrington 1914: 37).

1910 A pair of spotted owls nested along Frijoles Creek in the Jemez Mountains (Henderson and Harrington 1914: 37).

1910 Wild turkeys were relatively common on the east slopes of the Sandia Mountains, but only a few were found several years later (Ligon 1927: 114).

1910 Salt cedar was reported growing at Mesilla Park (Scurlock 1988: 138).

1910 Mountain lions were declared "fairly abundant" in the Carson National Forest and "very common" in the Jemez Mountains by Forest Service officials (Bailey 1971: 286).

1910 Archeologist Neil Judd reported that black bears were common in and around Frijoles Canyon (Rothman 1992: 140).

1910 (ca.) The waters of the Rio Grande commonly disappeared into its sandy bottom a short distance above Bernalillo (Harrington 1916: 101).

1910–11 Young *Juniperus monosperma* plants were spreading into the lower grasslands of the Estancia Valley (Watson 1912: 206).

1910–11 The gray wolf was seen occasionally in the Taos Mountains according to Tewa Pueblo informants (Henderson and Harrington 1914: 29).

1910–11 More than 900 permits to take beavers were issued to individuals who claimed damages to their property. At the same time, the Santa Fe Water Company was offering $50 for each pair of live beavers to transplant to the upper Santa Fe Canyon, where they would help conserve water for the city by their dam building (Bailey 1971: 219).

1910–11 Gunnison prairie dogs were reported as abundant in the Valle Grande. River otters were recorded in the Rio Grande from Taos to the Albuquerque area, as were mink. Black bears were noted as common, and coyotes were also reported as common, but the gray wolf was "very scarce" in the Tewa Pueblo area, but "occasionally seen" in the Taos Mountains. Wild horses were noted on the mesa south of Buckman (Henderson and Harrington 1914: 21, 23–29, 31).

1910–11 Carapaces of the tortoise, a common species in the Tewa area, were used to make dance rattles (Henderson and Harrington 1914: 52).

1910–11 Blue grouse and wild turkey were common in the Jemez Mountains. Western bluebirds were also common on mesa tops of the Pajarito Plateau (Henderson and Harrington 1914: 34–35, 37, 45).

1910–18 Fifty-five new irrigation ditches went into operation in the Middle Rio Grande Valley (Hedke 1925: 22).

1900s (early) The introduced tamarisk formed dense stands, especially along riparian corridors, and became a fire hazard for cottonwood-willow bosques (Pyne 1982: 187).

1900s (early) An agricultural field below Nambe Falls was abandoned and subsequently revegetated by prickly pear, cholla, junipers, pinyons, and unidentified shrubs (Ellis 1978: 62).

1900s (early) Intensive grazing, suppression of fire, and a "wet" period led to a "dramatic expansion of woody vegetation and a concomitant decay of the grass lands" (Pyne 1982: 524).

1900s (early) The Federal Government constructed reservoirs for pueblos that did not have a reliable water supply. These quickly began to silt up, resulting in a reduction of their capacities (Vlasich 1980a: 28).

1900s (early) The American Lumber Company was established in Albuquerque. Logs for the mill came from the Zuni and San Mateo mountains north of Grants (Balcomb 1980: 56).

1900s (early) By this time grizzly bears, elk, bighorn sheep, wolves, and pine martens had been exterminated by hunters and trappers in the Sangre de Cristo Mountains (deBuys 1985: 280).

1900s (early) San Felipe Pueblo was still conducting an annual rabbit hunt at this time. Clubs and rocks were used to kill the rabbits, as well as prairie dogs, gophers, lizards, snakes, and birds. Each year's hunt would take place at a new area, allowing the fauna in the previous year's area to recover (Balcomb 1980: 47–48).

1900s (early) Beavers had been largely extirpated in most mountain ranges in New Mexico (Bailey 1971: 251; Findley 1987: 86).

1900s (early) The Rio Grande beaver was extinct in the Middle Valley by this time (Huey et al. 1967: 188).

1900s (early) Sage grouse had been hunted to near extinction in the area between Taos and Tres Piedras (Pickens 1980: 83).

1900s (early) Florence M. Bailey (1928: 103, 156, 177, 180–181, 189–190, 211, 237) reported whistling swans and whooping cranes as extinct, goshawks as uncommon nesters, golden eagles as common residents in the mountains, bald eagles common in western Socorro County, peregrine falcons nesting west of Santa Fe, sage grouse common in the north until about 1908, band-tailed pigeon as fairly common in all of the high mountain ranges, and loggerhead shrike as a common nester for the study region.

1900s (early) The white-tailed ptarmigan was extirpated in the Sangre de Cristos (de Buys 1985: 280).

1911 (October) S.L. Fisher and Elliott Barker killed four male mountain lions in the Pecos District of the Santa Fe National Forest over 2 weeks of hunting. Barker (1953: 86) wrote "The two-week, thrill-packed lion hunt was over and we had four of the big male horse-and-deer-killers to our credit...."

1911 (post) Personnel from the State Engineer's Office constructed a levee to protect San Marcial from floods (Calkins 1937: 7–8).

1911–12 Salt cedar, or tamarisk, trees were being planted in Albuquerque as an ornamental. The species quickly spread over the Middle Rio Grande Valley (Scurlock 1988: 136, 138).

1911–26 Elk were reintroduced onto two Colfax County ranches, the Santa Fe National Forest, and a ranch in the Gila National Forest (Ligon 1927: 71).

1912 A new bridge connecting Alameda and Corrales was constructed, replacing the bridge destroyed in the 1904 flood (Eisenstadt 1980: 13).

1912 Apples, pears, peaches, apricots, quinces, and grapes were commonly raised in the Middle Valley. Vegetables raised included alfalfa, wheat, corn, and oats, with the first being farmed on about half the total tilled acreage. Chiles, onions, tomatoes, several varieties of beans, and cabbages were the main vegetables grown in the area (Nelson et al. 1912: 11–19).

1912 Personnel from the USDA Bureau of Soils conducted a soil survey of the Middle Rio Grande Valley. Based on field data, including soil corings, a detailed classification of soil groups, series, and types was developed. Some 1,500 borings were made to determine the depth of the shallow groundwater table under the floodplain. Crop plants, and their relationships to the water table and soil types, were also studied. The survey found that the water table ranged from 6 inches to 6 feet deep, with an average depth of 23 inches over 90 percent of the floodplain (Nelson et al. 1912: 8–9, 44–46).

1912 One-seed juniper was spreading into the grasslands of the Estancia Basin (Watson 1912: 206).

1912 "Many old abandoned river channels in the valley" had "been reclaimed and" were being "used for crops" (Nelson et al. 1912: 39).

1912 The last indigenous sage grouse in New Mexico was killed southwest of Chama. The New Mexico Game and Fish Department reintroduced the species to northern New Mexico with birds captured in Wyoming (Ligon 1961: 93).

1912–20s Access to common grazing lands previously used by La Tierra Amarilla land grantees was cut off as fencing for the Carson National Forest was initiated. The numbers of animals were reduced by implementation of permits as well. This action was taken to help restore the overgrazed, eroding forest lands (Wilson and Kammer 1989: 53).

1913 Hewett et al. (1913: 20) wrote "The Rio Grande and many smaller streams show evidence of volume formerly much greater than at present."

1913 The Rio Puerco channel at La Ventana was 15 feet deep (Dortignac 1962: 588).

1913 Vernon Bailey (1913: 74) described New Mexico's rangelands: "Many of the arid valleys in New Mexico have been for years so overstocked that the best grasses have been killed out and parts of the range rendered almost worthless. Some of the valleys show mile after mile of ground almost bare or overgrown with worthless vegetation that stock does not eat. Around most of the watering places the grass is killed for a long distance, often from 1 to 3 miles, the ground is trampled, and baked, and the little rain that falls runs down the trails and is wasted."

1913–15 The Forest Service advertised 117 million board-feet to be harvested in the Carson National Forest, near La Madera, Rio Vallecitos, and in the higher Valle Grande area. A new sawmill was put into operation at La Madera, which had a capacity of 60,000 board-feet per day (Gjevre 1969: 37).

1914 (pre) The Santa Fe Railroad operated an average of 15 locomotives to pull its transcontinental trains. Each engine had a tender that held 7,500 to 10,000 gallons of water (Worley 1965: 37–38).

1914 (pre) The Tewa Pueblos declared that the gray wolf was rare in their hunting area. They did report occasional sightings in the Taos Mountains (Henderson and Harrington 1914: 29).

1914 (pre) The Mexican bighorn sheep, a subspecies, was extirpated in the southern portion of the study region (Huey et al. 1967: 78).

1914 (June 30) The U.S. Congress authorized the Predatory Animal and Rodent Control (PARC) branch of the Biological Survey of the U.S. Department of Agriculture. Congress made this group responsible for experiments and demonstrations in destroying wolves, prairie dogs, and other predators on livestock. Some 300 hunters were employed under this program in 1914–15 (Brown 1983: 52, 126–127).

1914 There were 8,500 acres of cultivated Rio Grande floodplain in Valencia County. An estimated 67 percent of this total was adversely affected by seepage (Bloodgood 1938: 13).

1914 A firm purchased logging rights to 117 million board-feet of timber in the Carson National Forest. Ponderosa pine and Douglas fir were the two principal species harvested and sent to the company's sawmill at La Madera (Chappell 1971: 129–130).

1914 Aldo Leopold, a Forest Service employee, joined J. Stokely Ligon of the New Mexico Game and Fish Department in a program to eradicate the wolf in New Mexico and Arizona. Leopold later reversed his view toward wolves and other predators, which he eloquently explained in *A Sand County Almanac* (Burbank 1990: 101, 107–108; Leopold 1949: 129–133).

1914 The dramatic decrease in large game animals in northern New Mexico over the preceding 3 decades was attributed to the increase in Anglo hunters, and some Native Americans, with improved rifles and ammunition (Henderson and Harrington 1914: 2).

1914 late (and April 1915) The New Mexico Cattle Growers' Association voted to pay bounties of $25 for each hide of adult wolves or mountain lions taken on the ranges of its members. The organization also passed a resolution requesting Congress to provide funds to exterminate predators on public lands (Hagy 1951: 91).

1914–16 Some 115 black bears were killed on national forests (Bailey 1971: 353).

1914–25 More than 200 rail-car loads of apples were shipped annually from the Espanola area (Gjevre 1969: 18).

1915 The village of Paraje was condemned because of the construction of Elephant Butte Dam and was subsequently inundated by the reservoir (Marshall and Walt 1984: 279).

1915 Some 108 short-term grazing leases held by non-Indians on 509 Jicarilla allotments at the southern part of the reservation were generally overgrazed (Tiller 1992: 112).

1915 The demand for beef and mutton increased sharply with the start of World War I, and grazing restrictions on the national forest reserves were relaxed (Brown 1985: 129–130).

1915 Beaver populations were increasing along the Rio Grande above and below San Marcial (Bailey 1971: 215).

1915 The Forest Service released 37 elk from Yellowstone National Park into the Pecos District of the Santa Fe National Forest. In less than 20 years this small herd increased to about 300 animals, and hunting resumed within a short period (Barker 1953: 94–95, 163).

1915 Black-footed ferrets were reported from several locales in New Mexico (Bailey 1971: 326).

1915 Some 57 wolves were killed in New Mexico's national forests (Bailey 1971: 311).

1915–16 The pronghorn antelope population reached an all-time low of an estimated 1,200 to 1,700 animals in the state. In the 19th century there were an estimated 100,000 of these animals (Barker 1970: 192; Findley et al. 1975: 334).

1915–16 J. Stokely Ligon took charge of predator control in the New Mexico-Arizona district. He hired 32 hunters and trappers, including renowned bear hunter Ben Lilly. Nineteen grizzly bears and at least six mountain lions were killed. His staff of wolf hunters also killed 69 wolves in their first year in New Mexico and Arizona. An estimated 300 wolves remained in New Mexico at the end of the year (Brown 1985: 127; Burbank 1990: 102–103).

1916 (May 12) Construction on the Elephant Butte Dam was completed, creating a reservoir 40 miles long and covering some 40,000 acres of land with 2,638,860 acre-feet of water (Writer's Work Project 1940: 21).

1916 (December) J.B. Archuletta of La Jara reported that a wolf attacked his flock of 200 sheep at night, killing 70 of the animals (Ligon 1971: 310–311).

1916 An estimated loss of 24,350 cattle, 165,000 sheep, and 850 horses, valued at $2,715,250, was attributed to wolf, mountain lion, grizzly bear, coyote, bobcat, and "wild dogs" predation (Brown 1983: 57).

1916 U.S. Biological Survey personnel killed 100 wolves. Some 117, including those taken by the U.S. Forest Service, were killed in the national forests (Bailey 1971: 311).

1916 The U.S. Forest Service initiated a predator control program in the Jemez Mountains. The gray wolf, mountain lion, and coyote were targeted for trapping (Barker 1970: 113; Scurlock 1981a: 144).

1916 One thousand eighty-four coyotes were killed in the state (Bailey 1971: 313).

1916 About 1,740 pronghorns were reported in the state (Bailey 1971: 25).

1916 The Rio Grande Commission was authorized by the State Legislature. This group was to address regional and Middle Rio Grande water problems (Clark 1987: 205).

1916 Congress passed the National Park Act leading to the creation of the National Park Service (Udall 1963: 153).

1916 The governor proclaimed arbor and bird days for the state (Robinson 1993: 34).

1916 With completion of the Elephant Butte Dam, eels (*Anguilla rostrata*) could no longer return to the Upper Rio Grande (Koster 1957: 79).

1916 (ca.) Santa Ana residents cut "pines" in the Jemez Mountains to use as vigas in a new roof on their church. They also bought rough green lumber for use as tables or ceiling slabs (Kessell 1980: 168).

1916 (post) Following completion of Elephant Butte Dam, water "backed up" the Rio Grande, contributing to water-logging of agricultural lands in the lower reach of the Middle Valley (Forrest 1989: 31).

1916–17 Ashley Pond founded a sportsman's club that included a game preserve and hunting and camping areas at the north end of the Ramon Vigil land grant. The water source for this endeavor, a spring in Pajarito Canyon, dried up, and Pond abandoned the preserve (Ebright 1994: 244–245).

1916–18 When the United States joined the allies in World War I, the Forest Service increased the number of permitted livestock on national forest lands. Conditions caused by previous overgrazing and logging worsened (deBuys 1985: 231).

1916–19 The U.S. Forest Service issued livestock grazing permits for the sacred Blue Lake area to non-Indians (Sando 1989: 83).

1916–23 The density of black grama grass on New Mexico ranges decreased during this dry period (Gatewood et al. 1964: B43).

1916–24 When available, pinyon nuts were shipped by rail from the Taos junction area. The average annual shipment was 10 carloads; in 1921 there were 17 carloads (Gjevre 1969: 19).

1917 (January-May) An estimated 33 black bears were killed in the state, and some 157 still remained in forested areas (Bailey 1971: 353).

1917 The average depth of ground water in the floodplain of the Rio Grande in Sandoval County was 2.5 feet (Bloodgood 1930: 20).

1917 Congress increased grazing fees on public lands, and politicians, ranchers, and others protested vigorously (Clark 1987: 146).

1917 By this year half of the previously farmed land in the North Valley was no longer suitable for agriculture due to alkali deposits and a high water table that flooded extensive surface areas (Sargeant and Davis 1985: 19).

1917 The Sherwin-Williams Paint Company began mining lead and zinc deposits in the Magdalena Mountains (Fergusson 1951: 307).

1917 The grizzly bear population across New Mexico had declined to only 48 animals (Bailey 1971: 368; Brown 1985: 133).

1917 As the United States entered World War I, demand for beef increased sharply, and Stokely Ligon and Aldo Leopold used the situation to justify an intensified predator control effort (Brown 1983: 57).

1917 The Bureau of Biological Survey received $25,000 funding to control predatory animals and rodents in New Mexico. This amount was matched by the state (Hagy 1951: 93).

1917 Professional trappers took 103 adult wolves in the state (Bailey 1971: 307).

1917 The plains gray wolf population had been reduced to less than 100 in the state (Gehlbach 1981: 81).

1917 An estimated 84 mountain lions were killed; some 400 others were found in the state (Bailey 1971: 287).

1917 (ca.) The wood-fired stamp mill was shut down on Baldy Mountain (McDonald 1985: 51).

1917–18 Maximum numbers of livestock were reached in New Mexico because of the increased demand for food and wool during World War I (Donart 1984: 1240).

1917–18 Trespass livestock were common on Forest Service lands, which contributed to overgrazing (Roberts 1963: 120–121).

1918 (January) The Los Alamos Ranch School opened, and the water supply was a problem until a small dam was constructed in a canyon above the school 5 years later (Church and Church 1974: 7).

1918 (July) Government employees trapped 45 wolves (Bailey 1971: 307).

1918 (fall) Influenza struck all over the world, and many towns in New Mexico were hit hard. A majority of families in the state lost at least one member or friend to this disease (Melzer 1982: 221).

1918 The width of the Rio Grande "flood channel" varied from 300 to 4,000 feet. The river bed was aggrading at a "high rate" (Sullivan 1924: 6).

1918 Taos was the hardest hit community in the United States by the influenza epidemic (Tucker and Fitzpatrick 1972: 48).

1918 Numerous deaths due to influenza occurred at Lemitar (Scurlock 1982a: 14).

1918 There were 65 ditches with a water-carrying capacity of 1,957 cfs in the Middle Rio Grande Valley. These acequias irrigated about 47,007 acres (Hedke 1924: 20).

1918 Cerrillos experienced an earthquake, and many ceilings and chimneys fell (Northrop 1976: 85).

1918 During the influenza epidemic, villagers at Sandia Pueblo feared that they would be totally decimated by the disease. A delegation from Sandia went to Isleta Pueblo and deeded all of their lands to the latter (Parsons 1974: 204).

1918 The State Engineer reported that nearly 60,000 acres in the Middle Rio Grande Valley were covered with alkali, salt grass, or swamp (Rodey and Burkholder 1927: 17).

1918 There were 58,000 acres classified as alkaline or swamp, and some 47,000 acres were under cultivation (Hedke 1924: 25).

1918 Congress passed the Migratory Game Bird Treaty Act, making the U.S. Biological Survey (later the U.S. Fish and Wildlife Service) responsible for nationwide management of waterfowl and other migratory species (Huey et al. 1967: 153).

1918 Prairie dog "towns" were estimated to cover 20,000,000 acres of rangeland in the state (Mortensen 1983: 72), perhaps an inflated figure.

1918 Some 93 adult wolves and 30 pups were taken by the U.S. Predatory Animal and Rodent Control Division of the Biological Survey and New Mexico A&M College employees (Brown 1983: 58).

1918 Poisoning of grizzly bears was initiated by the U.S. Biological Survey (Brown 1985: 272).

1918–19 During this fiscal year, state and federal animal and rodent control killed 28 grizzly bears in New Mexico (Brown 1985: 137).

1918–29 Coal production in the Madrid area peaked (Elston 1961: 66).

1918–41 The Middle Rio Grande floodway aggraded at the rate of 1 foot about every 12 years. In the Bosque del Apache-San Marcial area the rate was about 1 foot every 5 years (Happ 1943: 2).

1919 (pre) San Ildefonso Pueblo lost more land to squatters than any other pueblo. Non-Indian removal of timber for commercial use severely impacted the Rio Grande-Pojoaque River watershed on their land (Arnon and Hill 1979: 312).

1919 Major losses in the flow of the Rio Grande above Elephant Butte Reservoir were attributed to evaporation of water from undrained areas and to percolation along the main river channel (Wozniak 1987).

1919 Of the 206,012 acres of floodplain land in the Middle Rio Grande Valley, about 51,977 acres were classified as "alkali and salt grass" (Bloodgood 1930: 5).

1919 Production of molybdenum began in the Questa mineral district of Taos County (Strauss 1947: 127).

1919 The highest annual, daily mean flow of the Santa Fe River near Santa Fe between 1910 and 1993 occurred (USGS 1994).

1919 (ca.) Pronghorn antelope and good grama grass were found on the west bajada of the Manzano Mountains in the La Cabra Spring area (Otero 1989).

1919–25 Sixty new irrigation ditches went into operation in the Middle Rio Grande Valley (Hedke 1925: 22).

1919–29 Scabies infected cattle herds in Valencia County, which was followed by a poor economic market and high feed prices (Magnum 1990: 71).

1920 (pre) The last mink in the Los Lunas area were reported. This species historically occurred as far south as Elephant Butte (Hink and Ohmart 1984, pt. I: 34).

1920 The Forest Service adopted a policy of no light burning in ponderosa pine forest, based on the belief that fire every 2 to 3 years would prevent restocking of the tree (Pyne 1982: 522).

1920 The first motorized vehicle to drive to the Sandia Crest was an Army Signal Corps truck (McDonald 1985: 11).

1920 The town at the Hagan coal mine was constructed (Olson 1976: 90).

1920 The U.S. Census Bureau counted 360,350 persons in New Mexico (Workers of the Writers' Program 1940: 434).

1920 The elk population on all of the national forests in New Mexico was 585 (Baker et al. 1988: 177). By this date the Rocky Mountain elk had almost been exterminated in Colorado (Warren 1942: 277).

1920 The U.S. Biological Survey's predator control program in New Mexico had reduced wolves from an estimated 300 to an estimated 60 (Brown 1983: 64; Flader 1974: 60).

1920 The pine marten was probably extirpated in the Sangre de Cristo Mountains by this year (deBuys 1985: 280).

1920 (ca.) Erosion created a new arroyo that cut

Abo Creek and diverted most of the water, diminishing the stream flow (Clark 1987: 329).

1920 (ca.) Aldo Leopold planted a tamarisk in front of his house in Albuquerque (Robinson 1965: A5).

1920–25 The cattle industry, and wildlife in general, declined due to rangeland abuse. Hunting pressure was also a factor in the decrease in indigenous animal populations (Ligon 1927: 31).

1920–33 Bootlegging alcohol was common in the Bernalillo-Corrales area during prohibition (Olson 1976: 91).

1921 Created earlier by the State Legislature, the Rio Grande Survey Commission, in cooperation with the U.S. Reclamation Service, began to study environmental conditions in the Middle River Valley (Wozniak 1987).

1921 Fifty-six gray wolves were killed in New Mexico and Arizona (Brown 1983: 64).

1921–25 The Bluewater-Toltec Santa Cruz irrigation districts were formed (Clark 1987: 204).

1922 An estimated six grizzly bears were in New Mexico (Brown 1985: 140).

1922–24 The White Pine Lumber Co. was organized; included in the operation was a rail line from the mill extending northward to the main logging camp in Guadalupe Canyon of the Jemez Mountains. Timber was cut on the upper San Diego land grant (Glover 1990: 5–6; Scurlock 1981a: 148).

1920s (early) An estimated 48,750 acres were cultivated, while 58,000 acres were waterlogged or otherwise not suitable for farming in the Middle Rio Grande Valley (Wozniak 1987).

1920s (early) Wolf eradication efforts reached their peak as over 100 animals were killed in New Mexico and Arizona (Burbank 1990: 106).

1923 The Reclamation Service was converted into the Bureau of Reclamation (Clark 1987: 189).

1923 Tamarisk were observed growing along an irrigation canal, but none along the Rio Grande west of Albuquerque's Old Town (Robinson 1965: A5).

1923 The most valuable crops per acre in the Middle Rio Grande Valley were cotton, sweet potatoes, cabbage, and alfalfa (Sullivan 1924: 15).

1923 Range managers considered intensive livestock grazing of woodlands or forests beneficial from the viewpoint of minimizing fires. Grazing kept herbaceous understory plants from accumulating and becoming fire fuel (Pearson 1920: 129–130).

1923 The U.S. Biological Survey and cooperating ranchers put out 103,000 strychnine poison baits to control coyotes and other predators (Brown 1985: 142).

1923 Thirty-two wolves were trapped, poisoned, or shot in New Mexico (Brown 1983: 67).

1923 The last grizzly bear in the high country of the Pecos District of the Santa Fe National Forest was killed (Barker 1953: 189–190).

1923–24 Robert Thompson purchased 55,000 acres of land, a tract that was the Alameda land grant. The headquarters was located on the north edge of Corrales. Some 3,000 to 5,000 herefords were on the ranch (Eisenstadt 1980: 21–22).

1923–25 The State Legislature passed the Conservancy Act, creating a district with a governing board to initiate projects to prevent flooding, regulate stream flow, reclaim waterlogged lands, develop irrigation works, develop or reclaim sources of water, and generate electrical energy (Clark 1987: 207). The Middle Rio Grande Conservancy District structure was formed within 2 years. About 277,760 acres were included in the district (Scurlock 1988a: 136).

1923–1941 Joseph M. Budagher owned a store in Domingo and homesteaded land 3 miles to the southeast. He sold fruit, fuelwood, and gasoline (Olson 1976: 182–183).

1924 (June 7) Congress passed the Pueblo Lands Act, which provided for the appointment of a commission to investigate Pueblo land titles and to litigate the thousands of non-Indian claims against Pueblo lands. Known as the Pueblo Lands Board, this commission was empowered to compensate Indians and non-Indians alike for lands lost via decisions (Brayer 1938: 29).

1924 (September) The White Pine Company sawmill at Bernalillo began operation and in 3 years was producing 145,000 board-feet of lumber per day (Olson 1976: 65, 67).

1924 Passage of the Pueblo Lands Act resulted in Hispanos acquiring legal title to about 18,200 acres of northern Pueblo land through adjudication. Most of this acreage was irrigable, and water rights were appropriated with land title (Forrest 1989: 58).

1924 There were about 40,000 acres of first-class cultivated land, 8,500 more acres of second-class cultivated land, 52,000 acres that were waterlogged or alkaline saturated, 6,500 acres inundated, and 37,500 acres of bosque (Sullivan 1924: 13).

1924 Alfalfa, beans, chile peppers, fruit, and indigenous salt grass were the main crops in the Middle Rio Grande Valley south of Bernalillo (Hedke 1925: 31).

1924 About 16.6 percent of New Mexico was forested (Baker et al. 1988: 34).

1924 Wild horses on the Carson National Forest were contributing to an overgrazing problem. Some 1,200 horses were rounded up; some were sold to residents surrounding the forest (Tucker and Fitzpatrick 1972: 79–80).

1924 New Mexico's wildlife populations reached their lowest numbers, and more species were threatened with extinction than at any other time. Several species, such as the gray wolf, elk, and grizzly bear, were extirpated within a few years (Ligon 1927: 15).

1924 The wild turkey population declined to its lowest figure in the historic period (Huey et al. 1967: 107).

1924 Thirty-four wolves were taken in the state, mostly along the southern border (Brown 1983: 70).

1924 (ca.) Seventy-five percent of the Middle Rio Grande Valley shallow ground water was less than 3 feet below the floodplain surface (Sullivan 1924: 7).

1924–25 Sixteen grizzly bears were killed in New Mexico (Brown 1985: 148).

1924–32 Black grama grass density on New Mexico ranges increased until the drought in subsequent years reversed this process (Gatewood et al. 1964: B43).

1925 (spring-summer) Some 565,000 acre-feet of water was depleted for the year. A shortage of 200,000 acre-feet at Buckman occurred (Hedke 1925: 14).

1925 (August) There was a demand for 68,000 acre-feet in the Middle Rio Grande Valley (Hedke 1925: 32).

1925 By this year there was only one large, roadless area (1/2 million acres) in New Mexico. Fifteen years before there were six such areas (Flores 1992: 8).

1925 Thirty-four wolves were killed in the state, and only a few were left on the Jicarilla Apache Reservation and along the southern border (Brown 1983: 71).

1925 The last grizzly bear east of the Rio Grande was killed near Raton (Brown 1983: 150).

1926 The Achison, Topeka, and Santa Fe Railroad contracted to provide 34,256 linear feet of trestle piling, 237,498 board-feet of native pine bridge timber, 81,610 board-feet of native pine box culvert timber, and 60,000 native pine track ties for construction of the Cuba Extension rail line from San Ysidro to north of Cuba (Glover 1990: 48).

1926 The statewide deer population was estimated at 41,000 (Huey et al. 1967: 42).

1926–27 The average depth of ground water below the surface of the floodplain of the Tome-Valencia area was 2.32 feet (National Resources Committee 1938: 274).

1927 (fall) Some wolves entered north-central New Mexico from Colorado. They took a large number of young cattle along the Rusas River in the Tres Piedras country (Brown 1983: 79).

1927 Predators, such as wolves, coyotes, bobcats, and mountain lions, were considered "the most serious enemy of game conservation in New Mexico" (Ligon 1927: 49–50).

1927 The last plains gray wolf in the state was exterminated by this year (Findley et al. 1975: 28).

1927 U.S. Biological Survey trappers Homer and Albert Pickens took seven gray wolves in the Canjilon Creek-upper Brazos drainages, the last of this species in the area (Pickens 1980: 11).

1927 Mule deer were rare or extinct "in the valleys, especially in the more settled parts" (Bailey 1971: 29).

1927 An estimated 2,950 pronghorns were found in the region (Ligon 1927: 25).

1927 Black bears received legal protection in New Mexico (Findley et al. 1975: 29).

1928 An estimated 16 grizzly bears remained in New Mexico (Brown 1985: 153).

1928 The exotic rainbow trout was stocked in 187 rivers, creeks, and lakes across the state (Kuykendahl 1994: 3).

1929–30 San Acacia Lake, drained by the Conservancy District in 1929–30, contained a large fish population and supported other wildlife (Marshall and Walt 1984: 281).

1920s Intensive grazing decimated plant cover, which resulted in severe erosion in the region (Forrest 1989: 140).

1920s There was commercial mining of copper-silver ore in La Bajada Canyon, Santa Fe County (Elston 1961: 161).

1920s A retail clothing store in Las Vegas sent two buyers to New Mexico and Arizona to buy furs, hides, and wool (Perrigo 1982: 62–63).

1920s Local bounties were paid for bobcats, and most sheep ranchers hunted them vigorously (Bailey 1971: 296).

1920s Wolves were virtually exterminated by trappers and hunters working for the Forest Service, U.S. Biological Survey, and ranchers (Brown 1983: 25).

1930 By this year Frank Bond controlled the best grazing lands in the Jemez Mountains. He leased land for grazing his sheep from the Forest Service, and after 3 years of use, his forest grazing rights became permanent (Rothman 1992: 129).

1930 By this year permits for grazing on the Santa Fe National Forest were reduced to correlate with carrying capacities (Rothman 1992: 159).

1930 The valley of the Rio Grande in the Socorro area supported dense stands of willow, tornillo, cottonwood, and rabbitbush. On waterlogged soils, vegetation was more sparse, and the open alkali flats were covered with salt grass. In wet depressions or around charcos, bullrush and sedge grasses were dominant. The adjacent dry uplands supported mesquite, creosote bush, rabbitbush, and sparse bunch grasses. Livestock were grazed throughout the year on salt grass pastures and in the bosques of the Rio Grande and lower Rio Puerco in Socorro County (Poulson and Fitzpatrick ca. 1930: 7).

1931 (March 2) Congress appropriated $10 million to fund predatory animal control in the West (Hagy 1951: 94).

1931 (March 2) Congress passed an act that provided $1 million to the Secretary of Agriculture to completely eradicate predatory animals over 10 years (Hagy 1951: 94).

1931 The U.S. Forest Service sold an estimated 207,900,000 board-feet of timber in the Rio de las Vacas watershed to the White Pine Lumber Company. This sale involved about 40,000 acres of land (Glover 1990: 26).

1931 The entire state reported a good pinyon crop (Brugge 1980: 383).

1931 The New Mexico Legislature passed a law giving the State Game Commission full regulatory powers to manage the wildlife of the state, including setting hunting seasons and bag limits (Barker 1970: 188; Flader 1978: 105).

1932 The net annual depletion of Rio Grande surface waters between Otowi and San Marcial was 480,000 acre-feet (Nelson 1946: 24).

1932–33 The Forest Service surveyed watershed conditions in the Rio Grande basin above Elephant Butte. Rapid deterioration of vegetation cover due to livestock overgrazing in the 1880s and subsequent accelerated erosion and gullying was documented. Increased sedimentation in the river had caused the loss of about 13 percent of Elephant Butte Reservoir's capacity (Clark 1987: 258).

1932–66 Nineteen bighorn sheep were introduced into the Sandia Mountains (Huey et al. 1967: 222).

1930s (early) More than 1,500 horses were removed from the Jemez River District of the Santa Fe National Forest (Tucker and Fitzpatrick 1972: 81).

1934 To control and manage grazing on the public lands, the Taylor Grazing Act was passed, establishing the Grazing Service within the Department of the Interior. In 1946 this agency was combined with the General Land Office to form the Bureau of Land Management (Clawson 1971: 34–38). The bulk of unappropriated grassland (80 million acres) was closed to further settlement by the act. These lands were to be kept as a grazing resource and managed by local livestock growers organized in districts and supervised by the Department of the Interior (Worster 1979: 190).

1930s (pre) Crested wheat grass was introduced into New Mexico and adjacent mountain states Hitchock 1935: 48.

1935 An earthquake rocked Belen and damaged the high school and two elementary schools to the extent that classes were suspended until the necessary repairs could be made (Northrop 1976: 85).

1935 By this year, irrigation works were constructed by the Middle Rio Grande Conservancy District for 118,000 acres between Cochiti and the northern boundary of the Bosque del Apache Wildlife Refuge (Nelson 1946: 12).

1935 Virtually all of the Tewa basin was described as "tragically overgrazed" (Weigle 1975: 36).

1935 Overgrazing of grant and public lands around El Rito resulted in a reduction in the number of livestock (Weigle 1975: 152).

1935 Pueblo rangelands at Laguna and Acoma were badly overgrazed, which, along with the drought, led to starving livestock. "They all knew, also, that there were many 'denuded areas' and 'the most nutritious plants' had disappeared from the range, leaving less digestible weeds or even poisonous plants" (Aberle 1948: 63).

1935 Deforestation 35 miles up the Rio En Medio and Chupadero watersheds by several lumber mill operations and local cutting for fuelwood resulted in severe soil erosion. Some 20 acres of farmland were lost near the Chupadero village (Weigle 1975: 66).

1930s (mid) Most of the residents from the middle Rio Puerco-of-the-East valley moved upstream to the higher Cuba area, where agriculture was still relatively reliable (Calkins 1937b: 18–19).

1936 The average depth of ground water below the surface of the floodplain in the Tome-Valencia area was 5.99 feet (National Resources Committee 1938: 274).

1936 The consumptive agricultural use of water between Isleta Pueblo and Casa Colorada was 2.7 acre-feet per acre (Titus 1963: 84).

1936 The New Mexico Lumber and Timber Co. of Bernalillo purchased the timber rights to the Baca No. 1 location in the Jemez Mountains. Here, and on nearby lands of the Santa Fe National Forest, there were an estimated 400 million board-feet of timber (Glover 1990: 36).

1936–41 The rate of floodplain aggradation of the Middle Rio Grande floodway was about 1 foot per year (Happ 1943: 2).

1936–47 Cottonwood, willow, and tamarisk cover increased from 38,400 to 51,120 acres in the Middle Rio Grande Valley (Lowry 1957: 4).

1937 A flood along the Middle Rio Grande washed out levees in a number of locations (Happ 1944: 3).

1937 All of Santa Ana's rangelands, except the mesa, were severely overgrazed and eroded. Extensive sand dune areas had formed along the Jemez River, siltation had ruined crops and clogged one of two wells, and desirable grasses had been replaced largely with ring muhly and snakeweed. The range agent reported that the rangelands "could support only 39 head of cattle and horses on a yearlong basis" (Bayer et al. 1994: 231, 233).

1937 About 85 percent of New Mexico's 77,488,536 acres was in a state of active erosion, with more than half of that suffering serious loss of topsoil and severe gullying. The legislature passed a soil conservation act (Clark 1983: 270).

1937 Three soil conservation grants totalling 174,000 acres were allocated to the Pueblos. These lands had a carrying capacity of 1,656 cattle. Three other such grants totalling 187,000 acres with a carrying capacity of 1,601 cattle were made to non-Indians, but primarily for Hispanic use (Forrest 1989: 141).

1937–66 Some 952 pronghorn antelope were transplanted into the Middle Rio Grande Basin (Huey et al. 1967: 221).

1938 (January) Jemez, Zia, and Laguna pueblos were granted grazing rights to a portion of the Espiritu Santo land grant (Bayer et al. 1994: 233–234).

1930s Electricity was introduced to the Valencia-Los Lunas area (Gallegos 1970: 75).

1930s Spanish livestock overgrazed the lands around Vadito, including locales on Picuris Pueblo land (Carlson 1979: 36).

1930s Trucks replaced horses in logging operations (Glover 1990: 37).

1930s Wild horses, which grazed the Manzano Mountains bajada, grazed inside the Albuquerque airport boundaries, even after it was fenced (Speakers 1965: 31).

1930s–40s Large herds of goats and sheep were grazed in the Los Pinos and Ladrone mountains. This intensive grazing changed the floristic composition of rangeland on the Sevilleta land grant (Manthey 1977: 10–11).

1940 The U.S. Forest Service and Bureau of Land Management began to fence federal land in the Rio Puerco-of-the-East valley and traditional grazing lands on Mesa Prieta and the San Mateo Mountains, including Mount Taylor (Garcia 1992: 23).

1941 (pre) Residents of Santa Clara Pueblo caught carp, sucker, eel, catfish, and trout for food (Hill 1982: 59).

1941 (May) The highest daily mean flow since late 1939, 5,980 cfs, occurred on the lower Rio Puerco (US Geological Society 1994).

1941 Probably owing to the abnormally high precipitation, fires burned perhaps the smallest area ever in a year (Swetnam 1990: 11).

1941–43 Each family on the Rio Puerco was permitted to graze 15 head of sheep in their grazing precinct by the Grazing Service. This number of livestock was considered below the minimum needed for subsistence (Forrest 1989: 159).

1942 There were 14,972 acres under cultivation in the Rio Puerco basin (Harper 1943: 11).

1942–56 The carrying capacity of grazing lands in New Mexico steadily decreased during this extended drought period (Gatewood et al. 1964: B43).

1943 (June 29) A flood on the Rio Puerco above Arroyo Chico probably exceeded 5,000 cfs (USGS 1994).

1940s (mid) The rapid aggradation of the Middle Rio Grande streambed was considered the most severe problem by local residents. This process, caused by the large amount of sediment carried by the river, was resulting in the reduction of the carrying capacity of the river, the waterlogging of farmland, and the increased danger of disastrous flooding (Clark 1987: 531).

1945–62 Seventy-four irrigation wells were drilled on the Rio Grande floodplain in eastern Valencia County (Titus 1963: 85).

1946 (pre) Sedimentation of the river channel had raised it to within 40 inches of the Alameda truss bridge (Nelson 1946: 18).

1946 There were about 4,700 farms in the Middle Rio Grande Valley, 66 percent of them were 15 acres or less in size. The remainder ranged from 16 to more than 160 acres (Nelson 1946: 13–14).

1946 There were 3,819 Pueblos living in the Middle Valley; land holdings totalled 379,732 acres. Average per capita cultivation was 3.2 acres (Nelson 1946: 70–71).

1946 About 60,000 acres were irrigated farmlands in the Middle Valley. Some 118,000 acres of irrigable lands were uncultivated (U.S. Bureau of Reclamation 1946: 3).

1946 An average of about 37 million tons of sediments were carried into the valley between Cochiti and San Marcial. About 25 million tons, or 13,500 acre-feet, of these were deposited in the valley (Nelson 1946: 19).

1946 Water used by native vegetative cover equalled or exceeded that used for irrigation of cultivated lands in the Middle Valley (Nelson 1946: 25).

1946 By this year "numerous drains" in the Middle Rio Grande Valley were partially "filled with vegetative growth," and their mouths were "sediment-clogged" (Nelson 1946: 15).

1946 The Isleta diversion dam was "in poor condition because of settlement after being undermined" (Nelson 1946: 40).

1947 There were 60,640 acres of native and exotic vegetation in the Middle Valley. Their water use depleted river flow by an estimated 238,700 acre-feet, or about 44.5 percent of the total depletion (Hay 1963).

1947 Four lakes in the San Marcial area provided good largemouth bass fishing. Good catches of crappie and channel catfish were also made (Pillow and DeVaney 1947: 10).

1947 The lower Rio Jemez provided no fishing because of species depletion (Pillow and DeVaney 1947: 10).

1948 Congress directed the Army Corps of Engineers and Bureau of Reclamation to prepare plans for district improvement. Subsequently, the Corps constructed river levees near Albuquerque, and the Bureau deepened river canals to drain water from agricultural lands. In the southern part of the valley, channel rectification was carried out as well (Sorensen and Linford 1967: 156–157).

1948 (ca.) A sawmill was built at Gilman just below the tunnels on the Guadalupe River in the Jemez Mountains (Glover 1990: 44).

1949 Some 72,989 acres were in irrigation in the Middle Valley (Sorensen and Linford 1967: 154).

1940s (late) The mink was still common throughout the northern half of the state (Huey et al. 1967: 189).

1950 (pre) The yellow perch was introduced into the Rio Grande, Pecos, and San Juan drainages (Sublette et al. 1990: 331).

1950 The population of the Middle and Upper basins was 275,000, of which about 15 percent were actively engaged in agriculture. There were 158,000 livestock units in the basins (Dortignac 1956: 56, 78–79).

1951 Invader shrubs had replaced black grama grass on upland sites from San Marcial to the mouth of the Rio Puerco. Older residents of this reach remembered grama being cut and baled here previously (Branson 1985: 38).

1954 (July 1) (to June 30, 1955) Belen residents used 158,835,996 gallons of water from three municipal wells (Titus 1963: 86).

1955 The average annual stream flow production in the Rio Grande above Elephant Butte was almost 3 million acre-feet. More than 900,000 acre-feet of water was consumed between the Colorado-New Mexico state line and Elephant Butte Dam. This was almost two-thirds of the water produced in this region. More than 400,000 acre-feet of the total was considered wasted or nonbeneficial use (Dortignac 1956: 29).

1955 There were an estimated 1,500 elk and 25,000 deer on national forests in the Upper and Middle basins (Dortignac 1956: 71).

1956 Some 22,600 acres were in cultivation from the southern boundary of the Isleta reservation to Bernardo. About half of crop production was alfalfa (Titus 1963: 3).

1956 The Bureau of Indian Affairs returned grazing control to the Navajo. Stocking increased steadily, causing severe overgrazing of rangelands by the mid 1980s (Eastman and Gray 1987: 106–107).

1958–66 Some 4,966 Afghan white-winged pheasants were released by the Game and Fish Department in the state (Huey et al. 1967: 169).

1959 The estimated average annual evaporation at Elephant Butte and Caballo reservoirs was 254,800 acre-feet (Sorensen and Linford 1967: 166).

1950s The overall population of band-tailed pigeons was declining (Huey et al. 1967: 155).

1950s The fathead minnow was introduced into the Gila and San Juan drainages, and in the next decade into the Zuni and San Francisco river drainages (Sublette et al. 1990: 166).

1950s Timber sales and logging occurred in the Capulin Springs area in the Sandia Mountains. Logging was "camouflaged" because of complaints of local residents and visitors. Firewood cutting was common (McDonald 1985: 11).

1960 The population of the Rio Grande basin was 484,700; 132,400 were rural residents. Some 241,216 persons lived in Albuquerque (Sorensen and Linford 1967: 152).

1960 The population of eastern Valencia County was an estimated 16,100. Belen and Los Lunas had populations of 5,031 and 1,186, respectively (Titus 1963: 3).

1960 The Pueblos, with a population of 13,611, owned 1,460,838 acres in the Rio Grande basin (Sorensen and Linford 1967: 150).

1960 By this year Russian olive had become a major understory component of the Middle Rio Grande bosque (Freehling 1982: 10).

1960 (late) The American Gypsum Co. began quarrying at White Mesa near San Ysidro. The raw gypsum was transported to the company's plant north of Albuquerque (Elston 1961: 164).

1960–62 About 84,600 acre-feet of water were diverted annually in the Rio Grande basin; this included surface and ground waters. About 42,000 acre-feet of this total was depleted; some 29,800 acre-feet, or 71 percent, was depleted by Albuquerque (Sorensen and Linford 1967: 163).

1962 Sagebrush (*Artemisia* spp.) made up 3–4 percent of the vegetative cover on the Rio Puerco watershed (Dortignac 1963: 508).

1960s (early) The fall-winter duck population varied from 100,000 to 200,000 birds (Huey et al. 1967: 161).

1960s (early to mid) There were a few reports of white-tailed deer in the San Mateo Mountains in Socorro County and the Sangre de Cristo Mountains (Huey et al. 1967: 52).

1963 (pre) Several springs along the Ojuelos fault ceased flowing, perhaps due to wells drilled nearby (Titus 1963: 79).

1963 About 16,400 acres of land in the Rio Grande basin were dry-farmed; most of this acreage was cultivated in wheat and barley. Some 3,000 acres were in corn (Sorensen and Linford 1967: 159).

1963 About 39,739,000 board-feet were harvested in the Rio Grande basin (Sorensen and Linford 1967: 159).

1963 Kokanee salmon were introduced into northern New Mexico streams (Sublette et al. 1990: 67).

1963 About 134,500 cattle and 135,500 sheep were on rangelands of the Rio Grande basin. Of these, 76,800 cattle and 64,600 sheep were grazed on national forest lands in the summer (Sorensen and Linford 1967: 159).

1963 State and federal trappers took more than 6,300 coyotes and 1,500 bobcats (Huey et al. 1967: 197, 199).

1964 About 20,000 acres were under irrigation in the Middle Valley. Almost all of this was within the Middle Rio Grande Conservancy District (Sorensen and Linford 1967: 157).

1964 There were an estimated 3,000 black bears in the state (Huey et al. 1967: 22).

1964 There were an estimated 301,750 deer, 11,046 elk, 15,000 pronghorn antelope, and 300 to 400 bighorn sheep in the state (Huey et al. 1967: 26).

1964 Some 72 bighorn sheep were counted in the Sandia Mountains (Huey et al. 1967: 70).

1964 There were an estimated 25,000 wild turkeys in the state (Huey et al. 1967: 26).

1966 There were an estimated 350 mountain lions in the state (Huey et al. 1967: 195).

1967 The beaver population of New Mexico was estimated to be 6,000 (deBuys 1985: 97).

1967 The white-tailed ptarmigan was "very rare" in the Sangre de Cristo Mountains and other northern New Mexico ranges (Huey et al. 1967: 129).

1960s Northern pike were introduced into several large reservoirs (Sublette et al. 1990: 77).

1970 The estimated saw timber volume on national forests in New Mexico was 12,645 million board-feet (Baker et al. 1988: 78).

1977 About 17 percent of New Mexico was forested (Baker et al. 1988: 34).

CHAPTER 5

HISTORICAL IMPACTS AND CHANGES: BIOTIC RESOURCES AND HUMAN POPULATIONS

As described in previous chapters, adverse impacts generated by humans on the surface water, vegetation, soils, and fauna began with their arrival in the region more than 10,000 years ago. In some instances these impacts and resulting environmental changes were interrelated with natural phenomena, such as extended droughts and fires. These elements have been discussed in Chapters 2–4, so they will only be summarized in this chapter.

Generally, as Native American populations grew and technological innovations advanced, these impacts affected ever increasingly larger areas, with greater pressures on selected resources. Several events or series of related events marked significant changes in impacts on the environment. In the late prehistoric period the introduction of the bow-and-arrow, cultigens, and associated agricultural knowledge were hallmarks in this evolution. Relatively large villages were established along the Rio Grande and tributaries, and areas of bosque were cleared for cultivation by the Puebloan groups.

In the 16th century the first Europeans brought firearms, metal tools, livestock, and a different view of the physical and biological world and their relationship with it, exerting new pressures on the environment. The Spanish population grew steadily, while Native American numbers, especially the Puebloans, decreased, primarily due to infectious diseases, also introduced by the Spanish. Importantly, livestock numbers increased disproportionately; grasslands around every Pueblo and Hispano settlement were intensively grazed. Irrigation farming expanded to the point that little floodplain land in the Middle Valley was uncultivated. By the early 19th century some waterlogging and build-up of salts in the soil were underway due to intensive irrigation. Riparian forests and pinyon-juniper woodlands near settlements were reduced for use as fuelwood and building materials. Fire was sometimes employed by Hispanics in these botanical zones to create pasture or farm land.

EFFECTS OF CLIMATE

The role of climatic fluctuations as related to short-term vegetational change has been investigated by a number of ecologists, botanists, environmental historians, geographers, and range specialists across the Southwest since the 1950s (Arnold and Reid 1964; Bahre 1991; Brown 1950; Dobyns 1981; Gehlbach 1981; Harris 1966; Hastings and Turner 1965; Hennessy 1983; Humphrey 1958, 1987; Johnson and Elson 1977; Neilson 1986; Swetnam 1990; Vale 1982, to name just some). Most of these studies examined climate and juniper-grassland savannas, pinyon-juniper woodlands, or ponderosa forests, as well as the interrelationships with other ecological factors, notably human-caused modifications such as grazing, fire suppression, fuelwood cutting, and logging. These studies also focused on changes in the recent past, that is, when Anglo Americans began colonizing the region in the mid 19th century.

The adverse effects of extended drought on vegetation were recognized as early as the mid 19th century. In 1857 a geologist with the Lt. Joseph C. Ives military expedition to the Colorado River recorded that the lower reaches of upland juniper stands were dead. Stands of dead "pine-trees," including ponderosa, were also observed at this time. This phenomenon was attributed to the extant drought conditions. More recent die-offs of juniper due to xeric conditions have also been noted on the Pajarito Plateau west of Santa Fe (Hewett et al. 1913: 56–57, 59, 62) and on the Sevilleta National Wildlife Refuge due to the 1950s drought.

A member of the U.S. Geographical Exploration and Survey team in northern New Mexico in 1875 speculated that the area was becoming increasingly xeric. This speculation was probably based in part on reports by local Hispanos, who related that springs and creeks had ceased flowing between 1775 and 1800. Another possible indicator of increasingly xeric conditions on the plateau was the encroachment of pinyons into the lower elevations of the ponderosa pine zone (Hewett et al. 1913: 52–53).

Climate fluctuations through time, combined with intensive grazing of cattle, have resulted in changes in vegetative cover and composition across the Southwest. One of the plant genera that has been most affected is *Juniperus*, which has increased its range markedly (Davis 1987: 123).

West (1984: 1310–1313) concluded that climate fluctuations were only one probable cause of vegetative change in pinyon-juniper in the late historic period. During wet periods, pinyon-juniper has invaded or reinvaded intensively grazed grassland areas where fuels for fire had been diminished and where juniper seeds were dispersed in feces. Density of both species has increased generally over the region. Decreased understory vegetation and compaction of soils by livestock grazing, coupled with droughts and then intense precipitation, may have led to soil erosion as well. Donart (1984: 1249) determined that drought can cause considerable damage to grazed and nongrazed vegetation, which can result in high levels of mortality of herbaceous plants. Drought-tolerant species or new species of plants can then invade the open areas created within a plant community.

Veblen and Lorenz (1991: 173–176) attributed historic changes in the ponderosa zone along the Front Range in Colorado to climatic variability, fire (before 1920), logging, and grazing. Except for logging, these factors have contributed to ponderosa invasion of grasslands. Reduction of natural and human-caused fires since 1920, a possible shift to a more mesic climate, and livestock overgrazing were cited as the agents of change.

A recent study of vegetational change in southeastern Arizona indicates that "no directional vegetation changes since 1870 have been clearly linked to any trends, changes, or fluctuations in the climate" (Bahre 1991: 103). This study and others, however, do support the hypothesis that short-term climatic changes or deviations do exacerbate human-caused modifications of plant communities, as indicated above. Thus, biologists and eco-culturists (anthropologists, environmental historians, and geographers) must continue to direct their research at understanding the complex interactions between humans and their environment, including climate, through time (Bahre 1991: 105; Worster 1984).

Periodic Rio Grande floods caused by melt of above-normal snowfall or intense rains on the watershed impacted various eco-cultural resources in the Middle Valley. One result of the high runoff was avulsion, or movement of the river from its current channel to a new one. From the 1600s to early 1900s the Rio Grande channel generally shifted to the west side of the floodplain from Angostura to Belen (Fig. 57), although there were some eastward movements.

Perhaps the earliest historic movement of the Rio Grande occurred near Tome Hill in Valencia County. Some time between 1692 and 1750 the river left its channel, which ran around the west end of the hill and along the south side of the eminence, and moved westward to near or at its present location (Scurlock et al. 1995: 118–119).

Fray Dominguez (Adams and Chavez 1956: 8) recorded a story about the eastward shift of the river in the Belen area, causing severe flood damage at Tome in 1769. In the early 1800s the Rio Grande again shifted westward in the Bernalillo area, forcing residents on that side of the river to resettle on the new east bank at the present town site (Bowen and Sacca 1971: 48–49, 60; Lange and Riley 1970: 176). The major flood of 1884 caused a westward shift of the river in the Los Lunas area (Crawford et al. 1993: 24).

There was a westward shift in the river's course between Algodones and Bernalillo between 1709 and 1739, which caused damage to the church and homes. Bernalillo at that time was located above the present town, which dates from the 1820s (Bayer et al. 1994: 90; Snow 1976: 172–175). Beginning about the same time, the Rio Grande in the Alameda area began to move westward and by 1768 flowed in or near its present channel. Alameda, originally located on the west bank of the river, was resettled on the east side (Chavez 1957: 3; Sargeant 1987: 38–39).

EFFECTS OF FIRE

The effects of fire on vegetation in the Southwest have been investigated since the 1920s (Arnold et al 1964; Bahre 1991; Hough 1926; Humphrey and Everson 1951; Kozlowski and Alhgren 1974; Leopold 1924; Pyne 1982; Stewart 1956; Weaver 1951, 1974; Wright 1980, to list only a few). Studies have centered on invasion or reinvasion of grasslands due to fire suppression, floral structure and composition of woodlands, availability of nutrients in soil, and other soil characteristics. Although much more is now known about the impacts of fire on flora, these phenomena are still poorly understood (Covington and DeBano 1990: 78–79).

Impacts and changes caused by fire on grasslands related to juniper movement in the Southwest have been addressed by Bahre (1991); Humphrey (1974); Johnsen (1962); Komarek (1969); and Vogl (1974). These investigators, in general, agree on the following historical impacts and changes produced by lightning or human-caused fires:

1. grassland fires were more frequent and widespread before 1900,
2. fires were "hotter" on the ground due to the presence of more grass biomass,
3. fires killed seedling or young woody shrubs and trees up to 5 years old, and
4. fires have been just one of several interrelated factors producing change in the grasslands.

Fire History

Prior to 1900, human-ignited fires and natural fires were relatively frequent in grasslands, woodlands, and forests at a given locale. Fire frequencies in the last 300 years, or intervals over the last 300 years, range from 1.9 to 25 years. Some presuppression or pre–1900 fires burned as long as several months over thousands of acres (Ahlstrand 1980: 4, 6; Cooper 1960: 137–138; Foxx 1981: 7). Clearly, vegetation associations and composition in the study region have evolved with periodic fire.

In the early to mid 1800s there seems to have been a shift in fire regimes to longer fire-free periods. One explanation for this phenomenon is the wet decades of the 1830–40s. Another possible explanation is the intense sheep grazing of the understory of the woodlands and forests during this period. In this century there appears to be some

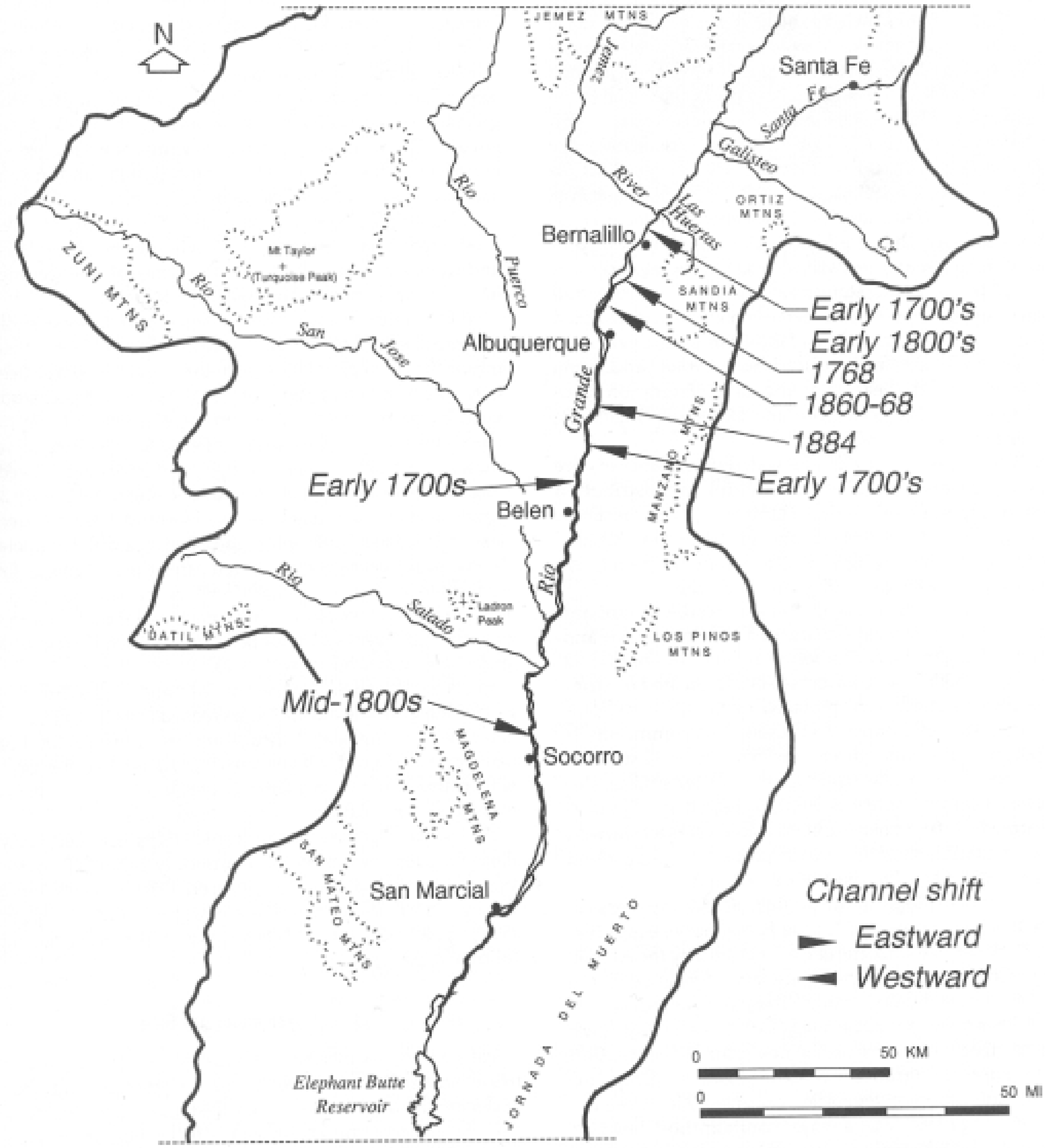

Figure 57—Major Middle Rio Grande channel movements.

correlation between fire frequencies and the El Nino Southern Oscillation, which brings tropical Pacific storms to Arizona and New Mexico during the normally dry spring and fall seasons (Swetnam 1990: 8, 7–11).

Many fire history and impact studies on specific pinyon-juniper and ponderosa locales in New Mexico and portions of adjacent states have been made in the last 20 years. These locales include the Fort Stanton Experimental Range in southeastern New Mexico (Dwyer and Peiper 1967), the Guadalupe Mountains and Carlsbad Caverns national parks in extreme southern New Mexico (Ahlstrand 1980), Bandelier National Monument in northern New Mexico (Allen 1990; Foxx 1981), Prescott National Forest in central Arizona (Deiterich and Hilbert 1990), Gila Wilderness (Baisan 1988), and the Coconino National Forest in Arizona (Jameson 1962). In general, these investigations indicate that fire historically has slowed or precluded invasion and growth of woodlands into adjacent grasslands, restricted stands to shallow rocky soils and rugged topography, maintained open woodlands, altered nutrient distribution and availability in soils, opened areas to soil erosion, and reduced herbaceous production by 30 percent in the year following the conflagration (Cooper 1960: 137, 161; Covington and DeBano 1990: 79, 81; Dwyer and Peiper 1967).

Wright and Bailey (1982: 195) stated that historical "fire has been the dominant force controlling the distribution of pinyon-juniper, particularly juniper, but fire cannot be separated from the effects of drought and competition." Other interrelated ecological factors that are poorly understood are grazing, logging, and chaining.

A large fire on the north end of the Sandia Mountains in north-central New Mexico burned ponderosa pine and white fir-Douglas fir zones between 7,000 and 8,500 feet in the early 1830s. The ponderosa stands, located on drier and warmer slopes, were replaced by Gambel oak, pinyon, and one-seed juniper. At present, this community is composed of the same three dominant species, with no reoccurrence of ponderosa. On the wetter and cooler slopes and canyon bottoms, quaking aspen and Gambel oak formed the first post-fire successional stage, followed by near-replacement of the two fir species up to the present (Cooper 1989; Dick-Peddie 1993; 61-63, 68).

In the nearby Jemez Mountains, a fire suppression policy has been employed by the Forest Service and National Park Service since the early 1900s and by the Atomic Energy Commission (Department of Defense) since the 1940s, resulting in vegetation changes previously discussed. This management strategy notwithstanding, there was a relatively large fire on the Los Alamos Reservation in 1954. This conflagration was extinguished quickly, and no major alteration of vegetation occurred. However, the La Mesa fire of 1977 was a major conflagration, burning more than 15,000 acres of Bandelier land in the northwest portion of the monument and adjacent land of the Los Alamos National Laboratory (Foxx 1981: 1, 3–4; Rothman 1988: 109).

A study of vegetation after the La Mesa fire revealed that 5,209 acres of the burn had few or no ponderosa seed trees remaining. The remainder of the stands on the almost 10,000 acres exhibited foliar damage ranging from 1 to 99 percent. The sprouting of *Quercus gambelii* and *Robinia neomexicana* (New Mexico locust) was relatively common in many areas of the burn. Of the six species of grasses seeded subsequent to the fire, only sheep fescue and slender wheat grass were considered a success in providing ground cover to reduce erosion and flash floods downstream. The highest success of germination and growth occurred on the most severely burned areas and in areas around trees where dense mantles of pine needles had previously precluded grass growth. The six grasses were least successful in stands of native grasses. Sheet wash and rill wash increased due to the removal of vegetation in the La Mesa burn (Foxx 1981: 53–54, 78).

At Guadalupe Mountains National Park in west Texas, where at least 71 fires occurred from 1554 to 1979, several interesting historical changes in the vegetation have been noted as a result of the fire history of a selected study area. Based on oral history and vegetation analysis, the woodlands and forests were "open and park-like as recently as the 1950s" and a "large number of conifer seedlings were becoming apparent about this time, nearly 30 years after the last major fire" (Ahlstrand 1980: 6). Trees less than 3.3 feet high or less than 2 inches dbh (diameter breast high) became established after the last major fire on the site in 1922. These have evolved into dense stands, which probably would not have occurred if the fire interval of about 2 years had not been interrupted by fire suppression (Ahlstrand 1980: 4–5, 7).

In recent decades, the number of "hot" large fires has increased, perhaps due to the increased density of understory tree seedlings and shrubs and the accumulation of duff on the ground, all combustible fuels. Another possible cause of the higher fire frequency is increased commercial and recreational use of public lands.

As indicated, Native Americans, Hispanics, and early Anglo settlers in the region commonly ignited fires for various reasons (Bahre 1991; Barrett 1980; Buskirk 1986; Covey 1983; Dobyns 1981; Foxx 1981; Jones 1932; Leopold 1924; Pyne 1982; Stewart 1956); these will be discussed on following pages.

Native American Fire

Indigenous peoples throughout the region employed fire as an environmental technique to produce a number of desired results. One of the earliest uses may have been to drive game to hunters or over cliffs to their death. One late 19th century observer noted that Indians in northern New Mexico burned forests and woodlands in the mountains to drive deer down into the canyons, where they might be more easily hunted (Cooper 1960: 138).

Other reasons for intentional burning were to stimulate growth of grasses or understory plants to improve available browse or graze, to remove brushy understory as a fuel for igniting crown fires, to kill shrubs and trees in grasslands, to enhance growth of food plants (such as berry-producing shrubs), to communicate or signal, to clear areas for campsites, to produce a cleared area for farming, to drive away mosquitoes or other biting insects, and to enhance travel through an area (Barrett 1980: 35–37; Covey 1983: 81; Pyne 1982: 72, 417–418; Stewart 1956: 119–120).

The Pueblo may have used fire to clear riparian areas for agricultural use, and lightning-strike fires undoubtedly occurred with some frequency in this zone. It is not known if they used fire in grasslands or montane woodlands and forests.

Apaches in the Southwest commonly used fire to drive game, to lure insect-plagued deer to smoke, to burn the forests of their enemies, to clear brushy or forested areas around camps to prevent concealment of their enemies, to signal, to produce young plant "shoots" used in basket making, and to remove stubble in fields and produce nutrient-rich ashes. They also believed that burning caused precipitation. (Buskirk 1986: 61, 135–136, 165–166; Dobyns 1981: 27, 28, 40; Hough 1926: 61).

Euro-American Fire

The Spanish sometimes used fire as a management tool in the region during the historic period. Spaniards reportedly burned forests to create grazing areas or to drive game (Allen 1984; Ebright 1994). In the 19th century, livestock pastures were also burned to stimulate new grass growth, and sheep rangelands were burned to kill invading woody species. The military and missionaries were responsible for suppressing fires around settlements.

Although some Anglos burned grasslands to improve grazing in the last half of the 19th century, fire suppression became the prevailing philosophy by the turn of this century, especially in the woodlands and forests included in the national forests (Foxx 1981: 1A; Jones 1932: 5; Komarek 1969: 15; Pyne 1982: 416–418; Swetnam 1990: 7–9). For example, the forests and woodlands of the Sandia Mountains have been protected from extensive fires since the early part of this century by the U.S. Forest Service. There was one fire in the Juan Tabo-La Cueva Canyons area early in July 1965 and a smaller fire in June 1990. The earlier fire was the largest fire in the Sandias in this century; 550 acres were burned up the canyon to the crest at 10,678 feet (Cooper 1988: 4). In recent years the Forest Service, recognizing the role of fire in maintaining plant communities in these mountains and the danger of a hot, widespread fire occurring, has begun limited control burns.

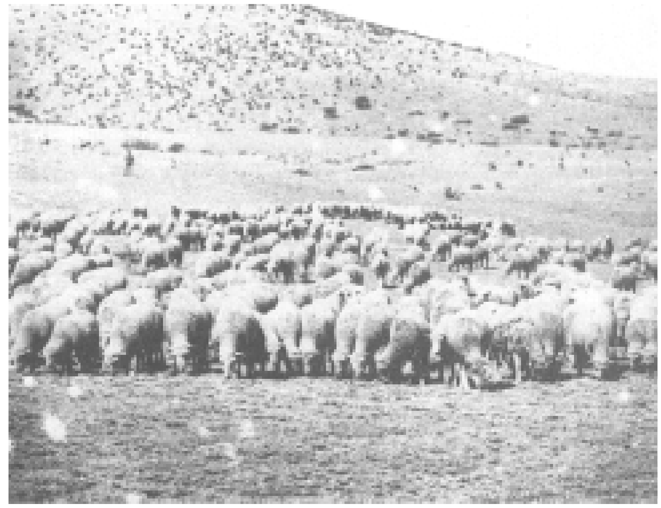

Figure 58—Sheep grazing in the Rio Puerco Valley, 1880s. Photo by Henry Schmidt, courtesy Center for Southwest Research, University of New Mexico, Albuquerque.

Historically, Hispanos and Anglos caused fires—intentional or accidental—in the valley. Burn areas were recolonized by either indigenous upland or lowland riparian species. In this century, areas burned by high intensity fires experienced little or no cottonwood regeneration, while exotics such as salt cedar and Russian olive quickly sprouted from their root crowns. The abnormal buildup of fuel litter, which produces fires of this magnitude, has occurred due to the loss of periodic flooding, which historically removed the materials (Crawford et al. 1993: 93, 202).

The species composition of Southwestern grasslands has changed due to fire suppression. Various woody shrubs and trees (such as juniper) were able to invade as the native grass species declined due to overgrazing and drought. Early in this century the juniper populations on sites like this were generally doubling every 3 years. These conditions also allowed the spread of a number of exotic species, such as Russian thistle and cheat grass (Bahre 1991: 57, 186–187; Humphrey 1974: 398–399, 17–19; Johnsen 1962: 204–205; Young and Evans 1980).

EFFECTS OF GRAZING

A number of studies on the effects of grazing on Southwest vegetation have been conducted since the late 19th century. These investigations have primarily focused on grasslands below the pinyon-juniper zone (Bahre 1991; Branscomb 1958; Brown 1950; Harris 1966; Hastings and Turner 1965; Humphrey 1987). Other studies, however, have addressed impacts on understory grasses in the pinyon-juniper and ponderosa zones, as well as impacts on pinyon and juniper. Juniper invasion of grasslands due to overgrazing and fire suppression has also been examined by a number of investigators. A few of the resulting reports are summarized below.

Cattle and sheep grazing (Fig. 58) on grasslands and woodlands have promoted shrub invasion and density increase by (1) opening up the grassland by weakening grass vigor and cover, thus lowering competition abilities with weeds and shrubs, and by exposing topsoil to erosion; (2) disseminating viable seeds in their droppings, hair, and hooves and scarifying the seeds in their alimentary tracts; (3) reducing grass cover (fine fuel load), which decreased the incidence of fires; (4) compacting topsoil, which causes soil creep on slopes and reduced moisture content; (5) making trails, which sometimes eroded into arroyos (Bahre 1991: 119–120; Duce 1918; Hough 1906: 450).

There is evidence that tree invasion into grasslands is inhibited by the browsing and trampling of tree seedlings by sheep. The same effect apparently results from intensive grazing pressure by cattle. Moderate grazing of cattle, however, may promote tree invasion of grasslands due to three phenomena: exposure of mineral soils, reduction of herbaceous competition, and decrease of fire frequencies due to decreased fuel loads. The removal of livestock from grasslands usually results in tree invasion due to reduced vigor of the grasslands and elimination of browsing and trampling of seedlings (Allen 1984: 145).

Overgrazing, which was common around Spanish colonial and Mexican period settlements, became more intense and widespread with the coming of Anglo Americans with their livestock. Especially heavily impacted were the Sangre de Cristo, Jemez, Sandia, and Manzano mountains and the valleys of the Rio Grande, Santa Fe River, and Rio Puerco-of-the-East. The U.S. military was also using large amounts of native grass hay across the study region for livestock feed in the last half of the 19th century. In the Valle Grande, a caldera in the Jemez Mountains, the Army cut an estimated 400 tons of hay each summer in the 1850s and early 1860s. Severe erosion, compaction of soil, and decimation or loss of surface water all resulted in general deterioration of regional rangelands (deBuys 1985: 216–225; McKeta 1986: 205–206; McNitt 1972: 184–185).

In the early years of the 20th century, heavy stocking of forest reserves was actually encouraged, as the resulting decimation of vegetation was considered a good strategy in reducing forest fire damage to timber (Leopold 1924: 6). The Forest Service attempted to control grazing on its lands through strict enforcement of the law and the issuance of grazing permits beginning in 1912. Livestock numbers were reduced to a level near carrying capacity, but with U.S. involvement in World War I the U.S. Forest Service grazing regulation was reversed as part of the war effort to produce more food. Grazing permits were issued upon request, and severe overstocking again resulted. Range deterioration and resulting erosion caused by this overgrazing in the forests peaked by 1920. After the war, the Forest Service initiated new measures to prevent overgrazing. Grazing permits were again issued, and fencing of Forest Service lands was carried out in the 1930s and 1940s to reduce grazing pressure by trespass livestock. A final action, enactment of the Taylor Grazing Act in 1934, which was prompted by overgrazing on not only Forest Service lands but also on Grazing Service (later the BLM) lands. This program was also implemented on Pueblo lands and the Navajo Reservation and led to reduced stock numbers (Bahre 1991: 118; deBuys 1985: 242–243).

Intensive grazing continued, however, on Pueblo lands in the 1940s, generally at above recommended livestock levels. For example, at Cochiti Pueblo livestock (354 cattle, 130 horses) grazed on 25,862 acres in 1943, which was at or above the range's carrying capacity. A study of Cochiti land conditions in the early to mid 1940s described the rangelands as "generally sandy," with small areas of alkali. Erosion caused by runoff was rated "light to moderate" in areas with some grass cover and "moderate to severe" in higher elevations with little vegetative cover. "Badland" conditions existed on small areas in the northwest corner of the reservation. Toxic plants, primarily locoweed (*Astragalus mollissimus*), were reported as a "medium infection," which was causing "moderate losses" of livestock. In 1950 there were only 192 cattle, 191 horses and mules, and 18 sheep. About 3,088 acres were leased from the U.S. Grazing Service and 640 from the state as rangeland (Lange 1959: 36–37).

Grazing pressure during this period also resulted from feral horses and burros, which originated from early Spanish and Indian escapees or releases of old lame animals. Later, Anglo mining areas were an important source of feral breeding stock, especially burros. Many of these animals sought secluded ranges in the uplands on public lands. Although the Forest Service, BLM, and National Park Service began round-ups and reductions by shooting in the early part of this century, some animals eluded their efforts. Even today there are small herds of horses and burros on public and reservation lands in the Southwest (Bahre 1991: 118; deBuys 1985: 244–245; Symanski 1985: 23–40).

By the 1930s the bunch grass-dominated rangelands of the Upper and Middle Rio Grande drainages had been replaced in many areas by ring muhly grass, broomweed, rabbitbrush, and cacti (Fig. 59). This vegetation change was probably due to overgrazing and timber cutting in the preceding decades, interrelated with periodic droughts in northern New Mexico and southern Colorado. The Forest Service estimated that at least 75 percent of the watershed was experiencing severe, accelerated erosion as a result (deBuys 1985: 230–232).

Grazing, interacting with impacts of other human activities and "natural" phenomena (fire, drought, etc.), has shaped the grasslands and woodlands on the west side of

Figure 59—Overgrazed rangeland on Sandia bajada. Broomweed, prickly pear, and walkingstick cholla dominants. Photo by author.

Figure 60—Scattered scrub oaks (*Quercus grisea*, *Q. turbinella*), three-leaf sumac (*Rhus trilobata*), and needle-and-thread grass (*Stipa comata*). Sandia Mountain foothills. Photo by author.

the Sandia Mountains. A 1963–64 study found a grassland, occurring below the pinyon-juniper zone at 5,500–6,000 feet on the Sandia bajada, had been grazed intensively for 250 years, primarily by sheep and goats. Dominant plants, all grasses, in descending order of importance, included *Sporobolus cryptandus*, *Bouteloua eripoda*, and *Muhlenbergia torreyi*. *Bouteloua gracilis* and *B. curtipendula* occurred on rocky areas on the sides of arroyos. *Hilaria jamesii* dominated low, flat areas between the arroyos (Naylor 1964: 91).

One-seed juniper was dominant from 6,000 to 7,000 feet. Just above this elevation, *Pinus edulis* and *J. monosperma* became co-equal in dominance, which was about 60 percent of the total plant coverage. At 7,300 feet, pinyon became the sole dominant, with trees 25–35 feet in height and up to 16 inches dbh. Dominants in the shrub stratum of the understory included *Quercus gambelii*, *Cercocarpus montanus*, and seedling *P. edulis* and *J. monosperma*. Between 6,200 and 6,500 feet *Quercus undulata*, *Q. turbinella*, and *Q. grisea* were dominants in some areas of the range. Occurring as dominants with these oaks were *Rhus trilobata*, *C. montanus*, and *Yucca baccata*. The dominant herbaceous understory included *Stipa neomexicana*, *Bouteloua hirsuta*, *B. curtipendula*, *Aristida divericata*, *A. purpurea*, and *A. purpurea* var. *nealley*. *Oryzopsis hymenoides* was increasing and appeared to be recovering (Naylor 1964: 22–23, 69–75; Soil Conservation Service 1994).

A 5,000-acre *Quercus* spp. association extended from about 6,800 to 8,500 feet, occupying old burns and eroded areas. A scrub oak-grass association of 820 acres was found along the foothills on the west-central side of the Sandias between 6,200 and 6,800 feet (Fig. 60). The woody dominants included *Q. grisea*, *Q. turbinella*, *Nolina microcarpa*, *Rhus trilobata*, *C. montanus*, *Krascheninnikovia lanata*, *Ribes* spp., *Fallugia paradoxa*, *Yucca baccata*, *Opuntia imbricata*, and *Opuntia* spp. Common herbaceous plants were *Lesquerella* spp., *Berlandiera lyrata*, *Verbena* sp., and *Gutierrezia sarothrae*. Dominant grasses include *Bouteloua gracilis*, *B. curtipendula*, and *Stipa comata*. This association was tentatively attributed to the more than 2 centuries of livestock grazing by Hispanics (Naylor 1964: 83–90; Soil Conservation Service 1994).

Historic overgrazing of the desert grassland community at the Sevilleta National Wildlife Refuge in central New Mexico resulted in the creation of many locations with denuded or decimated vegetation, which were invaded by a number of successional taxa such as *Ambrosia acanthicarpa*, *Salsola kali*, and *Yucca* spp. The periphery of the grassland community was also invaded by other species, notably *Gutierrezia sarothrae*, *Juniperus monosperma*, and *Larrea tridenta*. *Pinus edulis* and *Juniperus monosperma* have extended downward from higher elevations, intergrading with the desert grassland community to form a broad ecotone. At the upper elevation (about 7,000 feet) of the pinyon-juniper in the Ladron Mountains, decaying remains of *Pinus ponderosa* occur on rocky slopes and ridges. This condition indicates that the ponderosa community was more widespread historically, until a trend of increasingly drier conditions caused the recession (Manthey 1977: 26, 33–35; Soil Conservation Service 1994).

Another impact of livestock grazing and hoof action has been investigated in the region since the early 1900s (Duce 1918). Soil compaction due to cattle trampling has been studied on seven BLM allotments in the upper Rio Puerco-of-the-East drainage in recent years. Hoof impact was found to produce significant increases in resistance to moisture penetration in all soil types. Loam and clay soils were especially susceptible to compaction under moist spring conditions (Scholl 1989).

EFFECTS OF CLEARING, CUTTING, AND THINNING

The first clearing of woodlands or forests using stone axes, followed by burning, probably dates to more than three millennia ago in the study region. Cut and burn of stands of trees was perhaps employed by the Pueblo to create open areas for use as agricultural fields. This technique was probably used to remove riparian and pinyon-juniper stands. The botanical remains of cultigens such as corn and beans, dating as early as 2,000 B.C., have been found at a number of archeological sites located in the pinyon-juniper zone in New Mexico, Arizona, and northern Mexico. The woodlands at these sites were probably cleared for production of these two crop plants (Woodbury and Zubrow 1979: 43, 47–50).

Historically, most mountain woodlands and forests in the study region have been severely impacted by clearing with metal axes, hand saws, power saws, dragging of heavy chains or cables, and bulldozing. Metal axes were used to cut woodlands and forests for fuelwood, construction materials, and railroad ties (Fig. 61; cutting to clear the woodlands to create fields for farming or grazing also occurred (Ford 1987: 74, 86). Clearing or thinning extensive areas with axes decreased markedly in the first half of this century, but as late as the 1950s Fort Apache Indians in Arizona cleared 95,000 acres of pinyon-juniper using hand axes. In recent decades tractor-mounted circular power saws or hand-held power saws have replaced axes or buck saws (Arnold et al. 1964: 18; Springfield 1976: 14).

Removal or thinning of pinyon-juniper was undertaken on public and private lands in this century to (1) increase forage for livestock, (2) "improve" watershed conditions, (3) increase water yield or "improve" wildlife habitat, (4) obtain Christmas trees or nursery stock, and (5) increase pinyon nut yield (Fisher and Montano 1977; Hurst 1977).

Figure 61—Raft of railroad ties for Denver and Rio Grande Railroad, ca. 1915. Courtesy Museum of New Mexico Photo Archives, Santa Fe (negative no. 39350).

Taylor (1937: 5) was one of the first pinyon-juniper managers to improve a stand by thinning ostensibly to "improve" wood growth for products such as fence posts and to foster pinyon nut yield. Techniques for mechanically clearing trees and brush, such as chaining, cabling, and bulldozing, were developed in the 1930s and 1940s. Chaining or chopping was considered to be the most effective method of removing trees. By the 1950s root plowing, and then seeding (grass), was developed as an effective technique for removing undesired woody plants from grasslands (Davis and Spicer 1965: 7–9, 26). Most of these clearing operations in the region occurred in the late 1950s, 1960s, and early 1970s.

Extensive areas that had been denuded in the late 19th and early 20th centuries, and subsequently invaded by pinyon and juniper, on the Santa Fe and Carson National forests were cleared and sown to native and exotic forage plants by the Forest Service beginning in the late 1960s. On one tract, located on Rowe Mesa south of Pecos, New Mexico, agency personnel cleared 13,000 acres of pinyon-juniper and reseeded tracts with various grass species. This was done to eliminate overgrazing in the Pecos Wilderness and to ease conflicts between livestock permittees and recreationists. Non-ranchers in the area, primarily Hispanic, did not approve of this action because large areas of pinyon-juniper woodland that provided fuelwood for generations in their communities were lost (deBuys 1985: 267–268).

Fuelwood cutting on Santa Fe National Forest lands in the southern portions of the Sangre de Cristo Mountains was unregulated in the late 1960s and 1970s. One reason for this management policy was the need to develop the woodlands as an economic resource for surrounding communities whose villages established wood co-operatives. In spite of the continuing demand for green pinyon and juniper wood during the 1973–74 oil and gas shortages and high prices, these co-ops failed due to serious management problems. Around Las Trampas, Chamisal, and Penasco, there was a scarcity of pinyon and juniper at this time. The Forest Service, under pressure from local residents, allowed over 1,700 cords of wood to be harvested in 1977. This exceeded the sustained-yield production of the pinyon-juniper, and some areas were soon exhausted (deBuys 1985: 275–277).

There is some evidence that springs in pinyon-juniper woodlands have ceased flowing with increase in tree densities. Thinning of juniper at these locations has resulted in the resumed flow of these springs (West 1984: 1313).

HUMAN IMPACTS AND CHANGES

Colonial Period, 1540–1821

At the time of first European contact, there were more than 50,000 Pueblos living in over 100 villages in the Middle and Upper basins (Schroeder 1979). They had cleared some 25,000 to 30,000 acres in the Rio Grande Valley for agricultural use and probably 5,000 or more along tributaries. Most of the water used in this farming effort came from natural overbank flooding or runoff diversion from tributaries. Irrigation ditch agriculture was limited at this time. Pueblo farmers may have experienced some increased alkalinity in soils used over an extended period, but the flushing action of the river probably mitigated this process. These fields and associated villages obviously would have displaced riparian vegetation, which in turn would have reduced faunal populations dependent on these plant communities. Agricultural fields, however, would have provided an ecotone effect for some fauna, especially seed-eating mammals and birds.

Other local impacts on aquatic and terrestrial wildlife occurred around villages and in specific hunting locales. Social and conservation restraints probably precluded overhunting of a particular species, although hunting pressure by a growing Basin population in the late 1400s-early 1500s may have "pushed" various game species, such as deer and pronghorn, away from local villages and hunting territories. Most of the bison herds that roamed west of the Rio Grande in the 1300s–1400s may have been forced east of the chain of ranges along the east side of the rift valley just prior to Spanish arrival (Callenbach 1996: 17–18).

By utilizing conservation in harvesting wild plants for food, medicine, and so forth, the Pueblos probably caused only localized, temporary reduction in various species. The Pueblos probably did not singularly extirpate any plant species, although the eradication of a few species whose populations were significantly declining due to climatic change or other natural agents may have been hastened through harvesting.

The Pueblos rarely collected green wood for cooking and heating prior to Spanish occupation, but they were recruited by the Spanish civil authorities and missionaries to gather ever-increasing amounts of fuelwood, using iron tools for cutting and draft animals for transporting the fuelwood. Soon, supplies of dead wood, then living wood, were depleted near settlements, and Pueblo and Spanish residents were forced to travel ever-greater distances to gather this resource (Ford 1987: 85). Nearby and distant conifer stands were likewise cut for use in construction, although logging impacts were much less than those after the arrival of Anglo Americans in 1846.

Estimates of the Pueblo population in the study region vary considerably; the actual figure may have ranged from 40,000 to 50,000. As their populations were significantly reduced by European diseases, the survivors were forced by the Spaniards into fewer villages, which by 1706 numbered only 18, with a population of about 7,000 residents in the study region (Schroeder 1979: 254; Simmons 1979a: 185). This phenomenon substantially decreased Pueblo impacts on indigenous fauna and flora, although the increasing use by the Spanish of Pueblo and other Native American men and boys to herd livestock and to work in the fields probably offset, at least in part, their decreased harvesting of various biotic resources. Furthermore, the increased demand by the Spanish for animal hides and skins (bison, deer, elk, pronghorn, and bighorn sheep) resulted in more hunting pressure on faunal populations of the Middle and Upper basins (Snow 1981: 367–368; Weber 1971: 20–21).

With the introduced, more intensive technology of irrigation agriculture and the introduction of wheat and barley by the Spanish, Pueblo consumption of wild, edible plants decreased significantly as well. In the 1600s the Spaniards also recruited Pueblo and nomadic Indian servants to gather huge quantities of pinyon nuts to ship south to other Spanish provinces (Scholes 1937: 394–395). What impact this had on pinyon forests and associated fauna is not known.

In the 18th century the Spanish placed about 27,000 new acres of irrigated land into cultivation (Hedke 1925: 23). By the mid 1700s, agricultural land was scarce along the Rio Grande and major tributaries. Increased alkalinity resulting from continuous irrigation of valley soils became a problem by the early 1800s, perhaps even before. Good grazing lands were also scarce, not only around settlements but also adjacent to the valleys and into the foothills to high meadows (Baxter 1987: 24; Simmons 1988: 7). Grass around Albuquerque, Belen, and Cochiti was especially impacted, to the point of scarcity (Espinosa and Chavez n.d.: 177; Lange 1959: 37; Simmons 1982: 106–107). Local cienegas and other wetland areas were also severely impacted by livestock grazing (Adams and Chavez 1956: 111).

A number of exotic plants, in addition to cultigens, were introduced intentionally or accidentally by the Spanish, including alferillo, dandelion, and two sweet clovers, plants that were not as aggressive as later introductions or were limited climatically in their range following naturalization.

Besides new agricultural techniques and crops, Spanish livestock brought dramatic changes to riparian, bajada, mesa, and mountain grasslands and other vegetation. Grasses were decimated by sheep, goats, cattle, and horses around major settlements for up to several miles around. This removal of ground cover, as well as livestock hoof action, enhanced by droughts, resulted in sheet erosion and gullying (Ford 1987: 85–86; MacCameron 1994: 22–23, 25). Sediments transported by rapid-runoff floods and winds into the river increased in the late colonial period as well.

A corridor impacted early by livestock, as well as human traffic, were the branches of the Camino Real that connected settlements on both sides of the river (Hendricks 1993: 81; Scurlock 1990b: 6). Hundreds of thousands of head of livestock, thousands of wagons and carts, and as many soldiers, settlers, and travelers moved along these roads in the 16th century. Grasses were grazed away, cut by wheels and hooves, and trampled and worn away by pedestrians over the remainder of the Spanish-Pueblo colonial and following Mexican-early territorial periods (Fig. 62).

By the late 1700s-early 1800s many settlements were also experiencing inadequate fuelwood supplies, and residents were traveling up to 20 miles to cut wood (MacCameron 1994: 35; Moorhead 1958: 24; Oppenheimer 1962: 16). Attacks by Apaches and Navajos sometimes prevented Spaniards and Pueblos from traveling too far from their villages to collect wood. Livestock manure was sometimes burned as a substitute during these times.

Increased demand for coarse furs by a growing Spanish population, hunting, and the spread of brucellosis from cattle to wild ungulates also resulted in reduction of indigenous species, especially bison, pronghorn, and elk. Remaining herds of bison or individual stragglers joined the herds now found in the Pecos River drainage eastward into Texas (Callenbach 1996: 134–135). Spanish-sponsored trade fairs held annually at Taos, Picuris, and Pecos in the 18th century contributed to the demand for furs and skins (Adams and Chavez 1956: 252–253; Scurlock 1991b). Annual fall hunts to the east of the eastern mountain chains further depleted the Southern Plains buffalo herds and the deer, elk, and other game animals needed for subsistence by the Spanish and Pueblos. The dominance of the eastern plains by the Comanche after 1706 also brought significant hunting pressure on animal populations in that century (Scurlock 1993b: 48).

Mexican and Territorial Periods, 1821–1912

Intensive irrigation continued into the Mexican period (1821–46) to provide food for increasing Hispanic populations and the first Anglo American trappers and traders, some of whom became residents in the study region. By the 1820s more cienegas and esteros began to form in the Middle Valley due to the dumping of excess water from irrigation ditches (Wozniak 1987). Apparently, ditches at this time were being used to dump trash and dead animals, as the city council of Santa Fe issued a proclamation making it illegal to carry out these activities (Simmons 1992: 224). Acequias were also used for drinking water, bathing, washing clothes, and watering livestock (Simmons 1982: 97).

Intensive grazing and fuelwood collecting around old settlements by the early trappers and traders exacerbated existing environmental conditions, which were generally poor. At the same time, pressures on grasslands and wild game resulting from the brisk traffic of Santa Fe Trail traders adversely impacted these resources. Increased demands for native "hay" and agricultural produce placed added pressures on grasses, irrigation water, and soil fertility.

Wild horses were abundant on the margins of the study region, but their impact on grasslands is not known. Any

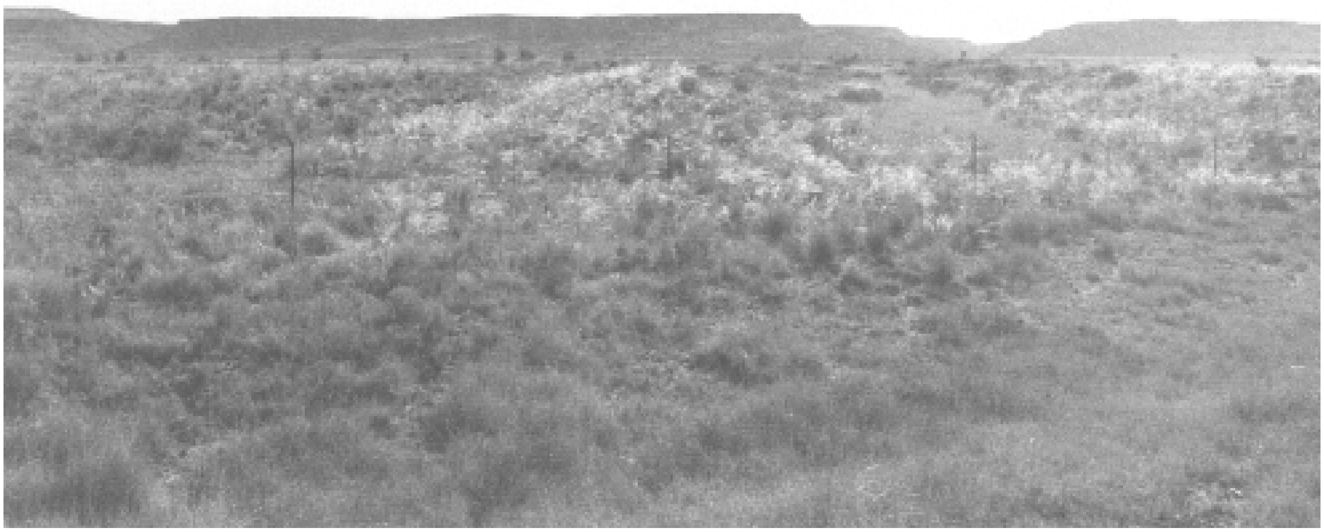

Figure 62—Road "scar," possibly a branch of the Camino Real south of Las Bocas (mouth of the Santa Fe River). Note eroded depression and light-colored vegetation (unidentified). Photo by author.

overgrazing was undoubtedly offset to some degree by the decrease in bison, elk, and deer populations caused by increased hunting. Franco and Anglo trappers entered the region in the 1820s, and beaver and river otter populations were reduced severely. Some local populations of these two species were extirpated by the end of the decade. Demand for their furs came not only from eastern U.S. and European markets but also from large trading houses in the region. Pressure on bison herds, elk, deer, and bighorn sheep was increased by these trappers and traders, who needed the meat for subsistence and the hides for economic support (Cleland 1963: 44; Connor and Skaggs 1977: 32–33; deBuys 1985: 93; Weber 1965: 65, 84, 118, 161). Following the collapse of the beaver market, buffalo hides became popular in the East as robes or coats, placing even more hunting pressure on the herds (Weber 1971: 219).

The importance of the land grant to Hispano settlers was discussed in Chapter 3. In 1846 about 95 percent of Hispanos and Pueblos were wholly and directly dependent on the land (Harper et al. 1943: 65), most of which was on grants. Degradation of lands due to long-time use, especially common lands used for grazing, harvesting timber and fuelwood, and hunting, induced change of the traditional economic structure in some northern Spanish villages. Later, grant lands were lost outright to unscrupulous lawyers and squatters, and because of the lack of precise and detailed surveys, failure to submit titles to the courts, failure to pay taxes, and inclusion in national forests (Briggs and Van Ness 1987: 274–278; Gonzalez 1969: 51, 198–199; Leonard 1970: 117–119, 122–123).

Livestock raising and farming on grants "were wedded to form a single system in the Hispanic cultural ecology." Without these traditional activities, the "entire Hispanic system of adaptation broke down; the traditional cultural ecology no longer functioned" (Briggs and Van Ness 1987: 195, 201–202).

Snow (1979: 52) addressed this same issue:

> It seems safe to say that the overriding values in New Mexico's rural Hispano communities are those which relate to land. It is the individual and community land which gave shape and char-

> acter to the village, which give justification for the village organization and roots to the people who live there. Without roots, without costumbre, the individual is homeless, without land the community ceases to exist.

Unlike the Hispano farmers of the Rio Arriba, more of those in the Rio Abajo below Albuquerque had relatively large, fertile farms on which they could grow cash crops and thus participate in the cash economy introduced by the Anglos. Additionally, for those who could afford them, iron plows and other farm machinery increased production (deBuys 1985: 207–208).

Most Hispanics, however, continued a subsistence lifestyle, producing adequate meat from livestock and vegetables and fruit from irrigation farming. As happened to the Hispanics in the Upper Rio Grande, however, common lands in various mountain ranges were lost due to their inclusion in national forests beginning in 1905. Also, the federal stock reduction program caused hardship, as did competition with Anglos running commercial livestock operations. Some Hispanics could not afford the grazing fees on forest lands or the taxes enacted by the Middle Rio Grande Conservancy District in the 1920s. In spite of these obstacles, many Hispanics held on to their land base and water rights. Those who could not survive due to limited resources left the state to work as farm laborers, cowboys, or sheepherders in west Texas, Colorado, Utah, Wyoming, Montana, Arizona, or California (Harper et al. 1943: 61–65, 69–73, 76–79).

The new cash economy of the dominant Anglo eco-culture resulted in additional problems, such as decline in the traditional subsistence economy. As Hispanics became more dependent on commercial sales, there was "over-utilization of resources and environmental degradation." Self-reliance also was eroded, and more men sought wage labor outside the village. This phenomenon was also associated with the loss of the land base, especially the common lands (Weber 1979: 79–83).

The arrival of the first significant wave of Anglo American settlers, primarily traders, cattle ranchers, and farmers protected by the U.S. Army, ushered in a new era of resource exploitation. More efficient technology was employed within a context of maximum economic gains for individuals or business groups. Land and water use pressures increased sharply, especially following the building of the first railroads across the study region in 1879–81. Ranching, logging, and mining proliferated, and new towns were established near or along the rail lines (Fig. 63). Railroad transportation linked the state to U.S. and other markets, especially for minerals, beef, wool, and agricultural produce. Rail transportation also created a market for coal and wood to fuel engines; for wood to construct railroad buildings, ties, and bridges; and for beef to feed construction and train crews. Pressure was exerted on big game animals such as deer, elk, and bighorn sheep as contract hunters provided meat for construction crews (Dortignac 1956: 60; Roberts 1963: 7–8).

Beginning in 1892, with the establishment of the first national forest reserve, Pecos, in the southern Sangre de Cristo Mountains, the initial conversion of private and common lands of a Hispanic land grant to public lands occurred. These public forest lands were either obtained from the second or third entity in the chain of ownership following the patenting and sale of a land grant, or from lands claimed by grant heirs but not patented by Congress. Often these land grant tracts were purchased from a timber or cattle company that had obtained them from a speculator, resulting in the Forest Service inheriting the associated discord and bitterness of land grant heirs (deBuys 1985: 257–258).

Initially, the Forest Service issued fee permits for grazing of livestock used principally for commercial purposes or free permits for animals used in traditional subsistence, such as plow horses or milk cows (deBuys 1985: 258–259). The free permit policy was rescinded in 1916, and many small-scale farmers and stock raisers, unable to pay a grazing fee, were forced to find employment outside the village or even the state. Local livestock herds declined, leaving farmers without a source of fertilizer. Loss of sheep also resulted in a decrease in the production of traditional wool textiles (Briggs and Van Ness 1987: 201–202, 231; Gonzalez 1969: 50).

Also during this period, some Spanish land grants, especially common lands, were commercially exploited by Anglo Americans for grazing, logging, or mining. Many patented grants, obtained through purchase by speculators, were used for intensive cattle grazing, to the exclusion of Hispanic livestock raisers (Westphall 1983: 125, 155–156). Two such examples were the Ramon Vigil and Cochiti de Canada grants on the Pajarito Plateau west of Santa Fe. In the early 1880s the Vigil grant was sold to an Anglo land speculator, who leased it as grazing land to a West Texas cattleman named W. C. Bishop in late 1885 or early 1886. This rancher had been forced to abandon drought-stricken rangelands in West Texas and to move his more than 3,000 head to northern New Mexico. His large cattle herd and reported threats against area Hispano and Cochiti Pueblo grazers and herders forced them off of the plateau, not surprisingly generating bitter feelings. Fortunately for these individuals, Bishop's enterprise was short lived due to his own greediness or ecological ignorance and a severe winter in 1886–87. The pre–1886 carrying capacity of the 32,000-acre Vigil grant for cattle has been estimated at one head of cattle for every 64 acres of rangeland. Bishop's 3,000 head of cattle represented one animal for every 10.7 acres, or about six times the estimated carrying capacity. The resulting deterioration of grasslands and a big winter die-off of cattle forced the rancher into irreparable losses, so he returned to Texas (Rothman 1989: 198–202).

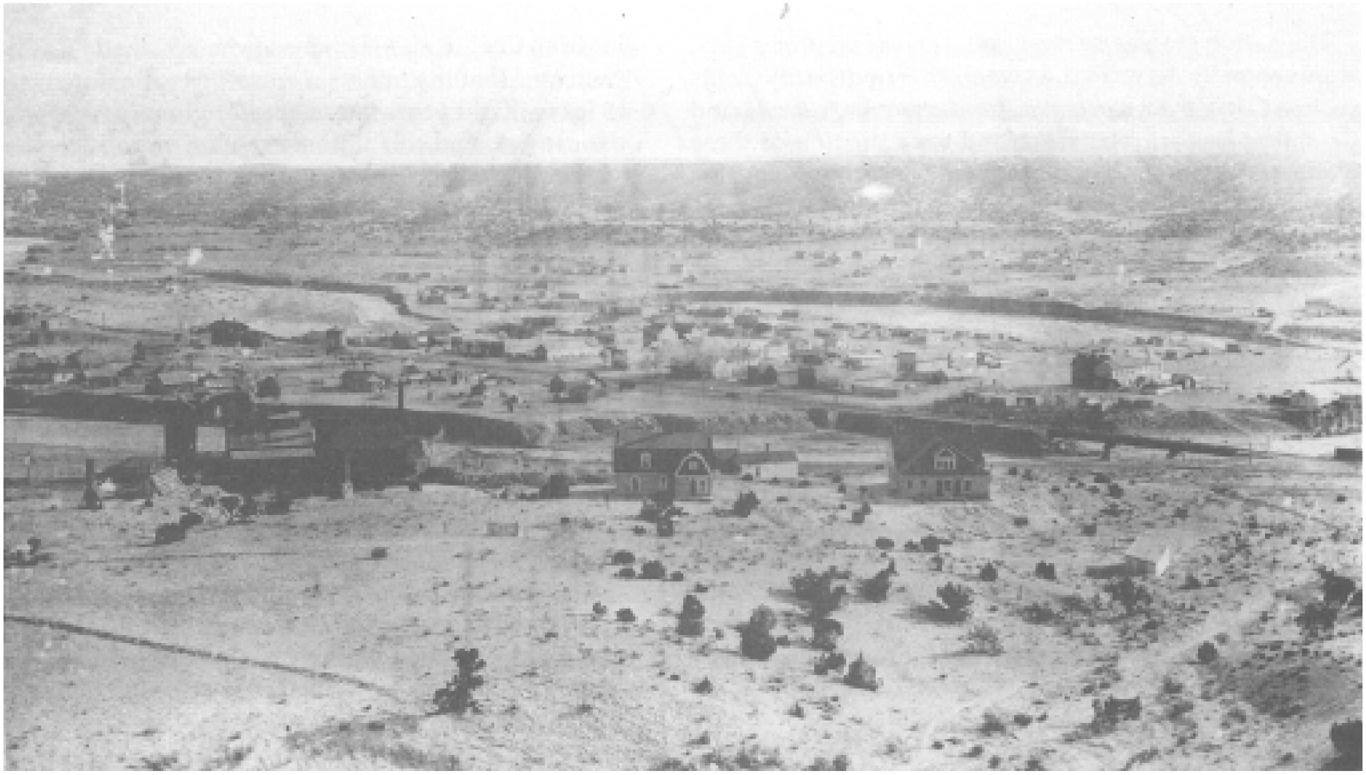

Figure 63a—View southwest of Cerrillos, a railroad-mining town, ca. 1904–05. Note very sparse vegetation. Courtesy Museum of New Mexico Photo Archives, Santa Fe (negative no. 14610).

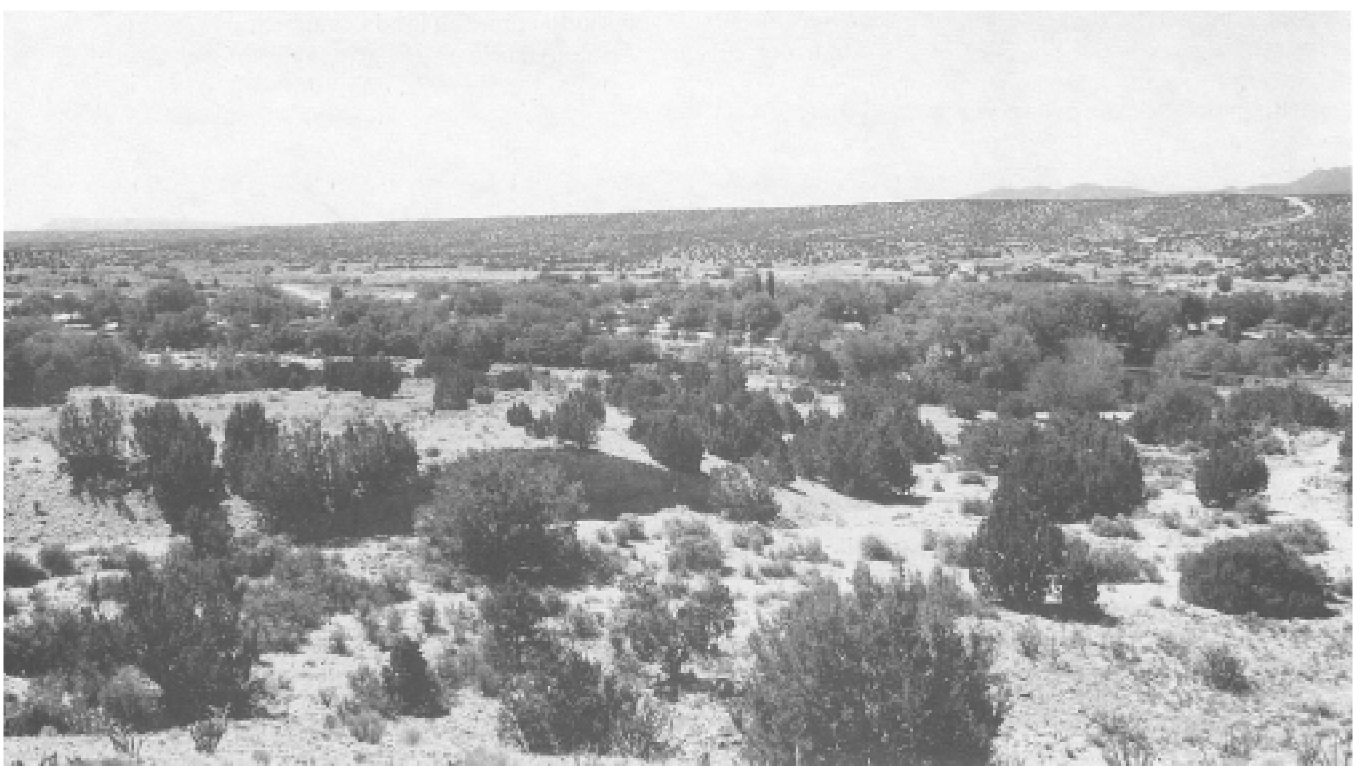

Figure 63b—Repeat photograph of above, 1995. Note scattered one-seed juniper, walkingstick cholla, and broomweed on front slope. Valley cottonwood, Siberian elm, poplar, and other trees virtually mask town structures (center). Photo by author.

The native grasses on the grant, such as *Bouteloua* spp., were generally decimated, as were other understory plants such as *Cercocarpus montanus, Krascheninnikovia lanata*, and *Ceanothus fendleri*. The vigor and reproduction of these plants was reduced, and subsequently less desirable grass and woody forbs and shrubs, such as *Gutierrezia sarothrae, Yucca glauca, Chrysothamnus* spp., and *Artemisia* spp., encroached where vegetation had been removed. Exotic plants such as *Verbascum thapsus*, *Setaria* spp., *Bromus* spp., and *Salsola kali* also spread into the understory. Fires, which had burned across the plateau every 7 to 8 years in the past, were suppressed, which also favored the invasion of woody forbs, shrubs, and trees. Topsoil in areas now devoid of grass cover was subject to sheet erosion of rain or snowmelt runoff and wind (Rothman 1989: 202–203).

Besides railroad construction, mining was a major reason for the logging and sawmill "boom" that followed on the Pajarito Plateau. In 1880 Anglo miners discovered gold and silver in Pino Canyon, later renamed Bland Canyon, but before they could file claims and begin mining, Pueblos from Cochiti and Hispanos from la Canada de Cochiti protested that the miners were trespassing, forcing them to leave. Eight years later, more Anglo miners arrived at the canyon, and this time these men were successful in staking claims and producing ore. Strikes in Pino Canyon resulted in establishment of the town of Bland (Fig. 64) and, in nearby Colle Canyon, the town of Albemarle. Fifteen hundred men were working the mines and conducting associated businesses, such as freighting and wood milling. There were four sawmills in the area; one, the Harry Buckman Sawmill, had actually started logging on the plateau before the strikes at Bland and Albemarle. Buckman had his mill on the Rio Grande 5 miles south of San Ildefonso Pueblo, and in 1898 he leased the Vigil grant to begin logging operations. He also had lumber camps in Water Canyon, near Frijoles Canyon (Rothman 1989: 203; Scurlock 1981b: 45–47; Stanley 1964: 16).

A second sawmill was begun at the mouth of White Rock Canyon, just north of Cochiti Pueblo. The associated sawmill and lumber camp, named Boom, was at the

Figure 64—Mining town of Bland, Pajarito Plateau, 1895. Courtesy Thomas Ball and Bureau of Mines Photo Archives, Santa Fe.

end of a new railroad spur. Still another sawmill was located on Sawyer's Mesa, and a fourth was operated in Media Dia Canyon (Fig. 65). To carry logs, lumber, and ore from the mines, a network of roads was opened through the stands of pinyon-juniper and ponderosa (Rothman 1989: 203, 205).

Surface and ground waters were used intensively to support all of these activities, adversely affecting some of the associated flora. The areas around Bland were cleared of shrubs and trees and subsequently overgrazed by the livestock of miners and freighters. This impacted area included the town site on the floor of the canyon and the tops of the flanking mesas. Exotic plants such as *Malva neglecta*, *Nepeta cataria*, and *Linaria vulgaris* were introduced, and they quickly naturalized and spread over disturbed areas (Noble 1980: 19; Robertson 1968: 36, 40, 42; Scurlock 1980: 53 and 1981b: 50; Stanley 1964: 14–15).

The Canada de Cochiti grant land on which Bland and Albemarle mines and towns were located remained in dispute with some Hispanic heirs. However, other grant claimants were selling the rights to mine or parcels of land within the grant. In 1894 the Court of Private Land Claims declared that all grant claims and the existing mines were on public domain. Following appeal of this decision, the Supreme Court upheld the Court of Private Land Claims decision, and mining continued on this part of the grant (Vieth 1950: 21–28).

Unregulated grazing by significantly increasing numbers of livestock on public lands in the late 1800s continued into the early part of this century. Although the Department of Interior and Forest Service began regulatory grazing programs at this time, protests, noncompliance, and trespass by livestock raisers hindered effective management (Eastman and Gray 1987: 36; Rowley 1985: 78, 89–90). Also, the demand for food and wool during World War I caused livestock numbers to peak on public and private lands in the state (Brown 1985: 112; deBuys 1985: 231; Donart 1984: 1240). As a result, watershed conditions in the national forests continued to decline.

New approaches to land use, such as suppression of wildfires, controlling floods, predator and rodent eradication, and commercial hunting, contributed to other major environmental changes in the early 1900s (Clark 1987: 195; Dick-Peddie 1993: 51, 56; Rowley 1985: 77). Some

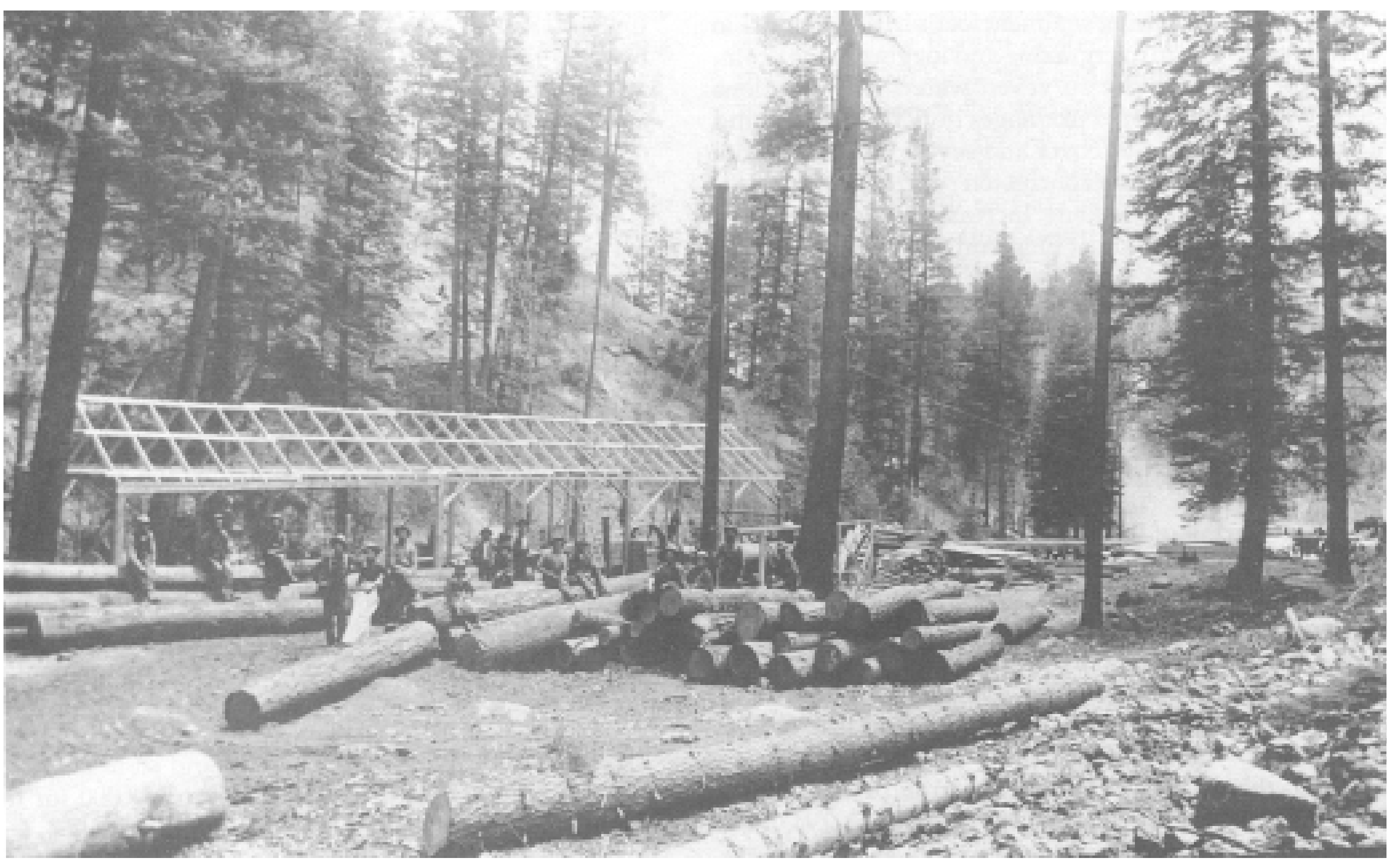

Figure 65—Sawmill in Medio Dia Canyon Pajarito Plateau, late 1800s. Courtesy Museum of New Mexico Photo Archives, Santa Fe (negative no. 5190).

of these impacts were irreparable, such as the extirpation of several mammals, or so severe, such as creation of a rising water table, waterlogging, and alkalinization of floodplain farmland, that government rehabilitation and management of these resources was required.

Statehood Period, 1912–1980

By this time 3 centuries of increasingly intensive use of the Middle Rio Grande Basin by various human groups had significantly changed the Basin. Intensive grazing, irrigating, logging, and mining decimated vegetative cover over most of the Upper and Middle basins. Some introduced exotic plants spread rapidly in disturbed areas, most notably in the riparian zone. Flood control structures brought major changes in the vegetation zone as well. The Rio Grande was a low-flow, heavily sedimented, shallow, and more frequently flooding river at this time (Crawford et al. 1993: 19–20). These floods, increased waterlogging and alkalinization, and the accelerated demand for surface water in the late 19th and early 20th centuries led to major water control development programs. Ditches, drainage canals, and dams resulted in various changes in the river ecosystem (Crawford et al. 1993:xi, 20, 32–35, 40; Scurlock 1988a: 136–138).

Clearly, the increasing sediment loads in the Middle Rio Grande were due to overgrazing and logging in the drainage. The Forest Service surveyed watershed conditions in the Middle and Upper drainages in 1932–33 and found a decimated vegetative cover and severe erosion. A state board came to the same conclusion regarding the condition of the public rangelands. Increased sedimentation in the river and deposition at Elephant Butte Reservoir had caused the loss of about 13 percent of the reservoir's capacity (Clark 1987: 255, 258).

Nevertheless, the Forest Service suspended grazing fees due to the emergency economic conditions of the 1930s depression. Intensive grazing also continued on other public, private, and Pueblo lands, and the impact was exacerbated by the beginnings of an extended drought in the mid 1930s (Aberle 1948: 17, 19; Rowley 1985: 246). About 50 percent of the forage had been lost to intensive grazing and erosion in the Upper and Middle basins by 1931. On about 75 percent of the land, rapid or accelerated erosion was taking place (Cooperrider and Hendricks 1937: 72–73). Sedimentation continued to increase; the Rio Grande floodway aggraded an average of 0.09 feet and the river bed 0.12 feet annually from 1927 to 1936 (Happ 1937: i, 3).

In 1935 there were still 669,000 sheep and 212,000 cattle in the Middle and Upper basins (Harper et al. 1943: 49). This intensive grazing pressure and an extended drought continued to decimate plant cover on rangelands. Gullying and arroyo trenching produced 65 percent of the total sediment load, sheet erosion 30 percent, and wind erosion 5 percent. The mean annual suspended sediment loads in the Middle and Upper basins amounted to 39 million tons (Dortignac 1956: 48–49). At least 90 percent of this total was derived from grazing lands (Happ 1944: 17). This volume of sediment was the primary factor in the continuing aggradation of the Rio Grande streambed.

By the mid 1930s increased use of water, evaporation, and lowering of water tables had resulted in a 50 percent decrease in the flow of the Rio Grande since 1880 (Kelley 1982: 18). Due to the rehabilitation of farmland through drainage, however, some 61,294 acres of land were in cultivation in the Middle Valley in 1936 (Wozniak 1987), representing an increase of 26.5 percent.

The pattern of drought followed by intensive rains continued and led to more erosion and tributary stream entrenchment. For example, by the early to mid 1930s Tonque Arroyo had eroded to a depth of 5 to 20 feet and to a width of 20 to 50 feet. Prior to this time, this drainage had been only a shallow depression (Cooperrider and Hendricks 1937: 12).

Intensive logging on the Middle Rio Grande watershed, begun in the late 1800s (Fig. 65), continued, as did the cutting of pinyon-juniper woodlands in the 1920s-early 1930s (Cooperrider and Hendricks 1937: 13–14, 60, 62; Glover 1990: 26). An estimated 60 million board-feet of timber were cut in the Upper and Middle basins in 1941; by 1950 this figure had risen to 70 million board-feet. About half of the ponderosa pine stands had been logged, and less than 10 percent of the spruce-fir stands. Three-quarters of this cut timber was on federal, state, or Indian lands (Dortignac 1956: 67–69).

Various federal and state conservation programs begun in the late 1930s marked the beginning of a concerted effort to restore vegetative cover on public lands (Potter and Krenetsky 1967). The overall stocking rate of the Middle and Upper basins, however, was still above carrying capacity by almost 50 percent (Harper et al. 1943: 50). Most commercial sheep and cattle ranchers were convinced that the severe soil erosion was simply a result of "natural aridity," an inevitable process that they or the government could do nothing about (Forrest 1989: 160). An estimated 255,800 cattle-units were on the 12,100,000 acres of rangelands in the Middle Basin in 1942. In actuality, the carrying capacity of these lands was estimated at 139,800 cattle-units per year (Harper et al. 1943: 50). Not surprisingly, the carrying capacity of grazing lands in the region steadily decreased during the extended dry period, 1942–56 (Gatewood et al. 1964: B43).

Reduction of livestock on federal and state lands reduced the number of livestock units to 158,000 for the Middle and Upper basins by 1950 (Dortignac 1956: 56). However, the ensuing drought of 1951–56 decimated grasslands, especially the pinyon-juniper and sagebrush ranges, which were in "extremely poor condition." This forced ranchers to keep their livestock longer on winter ranges or to drive them to higher ranges, which were normally reserved for summer grazing, resulting in overgrazing (Dortignac 1956: 56, 64).

After World War II, recreational use of public lands increased sharply, especially in the national forests, including such activities as hunting, fishing, camping, skiing, and hiking. As a result, areas in the study region experienced accelerated soil erosion, water pollution, and accidental forest fires. Between 1945 and 1953 visitation to the Sandia District of the Cibola National Forest alone increased from 99,000 to 1,068,000 (Dortignac 1956: 85–86).

Middle Rio Grande Geomorphology and Hydrology

After 1850 the bed of the Rio Grande began to aggrade more rapidly due to reduction of river flow and the increasing sediment load produced primarily by rapid runoff caused by intensive grazing and logging on the watershed (Clark 1987: 205; Hedke 1925: 11). As irrigation intensified, especially in the San Luis basin of the Upper Rio Grande in the mid to late 1800s, river flow in the southern reaches of the river were severely reduced or even halted. Severe arroyo cutting also began at this time, and some tributary streams, such as the Rio Puerco, began major entrenchment (Leopold 1994: 17). This process eventually caused abandonment of irrigated land as lowering stream levels precluded farmers' from diverting the water to their fields (Bryan 1928a: 274, 279).

The increasing sedimentation and aggradation of the river had become a serious environmental problem by the late 19th century. From 1880 to 1924 the bed of the river rose 7 feet at the Isleta bridge and 9 feet at San Marcial. The rate of rise in the streambed for 1914–26 was 0.29 feet per year. The floodway rose 0.28 feet per year during this period. For 1926–36 the river bed aggraded an average of 0.54 feet annually at this location; the floodway aggraded an average of 0.09 feet (Happ 1937: i, 2–3, 1944: 18; Sullivan 1924:7). In 1946 some 37 million tons of sediment were transported by the Middle Rio Grande, and about 25 million tons, or 13,500 acre-feet of this total, were deposited in the valley (Nelsen 1946: 19).

The decline in Rio Grande water flow also continued to be a major problem in the region, especially south of Albuquerque. In 1925 some 565,000 acre-feet of water were depleted; a shortage of 200,000 acre-feet occurred at Buckman. About 68,000 acre-feet were used in the Middle Valley in August alone (Hedke 1925: 14, 32).

By the time the legislation establishing the Middle Rio Grande Conservancy District was passed in 1923, irrigated acreage had decreased to its lowest level (49,000 acres) since the early to mid 1800s (Bloodgood 1930: 5). The district, embracing some 277,760 acres, was created to deal with severe flooding, waterlogged lands, and failing irrigation facilities. About 8,000 acres of the Middle Valley were "swampy" due to a high water table, and another 52,000 acres were covered with alkali deposits (Hedke 1925: 10). The conservancy was also responsible for regulating stream flow, developing or reclaiming sources of water, and generating electrical energy (Clark 1987: 207; Scurlock 1988: 136).

Many traditional water control systems existed in the district, including those of the six Middle Valley pueblos (Sando 1992: 123). Most of the irrigation facilities, however, belonged to Hispanic farmers, some of whom, along with the Pueblos, expressed concern for the project, as it might affect their traditional ditch systems and irrigated lands (Orona 1994).

To deal effectively with these problems, the district developed a plan in 1928, and implementation of various water control measures soon occurred. From 1930 to 1934 construction of six diversion dams, the El Vado dam and storage reservoir on the Chama River, 250 miles of main irrigation canals, 350 miles of drainage canals, and 190 miles of levees was completed (Harper et al. 1943: 53). These flood-protective levees were constructed with earth excavated from the riverside drains and adjacent land. Rising about 8 feet above the river bed, these earthen structures created a floodway some 1,500 feet wide (Crawford et al. 1993: 26).

Between 1935 and 1975 the district, the Corps of Engineers, and the Bureau of Reclamation constructed six major dams on the Upper and Middle drainages to control floods, store water, and catch sediment (Table 55; Fig. 66): El Vado (1935) on the Chama River, Jemez Canyon (1954) on the Jemez River, Abiquiu (1963) on the Chama, the Galisteo (1970) on Galisteo Creek, the Heron (1971) on Willow Creek, and Cochiti (1975) on the Rio Grande (Crawford et al. 1993: 44). Four irrigation diversion dams were built in the Middle Valley in 1936 (Table 55; Fig. 66 and 67a and b).

Table 55—Middle and Upper Rio Grande dams and reservoirs.

Name	Stream	Year completed
Flood Control–Water Storage		
Elephant Butte	Rio Grande	1916
El Vado	Chama	1936
Jemez Canyon	Jemez	1953
Abiquiu	Chama	1963
Heron	Willow	1963
Galisteo	Galisteo	1970
Cochiti	Rio Grande	1975
Irrigation Diversion – Rio Grande		
Cochiti		1936
Angostura		1936
Isleta		1936
San Acacia		1936

Sources: Clark 1987; Wozniak 1987

Between 1940 and the completion of Cochiti Dam in 1975, the Rio Grande, from Cochiti to Albuquerque, had become more narrow and less braided. Its channel has been incising or degrading and becoming more sinuous downstream. Below Bernardo the river was aggrading and becoming more braided (Crawford et al. 1993: 56–57).

Channel modification of the Middle Rio Grande was initiated in 1953 by the Bureau of Reclamation to maintain channel capacity for carrying high flows and moving sediments through the valley. The "silt burden" in the river at San Marcial exceeded one-half million tons in that year. Most of the sedimentation in the Middle Basin was derived from gully-arroyo trenching and sheet erosion of lower-elevation lands (Dortignac 1956: 2, 38; Fig 68). The channelization project was completed in 1959 (Crawford et al. 1993: 43–44; State Engineer Office 1956: 5). During this same period, Kellner jetty jacks were installed in the Middle Valley to help stabilize the river channel and protect the levees. These jacks created large areas of moist alluvium that were subsequently colonized by native and exotic trees and shrubs (Crawford et al. 1993: 31–32).

Figure 66—Major 20th century dams on the Rio Grande and tributaries.

The average, annual streamflow production in the Rio Grande above Elephant Butte was almost 3 million acre-feet in 1955. Almost two-thirds of this amount, 900,000 acre-feet, was consumed between the Colorado border and Elephant Butte. More than 400,000 acre-feet of this total was considered wasted or nonbeneficial use (Dortignac 1956: 4, 29).

The riverside diversions at Corrales and Atrisco were replaced in the 1960s by inverted siphons that ran under the river from riverside drains. These were converted seasonally into water conveyance channels (Kernodle et al. 1995: 19).

Today (1995) the width of the Middle Rio Grande is generally 200 to 300 feet. The river "flows on a shifting sand and gravel substratum and has low, poorly defined banks" (Bullard and Wells 1992: 10–11). Floodway widths in the Basin vary from about 165 to 1,475 feet in the Cochiti reach, from 360 to 1,475 feet in the Albuquerque reach, and from 295 to 2,360 feet in the reaches below Albuquerque. The floodways are generally confined between earthen levees. The river channel is a primarily shifting, alluvial channel, characterized by bedload transport of medium-grained sand. In the narrow canyons the channels are bedrock (Bullard and Wells 1992: 11).

Channel pattern dynamics have been modified by the construction of these flood and sediment control structures on the Rio Grande and tributaries. These structures have eliminated some problems caused by discharge of flood-transported sediments into the river. At the same time, flood control structures have contributed to channel migration in some reaches downstream from dams (Bullard and Wells 1992: 11).

Typical river channel patterns have been described as "low sinuosity meandering, straight, and braided meandering." These configurations are determined within the levees by sediment bar formation in the channel during low-flow periods, especially during the recession of flood flows, combined with rapid growth of vegetation. Below the mouths of high-sediment-discharge tributaries, such as the Rio Puerco and Rio Salado, braided meandering patterns are common (Bullard and Wells 1992: 11).

Vegetation Changes

The first detailed botanical description of the Middle Valley and flanking uplands was published by Watson (1912). For the Rio Grande floodplain he described two major floristic associations: (1) nearly pure stands of valley cottonwood with a scattering of willows, *Baccharis*, *Senna*, and sedge, and (2) a wet, meadowlike community of sedge, yerba del mansa, *Baccharis*, common sunflower, and canaigre (*Rumex* spp.). Watson did not mention salt cedar or Russian olive as components of the bosque but did state that salt cedar was being planted in Albuquerque as an ornamental (Watson 1912: 199–200; Hink and Ohmart 1984: 33–34). On the bajadas and mesas flanking

Figure 67a—San Acacia narrows north of Socorro, 1905, and site of irrigation dam constructed in 1936. Note carrizo (cane) grass (*Phragmites australis*) (front) and valley cottonwoods (leafless) along both banks of the Rio Grande (center). Photo by R. H. Chapman, courtesy U.S. Geological Survey Photo Archives, Denver.

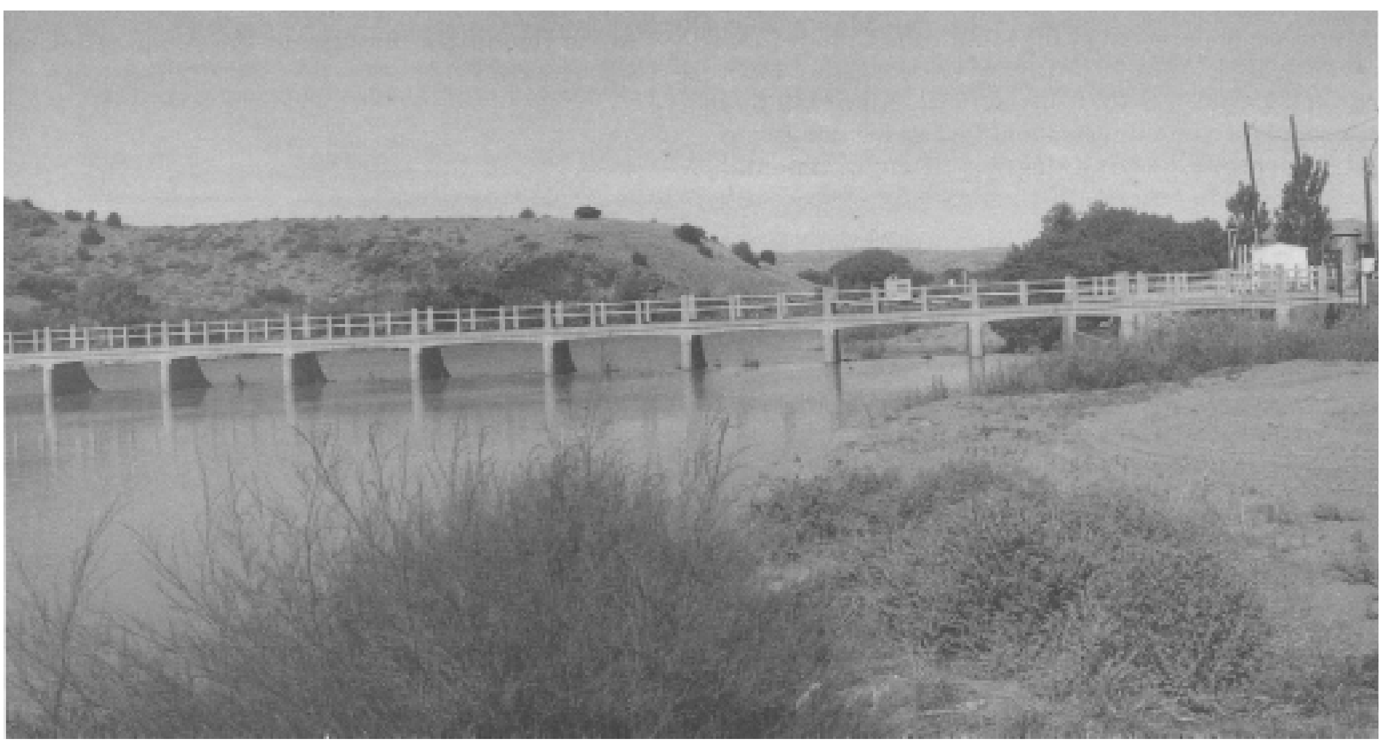

Figure 67b—Repeat photograph of Figure 67a, but from opposite bank, 1995. Note absence of carrizo grass, replaced by Russian thistle. San Acacia irrigation dam (center), scattered valley cottonwoods (behind). Photo by author.

the valley he described grass-shrub associations similar to those of today, commenting "This was undoubtedly originally a grassland, and is so yet where it has not been too seriously over-grazed . . . it has been so invaded by the composite *Gutierrezia* (snakeweed)." Another invader species, *Juniperus monosperma*, was also recorded on these uplands above 5,000 feet (Watson 1912: 200–206).

Near some communities, such as Socorro, long-time residents, miners, and others had cleared the cottonwood-willow bosque in the late 1800s-early 1900s (Fig. 69a). Livestock grazing around these settlements and mines resulted in decimation of the native grass cover. Four-wing saltbush, broomweed, creosotebush, mesquite, prickly pear, and other aggressive native shrubs and forbs subsequently invaded these disturbed areas (Fig. 69b).

A 1917 map of the valley between Cochiti and San Acacia indicates that there were 18,294 acres of "timber and brush" and 3,585 acres of "marsh." The timber stands were dominated by cottonwood (Hink and Ohmart 1984: 59–60; U.S. Reclamation Service 1922; Fig.70). Apparently neither salt cedar nor another species introduced later, Russian olive, was present. However, these two species were recorded in the area by the early 1930s by Van Cleave (1935: 7), who studied vegetative changes due to lowering of the high water table and other changes in the hydrology of the Rio Grande Valley. This change in the water table was due to drainage projects undertaken by the Middle Rio Grande Conservancy District in 1925 (Berry 1995; Salazar 1995; Scurlock 1988a: 136–137; Torres 1995). All of the five types of plant communities identified on the floodplain had undergone varying degrees of environmental changes between 1925 and 1935. Three of these communities—lakes, swamps, and marshes—virtually disappeared, but remnant vegetation survived along ditches and drainage canals. Another association, wet meadows, was drying up; cottonwood and willow in the bosque and "fringing woodlands" (along the edge of the river) were decreasing, while salt cedar (*Tamarix ramosissima*) and Russian olive (*Elaeagnus angustifolia*) were increasing, especially in the southern portion of the district (Table 56). The latter two species, exotic phreatophytes, have deeper root systems and can tolerate higher soil alkalinity than cottonwoods or willows. Increased alkalinity resulted from the lowering of the water table, which increased evaporation and accelerated accumulation of alkali in valley soils. Cessation of periodic flooding (the result of dams and channelization), which flushed out the alkali from these soils, compounded the problem (Van Cleave 1935: 4–31, 42–44).

In recent years tamarisk and Russian olive have become the dominant species on portions of the Rio Grande floodplain, especially in the southern one-third of the Middle Valley (Campbell and Dick-Peddie 1964: 492, 499). Russian olive has become a major understory component of the valley woodlands from above Albuquerque to Belen (Freehling 1982: 8). Shade-intolerant salt cedar does not appear to be increasing in the northern half of the study area except where cottonwoods are cleared or die out due to flooding. On the other hand, Russian olive continues to increase on the Rio Grande floodplain throughout the Abajo (Hink and Ohmart 1984: 71).

Figure 68—Sandbar in the Rio Grande near Corrales, 1995. Photo by author.

Table 56—Historical change in areal extent of floodplain vegetation communities from Cochiti Dam to San Marcial, 1918–1989.

Year	Category	Hectares	Acres
1918	Cottonwood forest	14,760	36,459
	Brush marsh	2,540	6,274
1926	Bosque	15,312	37,821
	Salt grass meadow	19,677	48,603
	Swamp and lake (marsh and open water)	1,346	3,324
	Alkali	111	275
1936	Bosque	15,540	38,384
1966	Phreatophytes	14,939	36,900
1982	Forest, shrub (including salt cedar)	18,462	45,601
1989	Marsh and open water	1,486	3,671

Source: Crawford et al. 1993: 33

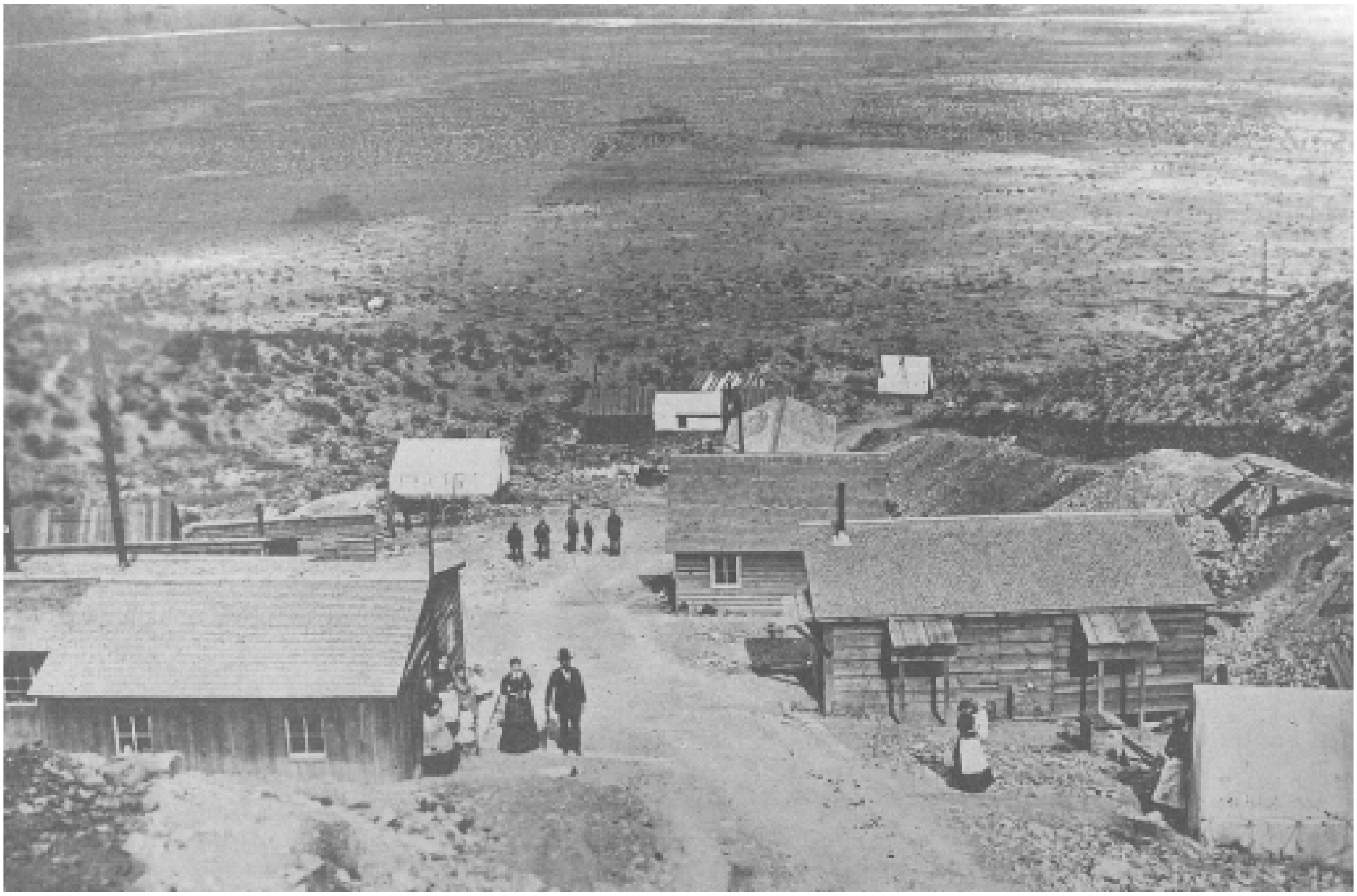

Figure 69a—Merritt Mine Camp, ca. 1890. Note slopes dotted with one-seed juniper and mesquite. Virtually treeless banks of Rio Grande (back). Photo by J.E. Smith, courtesty New Mexico Bureau of Mines and MR photo collection, no. 48, Socorro.

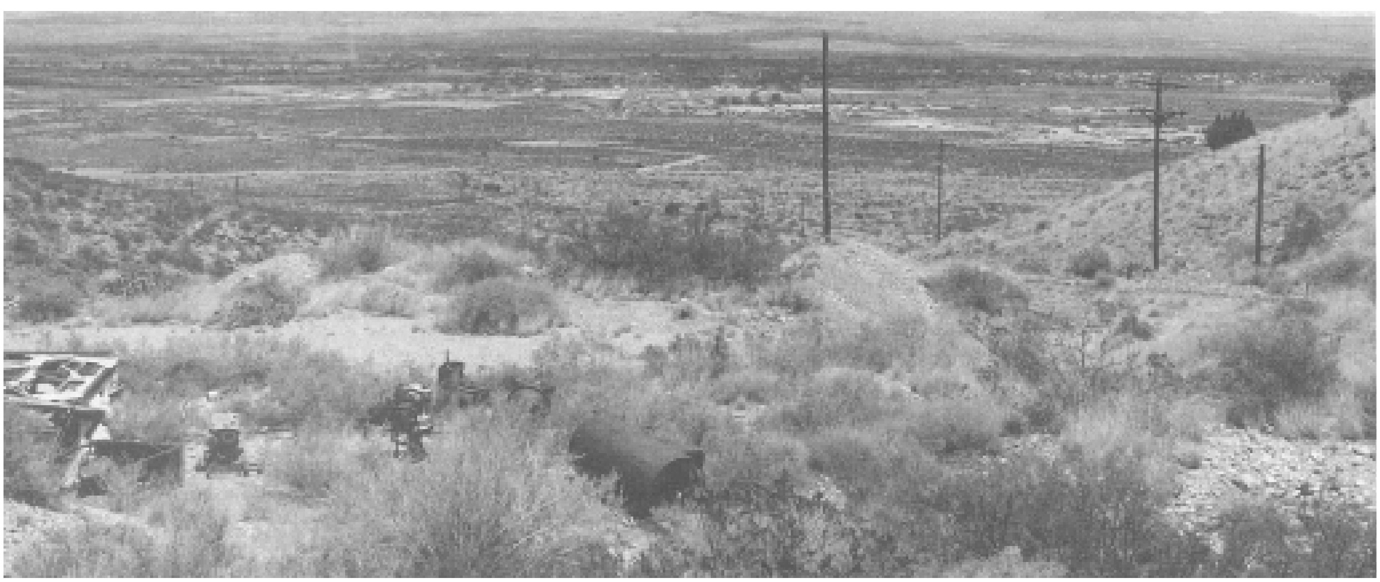

Figure 69b—Repeat photograph, 1995. Note four-wing salt brush, creosotebush, and mesquite on slope (front), cottonwood and salt cedar bosque along Rio Grande (back). Photo by author.

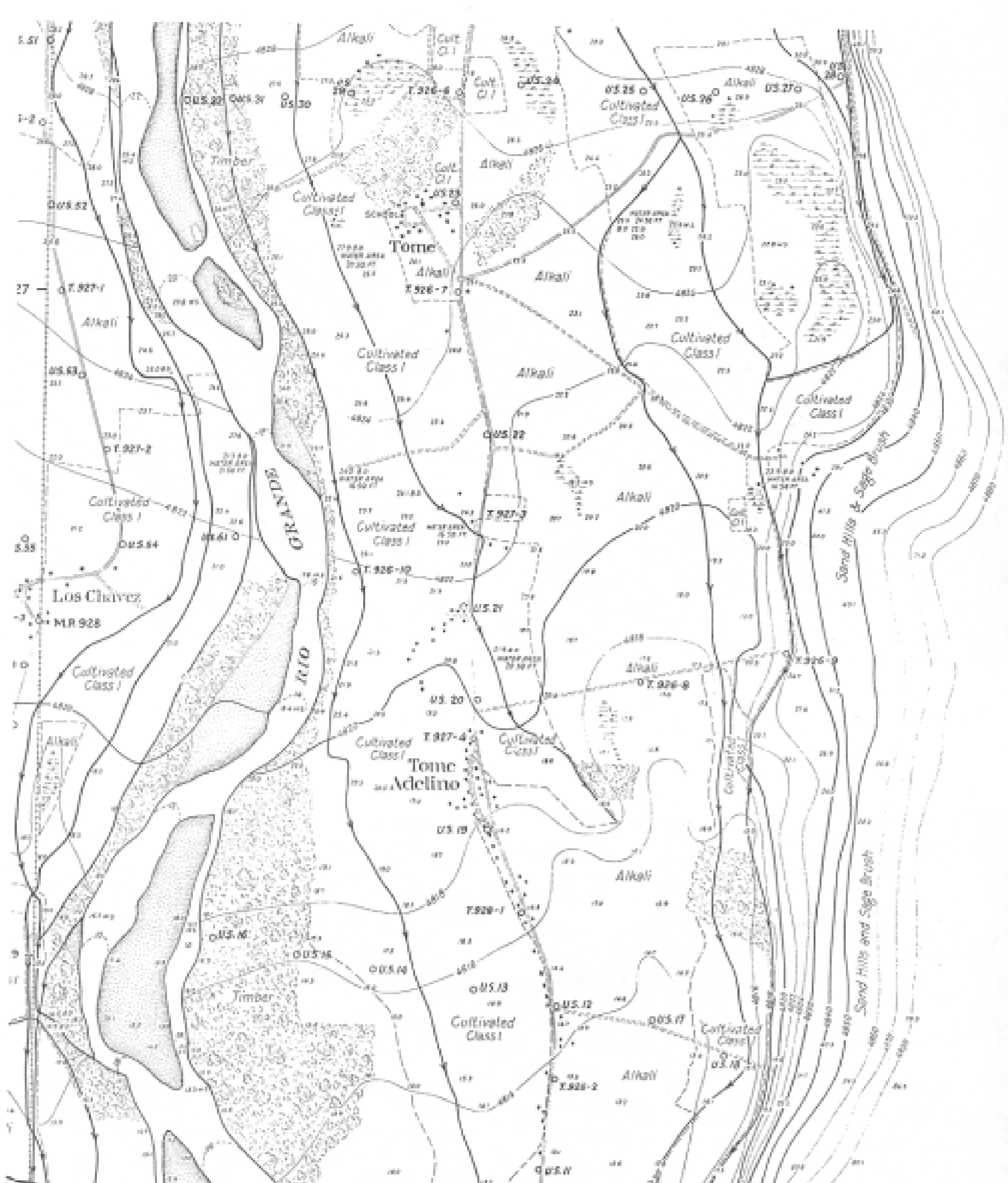

Figure 70—Bureau of Reclamation vegetation map, Rio Grande Valley, Tome area, 1917.

Figure 71—Middle Rio Grande Conservancy District drainage canal near Los Lunas. Note Siberian elm along left side of canal. Photo by author, 1995.

Russian thistle (*Salsola kali*) was introduced to the grasslands of the Rio Grande Basin in the late 19th century. Since that time it has increased and is generally regarded as a serious range pest (Harris 1966: 422).

Another introduced species that has spread and invaded portions of the floodplain and uplands from plantings in towns and cities is the Siberian elm (*Ulmus pumila*) (Lamb 1975: 51; Fig. 71). In Albuquerque, the Chamber of Commerce, the U.S. Forest Service, and the city purchased several hundred exotic trees—Lombardy popular, salt cedar, green ash, honey locust, and American elms—for planting in residential areas and public parks in 1919. The introduction of the first Siberian elms soon followed, championed by Mayor Clyde Tingley in the late 1920s, and quickly became a prominent part of Albuquerque's treescape (Simmons 1982: 346; Walton 1984: 6–8).

The economic costs and environmental impacts of introduced plants in the Middle Rio Grande Valley and the Southwest have been extensive. Additional information on these aspects of exotic plants may be found in Hay (1972) and Robinson (1958, 1965).

Water and Air Pollution

To some degree, the Middle Rio Grande has long carried wastes from human activities and livestock. Ranching, farming, logging, mining, and other historical land uses have introduced toxins into the river, but impacts were relatively minor compared with recent conditions. Since the end of World War II wastewater effluent, pesticide-herbicide runoff, heavy metals such as lead and mercury leached from abandoned mines, and other pollutants have lowered water quality, adversely impacting potability, aquatic fauna (especially fish), and associated flora (Bullard and Wells 1992: 32; Crawford et al. 1993: 71).

The earliest sources of air pollution in the Middle Basin were the railroad, mine smelters, and large sawmills (Fig. 72). These sources were not regulated for air quality until the 1960s. By this time automobiles and trucks were a major source of pollution, and the "brown cloud" was first seen over Albuquerque. Coal processing facilities north of the Basin, along with ever-increasing numbers of vehicles in the greater Albuquerque

Figure 72—Air pollution from the New Mexico Timber Company sawmill in Bernalillo, 1925. Photo by W.T. Lee, courtesy US Geological Survey Photo Archives, Denver.

area, have produced serious air quality conditions during temperature inversions in the winter.

IMPACTS AND CHANGES IN THE RIO PUERCO, 1846–1980: A CASE STUDY

The best documented environmental impacts and changes of a Middle Basin tributary from the mid 1800s to present are for the Rio Puerco. A history of intensive grazing and erodible soils, combined with periodic droughts and intensive rains, has led to the use of the term "abused basin" to describe the Puerco. In the recent past (1920s to 1960s), a number of environmental studies have been conducted. Today several federal agencies, including the U.S. Forest Service and Bureau of Land Management, are continuing to study runoff, erosion, vegetation change, and other aspects. Because of the these factors, the Puerco has been selected as a case study in this report.

In the mid 1800s the upper Rio Puerco valley, from Guadalupe to its headwaters above Cuba, was a "grassy wilderness" with "swampy vegas," "clear water," and "willow-lined banks" (Maes and Fisher 1937: 10). The river channel at this time was discontinuous. During the dry seasons (late September to early December), the river was dry at its mouth, as it is now. The entire channel was dry during extended droughts. In mid October 1846, west of Atrisco, Lt. Abert (1962: 74–78) described the valley as "wide, flat, overgrown with varieties of artemisias and coarse grass" and the river banks as "10 or 12 feet high" and "a few cottonwood trees" in the river bed, which was dry. To the north, near the abandoned town of Poblazon, the banks were 30 feet high (Table 57).

In 1849, Lt. J.H. Simpson (McNitt 1964: 29) estimated the river bank to be 20 to 30 feet high and the width of the river at about 100 feet. Four years later, the Puerco near present Interstate 40 was described as 100 feet wide and its streambed 18 feet deep with scattered pools of water (Foreman 1941: 119). The channel was about 18 feet deep (Rittenhouse 1965: 27–28). About this time, the channel was about 8 feet deep at La Ventana (Dortignac 1962: 588).

By 1862, with cessation of Navajo raids in the area, Hispanics and Anglos began to intensively graze the upper Puerco (Maes and Fisher 1937: 10–15). In the 1870s the Rio Puerco channel in the Cabezon area was still relatively shallow, with a wagon road crossing marked by large logs laid in the streambed. There were "large groves of cottonwood trees, high grass, and weeds." The channel at La Ventana was about 8 feet deep (Dortignac 1963: 507). By 1877 there were "high banks marked by recent cave-ins and falling trees" (Bryan 1928a: 268, 273). Native grasses were being cut and sold as hay (deBuys 1985: 217; Rittenhouse 1965: 64). A major flood, which undoubtedly eroded banks and downcut the river channel more, occurred in the area in 1880 (USGS 1994).

During the 1880s the number of sheep in the area increased to over 100,000, and there were about 9,000 cattle (Scurlock 1990a: 18). By the turn of the century sheep numbers had increased to several hundred thousand. Harvests of corn and other irrigated crops were good during this period, probably due to better, moister conditions from above-normal precipitation (Maes and Fisher 1937: 11–12, 14). About 10,000 acres were under irrigation in the upper Rio Puerco valley at this time (deBuys 1985: 217).

Intensive grazing continued into the early decades of the next century; in 1937 there were relatively large numbers of livestock on 75,284 acres of public lands in the Upper Basin. Droughts and intensive floods, probably caused in part by exposed rangeland soils, contributed to severe erosion during this period (Calkins 1937b: 6; Maes and Fisher 1937: 15–19, 34). Continued entrenchment of the Puerco became a problem for irrigation farmers in the Cabezon area (Bryan 1928a: 274). Irrigated lands in the same area dropped to 3,000 acres, a decrease of 70 percent in less than 3 decades (Harper et al. 1943: 52). Some farmers may have shifted their operations to the Puerco valley above Cuba, where there were 5,500 acres under irrigation in 1939 (Dortignac 1960: 48).

A surveyor referred to a "new channel" for the river at Cabezon in 1899; it was 198 feet wide. Seven years later the channel at the same location had widened to 244 feet, with a depth of 20 feet. At nearby San Luis the depth of the Puerco channel was the same (Bryan 1928a: 271–273; Tuan 1966: 589). To the north, at La Ventana, the river channel was 15 feet deep in 1913 (Dortignac 1962: 58; Fig. 73a and b).

By 1925 environmental problems in the Rio Puerco basin were becoming increasingly serious. Continued excessive grazing, coupled with periods of drought followed by intensive rains, was causing severe erosion, including rapid downcutting of the river channel. Channel depth at La Ventana was about 40 feet, at San Luis about 22 feet, and south of the Santa Fe rail line about 40 feet (Bryan 1928a: 275, 277; Tuan 1966: 589). Diversion dams were destroyed, and the water table generally lowered. Irrigated land in the basin declined to 3,000 acres.

The high sediment load of the river continued to increase (Harper et al. 1943: 52). As a result, the Rio Grande

Table 57—Rio Puerco-of-the-East: historical conditions and channel changes, 1846–1964.

Date	Channel depth	Channel width	Date	Channel depth	Channel width
1846	10–12 feet (lower reach)		1906	20 feet (near San Luis-Cabezon)	244.4 feet (Cabezon)
1846	30 feet (at Poblazon)				
1849	20–30 feet (near San Luis)	100 feet			405.9 feet (near Guadalupe)
1850s (early)	8 feet (at La Ventana)				
1853	18 feet (at Interstate 40 W)				
1855	20 feet (lower reach)		1913	15 feet (at La Ventana)	
1860s	"Shallow" (at Cabezon)		1927	40–41 feet (at La Ventana)	
1874	8 feet (at La Ventana)		1927	22 feet (at San Luis)	
1875	"Shallow" (at San Luis)		1927	40 feet (lower reach)	
1876–1880	"Shallow" (at Cabezon)		1928	40–41 feet (at Cabezon)	
1877		26.4–29.2 feet	1940	26 feet (lower reach)	
1870s	"Shallow" (at Cabezon)		1959	50 feet (at La Ventana)	
1881	"Deepening" (lower reach)		1964	55 feet (at La Ventana)	
1887	3 feet (at Guadalupe)	30 feet	1964	36 feet at (San Luis)	
1890	"Deepening" (at Cabezon)		1964	30 feet (at Poblazon)	
1899	198 feet (at Cabezon)		1964	36 feet (at San Ignacio, lower)	

Sources: Abert 1962; Bryan 1928; Dortignac 1962; Lopez 1980; Love and Young 1983; Maes and Fisher 1937; McNitt 1964; Rittenhouse 1965; Tuan 1966.

Figure 73a—View north of the town of Cabezon (center) and entrenched Rio Puerco (lower center,) 1917. Note four cottonwoods. Photo by W.T. Lee, courtesty US Geological Survey Photo Archives, Denver.

floodway, just below the mouth of the Puerco, aggraded 4 to 5 feet from 1927 to 1936 (Happ 1937: i, 3). Alluviation on the lower reach of the river, below the Santa Fe rail line, raised the channel 14 feet (Tuan 1966: 593).

The ongoing erosion in the Rio Puerco valley between La Ventana and Cuba was so severe that the railroad had to be abandoned (Cooperrider and Hendricks 1937: 11–12). The eroding, downcutting action of the stream caused most of the residents from the Middle Valley to move upstream, where irrigation agriculture was still relatively reliable in the mid 1930s. A few years later there were more than 5,500 acres of irrigated farmland with 17 ditch systems in the drainage above Cuba (Calkins 1937b: 18–19; Dortignac 1960: 48). By the 1940s virtually all of the irrigated lands below Cuba were abandoned due to the flood damage of water control structures and the downcutting of the river (deBuys 1985: 217–218). Populations of towns such as Cabezon, Guadalupe, and Casa Salazar declined rapidly.

The San Luis Dam was destroyed by a flood in 1926 or 1927 (Widdison 1959: 276–277), and area roads and bridges were frequently washed out in the late 1920s and 1930s (Cooperrider and Hendricks 1937: 20). A new San Luis irrigation dam was constructed a mile above the old site by the Soil Conservation Service in 1936 (Widdison 1959: 277). Unlike that of Cabezon, San Luis' population did not decrease dramatically during this period. There were 44 families living in the town in 1939, but all but two were government employed or aided by government welfare programs (Widdison 1959: 281).

During the drought year of 1934 the U.S. Government purchased the "badly overgrazed and eroded" Ojo del Espiritu Santo land grant and initiated a resource management program (Varney 1987: 35). There were some 14,500 cattle-units in the upper Puerco Basin in 1936, almost four times the estimated grazing capacity (Maes and Fisher 1937: 34). In 1937 there were 56,240 acres of public domain, 19,044 acres of national forest land, and 75,431 acres of private land being grazed in the valley from Regina-Cuba to Casa Salazar (Calkins 1937b: 6). By 1940 the U.S. Forest Service and Bureau of Land Management began to fence federal land in the valley and on Mesa Prieta (Garcia 1992: 23).

A resurvey of the Puerco channel in 1939 determined that the sediment volume between Cuba and the mouth of the river was 267,000 acre-feet, an increase of 250,000

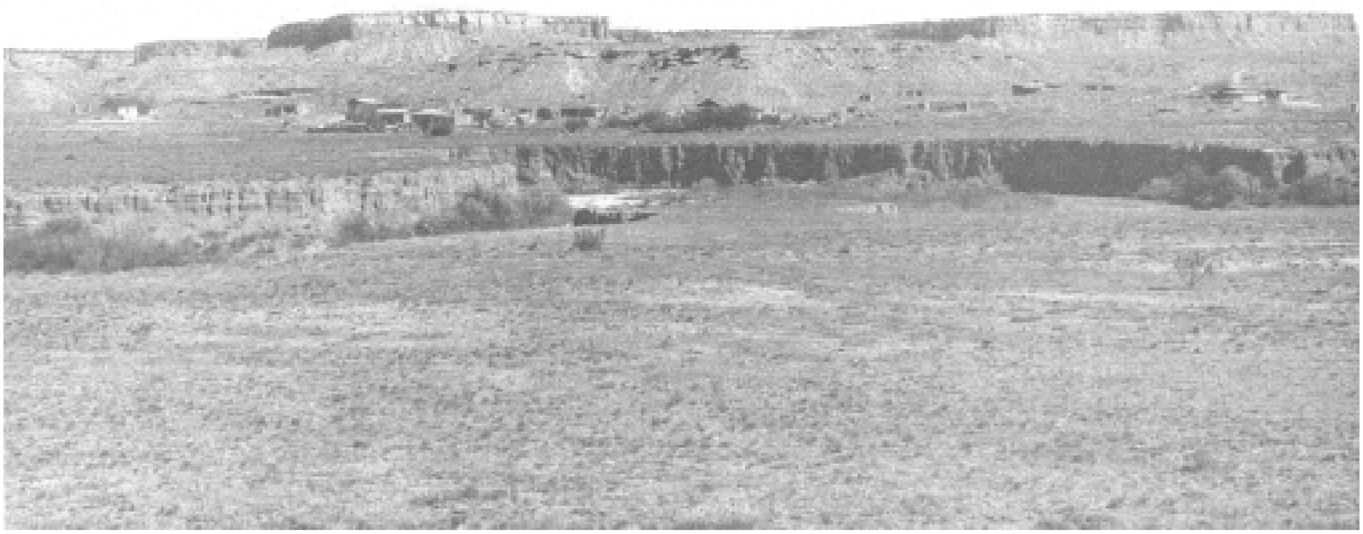

Figure 73b—Repeat photograph of Figure 73a, 1995. Note deeper and wider river channel and salt cedar. Photo by author.

acre-feet since 1884. The mean annual suspended sediment load in the Puerco basin was 41 percent (Dortignac 1956: 49). In an attempt to arrest erosion in the watershed, the Grazing Service began reducing the number of livestock in the Puerco valley between 1941 and 1943. Each family in the area could have no more than 15 head. This number, however, was below the minimum needed for subsistence (Forrest 1989: 157–159), resulting in the abandonment of more ranches and farms. Most of Cabezon's population had moved away from the village by 1941. A few stayed on, raising livestock and operating a trading post, but they were all gone by 1950 (Varney 1987: 35).

By the mid 1950s the sediment load of the Rio Puerco began to decrease, primarily due to improved land management and climatic patterns (Crawford et al. 1993: 54). The river continued to downcut. Its channel at La Ventana was about 50 feet deep in 1956 (Dortignac 1960: 47), and 3 years later it was about 55 feet (Dortignac 1962: 588). Downstream, channel depths were 36 feet at San Luis, 43 feet at Poblazon, and 36 feet at San Ignacio (Tuan 1966: 589).

Although sediment concentrations have decreased steadily since the mid 1950s, in recent years the Rio Puerco has contributed about one-half the sediment load (2.6 million tons per year) carried from its mouth to Elephant Butte Reservoir by the Rio Grande (Crawford et al. 1993: 54).

IMPACTS AND CHANGES IN UPLAND GRASSLANDS, WOODLANDS, AND FORESTS

Prior to the arrival of Europeans in the Southwest, grasslands supported few woody shrubs or forbs, and woodlands and forests were probably less dense (more open or savannalike) than stands of recent times. Also, grasslands, pinyon-juniper and ponderosa woodlands, and montane meadows in New Mexico probably had a higher carrying capacity for livestock grazing in the mid 1820s and 1830s than in this century. The main concentration of sheep was along the Rio Puerco-of-the-East and in the valleys and uplands along both sides west of the Middle Rio Grande Valley from the Santa Fe-Galisteo area to the Belen area. The sheep numbers in these areas, as well as in the Jemez Mountains-Pajarito Plateau and Sangre de Cristo Mountains, were high until the early 1900s. This intensive grazing, reoccurring droughts, and periodic, high-intensity rainfall appear to have been significant interrelated ecological factors in triggering the beginning of a severe erosional period beginning in the late 1870s-early 1880s (Denevan 1967: 699–702). Changes in composition of species and density have resulted from the previously discussed human uses (burning, grazing, cutting, etc.), wild fires, and fire suppression, as well as climate. Each of these phenomena obviously brought changes to the area over the short term, but these factors have interacted over a longer period to cause changes observed in recent decades (West 1984: 1301, 1311–1313).

A recent study of vegetative change (Bahre 1991: 180–187) in southeastern Arizona demonstrated that historical alteration has resulted from removal of native plant cover by various Euro-American settlement activities, introduction of exotic plants, and suppression of fires. These factors have resulted in five directional changes: (1) an overall decline in native grasses, (2) an expansion of exotic grasses and other plants, (3) an increase in woody plants, notably in the grasslands and lower elevations of the woodlands, (4) an increase in protected stands of oak, juniper, and ponderosa pine, and (5) a general degradation of vegetative cover. The spread of various *Juniperus* species into grasslands in northern Arizona has also been well documented (Johnsen 1962; Lowe 1964: 58).

Gross and Dick-Peddie (1979) reconstructed the “primeval” vegetation in New Mexico below the ponderosa pine zone using territorial survey records (see Fig. 52). The most significant historic changes in vegetation have occurred in the grassland-woodland and savanna-desert shrubland types. In many areas, woodland savannah has apparently replaced the upper elevation grasslands.

Grover and Musich (n.d.: 10) presented evidence of shrubland encroachment in desert grasslands in the southern part of the region, leading to local and regional climatic changes due to increased surface temperatures. These plant community changes might have significant impacts on albedo and sensible heat flux. Additionally, physiological and phenological differences between grasses and shrubs can influence rates of evapotranspiration. Grass growth and decomposition and mineralization processes needed for nutrient cycling are inhibited by chemical compounds in the needle litter of pinyon and juniper. This has led to an increase in density of these two species (Grover and Musick n.d.: 10).

One investigator (Dittmer 1951: 351) concluded that pinyon-juniper woodlands in the Southwest, with their understory of *grama* species and other nutritious bunch grasses, were overgrazed in the late 19th and early 20th centuries, decimating these grasses. Another valuable understory plant, *Krascheninnikovia lanata* (Soil Conservation Service 1994), which also occurs in the upper grassland elevations, has been severely depleted over the last 150 years.

Gross (1973) found that large portions of northwestern and north-central New Mexico experienced near complete replacement of the late 19th century vegetation communities. The historic pinyon-juniper-sagebrush (*Artemisia tridentata*) association has been replaced by sagebrush-grassland. The lower grassland community has also become a secondary successional stage of sagebrush-grassland association. The replacement of the pinyon-juniper communities by sagebrush was probably due to fire, as pinyon-juniper does not survive conflagration well. Other large stands of pinyon-juniper were cleared by homesteaders for use in dryland farming, grazing, fence posts, and fuelwood (Gross 1973: 10, 43–44).

Southwest of Cuba most of the historic pinyon-juniper communities have disappeared; only a few isolated, relict stands have survived. These, too, have changed to sagebrush-grassland. On the 9,389-acre Chijuilla community grazing allotment located in T21N, R23, early sheep grazing and later homesteaders impacted the pinyon-juniper community as indicated above. In 1963, 321 acres of pinyon-juniper were chained, and 673 acres of “brush” were cut in sections 19, 20, and 30 in an effort to increase the production of grazing forbs and grasses. About a quarter of a century later, 20 study plots of pinyon-juniper were identified by the Bureau of Land Management. Ten plots were thinned on the allotment, while the other ten were not thinned. Grasses and forbs on the plots were clipped and weighed in September 1990 to determine production. The thinned plots produced 2,174 pounds green weight per acre, but the untreated plots yielded only 520 pounds per acre (Bodine 1990; Gross 1973: 16; Levine et al. 1980: 4, 44–47, 50, 131, 136).

Watson (1912: 205–207) noted that *Juniperus monosperma* in the Estancia Valley of central New Mexico was invading into the lower grassland from the “Cedar Formation.” *Gutierrezia sarothrae*, *Yucca glauca*, and *Opuntia imbricata* were “abundant.” In the pinyon-juniper zone, common plant associates in the area included *Yucca baccata*, *Cercocarpus montanus*, *Philadelphus microphyllus*, *Tragia nepetifolia*, and *Lesquerella* spp.

Covington and Moore (1994: 39) wrote about impacts and change in ponderosa pine forests:

> Heavy grazing, logging, and fire exclusion, in conjunction with climatic oscillations and elevated atmospheric CO_2, have led to many more younger and smaller trees; fewer older and larger trees; accumulation of heavy forest floor fuel loads; reduced herbaceous production; and associated shifts in ecosystem structure, fire hazard, and wildlife habitat.

Prior to Euro American settlement these forests were much more open and parklike, with scattered stands varying in age, and crown cover usually not exceeding 25 percent. Crown fires were rare (Covington and Moore 1994: 39–41).

In the upper Pecos River drainage *Pinus ponderosa*, *P. edulis*, and *Juniperus monosperma* were harvested intensively for use as lumber, posts, and fuelwood in the 19th century. There were 500 sheep grazing in the area of Rowe at this time. In the early 1900s all of the trees north and east of Rowe were clear-cut to create pasture for cattle. Some relatively recent chaining of pinyon-juniper was carried out between the present Interstate 25 and the town (Meszaros 1989: 13–14, 52–55).

CHANGES IN PLANT SPECIES

Extirpated Plants

Several plant species identified from archeological excavations or historical records appear to have been depleted or extirpated locally, primarily through abusive land use such as overgrazing in the late 19th and early 20th centuries (Bohrer 1978). All were prehistoric-historic food sources, which indicates they may have been relatively widespread and abundant prior to more recent impacts causing decimation or extermination. These species are listed below in Table 58, with known distribution within the study region.

Almost 400 species of grasses have been collected and identified in New Mexico. Several of these, listed in Table 59, have not been found since their collection date 50 or more years ago. Most, if not all, are probably extinct (Allred 1993).

Introduced and Naturalized Plants

Some 101 non-native plants have been introduced in the study region, primarily from Europe and Asia, during the historic period, 1598 to the present (Table 60). For the most part, these species have been considered ecological and economic pests. Some of these introductions were intentional, but others were accidental. The Spanish brought several plants to New Mexico early in the colonial period, for example, clovers (*Melilotus* and *Trifolium* spp.) for livestock feed and alferillo (*Erodium cicutarium*) and hoarhound (*Marrubium vulgare*) as medicinals (Table 60). Others, such as goathead (*Tribulus terrestris*), were unknowingly carried by livestock, in agricultural seed bags, or in clothing. Mullein (*Verbascum thapsus*), an important medicinal plant to the Spanish, has thrived in disturbed areas, especially in new burn sites. Less aggressive is shepherd purse (*Capsella bursa-pastoris*), which is found in meadows (Gay and Dwyer 1970: 62; Wooton 1915: 556).

Table 58—Plant species extensively decimated or extirpated.

Common name	Scientific name	Range
Stickleaf	*Mentzelia albicaulis*	NW and W New Mexico
Purslane	*Portulaca* spp.	NW and NC New Mexico
Winged pigweed	*Cycloloma atriplicifolium*	NW and NC New Mexico
Contrayerba	*Kallstroemia* sp.	NW New Mexico
Wild onion	*Allium macropetalum*	NW New Mexico
Nodding onion	*A. cernuum var. obtusam*	C and W New Mexico
Spiderwort	*Tradescantia occidentalis*	NW and C New Mexico

Source: Bohrer 1978 and Soil Conservation Service 1994

Table 59—Extirpated grass species.

Common name	Scientific name	Location	Year last collected
Bristlegrass	*Setaria verticillata*	Mesilla Valley	1907
Sacaton or dropseed	*Sporobolus vaginiflorus*	Las Cruces and Bernalillo Co.	1895
Wright's Bluestem	*Bothriochloa wrightii*	Grant Co. (two locations)	1885, 1904
Cordgrass	*Spartina gracilis*	Santa Rosa	1945
Gamagrass	*Tripsacum lanceolatum*	Guadalupe Canyon	1915 pre
Muhly	*Muhlenbergia arsenei*	Soda Dam, Sandoval Co.	1938
Muhly	*Muhlenbergia andina*	Upper Pecos River	1908
Rattlesnake Chess	*Bromus brizaeformis*	Pecos National Forest	1913 pre
Lovegrass	*Eragrostis hypnoides*	Elephant Butte Dam	1941

Source: Allred 1993 and Soil Conservation Service 1994

Anglos brought even more exotic species than the Spanish to the study region (Table 60), some of which have become serious problems due to their aggressive invasion of native plant communities, use of substantial water, and successful competition with the native flora (deBuys 1985: 224–226; Hitchcock 1935: 49, 76, 112–114, 230–231). The two most costly flora introductions, ecologically and economically, have been Russian olive (*Elaeagnus angustifolia*) and salt cedar or tamarisk (*Tamarix ramosissima*). Both are native to regions of Euro Asia, with climates and soils similar to those of central New Mexico, so these two species have spread rapidly. Salt cedar was introduced as an ornamental in Albuquerque as early as 1908, and by 1926–27 had been used widely to control erosion and silt on tributary streams. By 1936 it had invaded the valley extensively, helped by the flood of 1929 (Crawford et al. 1993: 30; Robinson 1965: 147; Scurlock 1988a: 138). Between 1935 and 1947 salt cedar had spread over an estimated 24,500 to 51,120 acres of irrigable farmland in the Upper and Middle valleys (Hay 1972: 288; Lowry 1957: 4).

Similarly, the Russian olive was planted for bank stabilization and ornamental purposes in the early part of this century. By 1934 it had spread into the Rio Grande bosque, and 26 years later was a dominant component of the ecosystem (Crawford et al. 1993: 30; Freehling 1982: 10).

Between 1946 and 1956 the Bureau of Reclamation sprayed the herbicides 2,4-D and 2,4,5-T on stands of tamarisks in the main valley and tributaries in an attempt to control its spread, which was largely ineffective, The tree expanded its range over about 60,000 acres. Annual water use by the tamarisk stands was estimated to be 240,000 acre-feet, or about twice the amount used by cultivated crops (Dortignac 1956: 47). About 20,000 acres along the main stem of the river are now dominated by salt cedar and Russian olive (Crawford et al. 1993: 35).

Other exotic tree species that are becoming major components of riparian ecosystems are Siberian elm (*Ulmus pumila*), tree of heaven (*Ailanthus altissima*), and white mulberry (*Morus alba*) (Crawford et al. 1993: 30; Scurlock 1988a: 139). Russian thistle (*Salsola kali*) was introduced accidentally, via the cow-catchers of the Santa Fe trains, into the Galisteo basin pre 1890. This species has now spread to the upland grasslands flanking the valley and onto the floodplain (Wooton 1895).

During the 1930s, crested wheat grass (*Agropyron cristatum*) was introduced into New Mexico by the U.S. Department of Agriculture for its forage value and is now established across the region (Hitchcock 1935: 231). Kentucky bluegrass (*Poa pratensis*) was introduced to regional mountain ranges in this century as well (deBuys 1985: 289).

CHANGES IN ANIMAL SPECIES

By the end of World War I, intensive hunting and trapping, grazing, and habitat modification had severely reduced populations of predatory mammals, as well as game species. As natural prey species of the wolf, coyote, grizzly bear, bobcat, and mountain lion were reduced by various human activities, the predators began to take much more livestock. J. Stokely Ligon, head of the New Mexico Game and Fish Department at the time, considered wolves, coyotes, bobcats, and mountain lions "the most serious enemy of game conservation in New Mexico" (Ligon 1927: 49–50). He, along with Aldo Leopold of the Forest Service, led the government effort to eradicate these predators, especially the wolf and the grizzly bear.

By the early 1900s, bears, especially grizzlies, and wolves were restricted to the higher, more remote mountain ranges due to these hunting and trapping pressures. They were relatively common in the San Mateo range near Grants in 1905 (Bailey 1971: 365). An estimated 48 grizzly bears remained in the state in 1917, scattered from the Sangre de Cristo to the Black Range. By 1928 an estimated 16 grizzly bears remained in the state. Several grizzly bears were reported on the Jemez District of the Santa Fe National Forest in 1940, the last recording of this species in the state (Brown 1985: 133, 137, 140, 153, 160–161). Black bears, however, had received protection from the State Legislature in 1927, and populations remained relatively stable (Findley et al. 1975: 29).

Gray wolves were still found in the Manzano Mountains in 1903, preying on livestock, some were reported there in 1916. There were 19 wolves killed in the Santa Fe National Forest in 1915 and 37 in 1916 (Bailey 1971: 309–311). Some 34 wolves, gray and Mexican subspecies, were trapped, poisoned, or shot in the state in 1925 (Brown 1983: 150). Only a small number of gray wolves were extant in the Middle and Upper basins. In 1934 the last gray wolf in Colfax County was killed (Brown 1984: 85). The last gray wolf in the study region was killed in 1932 in the Valle Grande of the Jemez Mountains by a rancher (Scurlock 1981a: 148).

Among the larger game mammals with low numbers in this period were pronghorn, mule deer, elk, bighorn sheep, and black bears. Only remnant populations of pronghorn were scattered over the grasslands, and mule deer were rare to extinct anywhere near settlements (Ligon 1927: 29). State and federal laws were passed in the 1920s and 1930s to manage and protect various game species. Some species, such as the pronghorn and mule deer, increased in number in some locales under professional management. Near population centers and in competition with livestock, pronghorns did not do so well. A few pronghorn were observed grazing about 10 miles south of Santa Fe in 1942 (Hewett and Dutton 1945: 108). Small numbers of this species were observed east and west of Albuquerque until the late 1940s or early 1950s. This was also a period of reintroduction of species such as bighorn sheep and elk to mountain ranges in the study region (Barker 1976: 100–101, 188; Clark 1987: 267; Flader 1978: 105; Pickens 1980: 83).

Table 60—Introduced plants.

Common name	Scientific name	Date of introduction	Source
Alfalfa	*Medicago sativa*	pre–1866	Meline 1966: 152–153; Wooton 1915: 343
Alfalfa dodder	*Cuscuta approximata*	?	Reed 1970: 294–295
Alferillo	*Erodium cicutarium*	?	Curtin 1965: 27; Tierney 1983: 16
Amaranth	*Amaranthus retroflexus*	post–1598	Haughton 1978: 19
Asparagus	*Asparagus officinalis*	pre–1851	Bartlett 1965, I: 237
Barnyardgrass	*Echinochloa crus-galli*	?	Reed 1970: 60
Bedstraw	*Galium aparine*	?	Reed 1970: 352–353; Tierney 1983: 112
Beggartick	*Bidens frondosa*	?	Reed 1970: 378–379
Bermuda grass	*Cynodon dactylon*	post–1880s	Wooton 1915: 84; Hoover et al. 1948: 663
Bindweed	*Convolvulus arvensis*	?	Reed 1970: 290–291
Black medic	*Medicago lupulina*	?	Reed 1970: 230–231
Black mustard	*Brassica nigra*	?	Reed 1970: 194–195
Bull thistle	*Cirsium vulgare*	?	Reed 1970: 398–399
Burdock	*Arctium minus*	?	Reed 1970: 372–373
Butter and eggs	*Linaria vulgaris*	?	Reed 1970: 42–45
Carpetweed	*Mollugo verticillata*	?	Reed 1970: 150
Centipede grass	*Eremochloa ophiuroides*	post–1919	Hoover et al. 1948: 671
Chickweed	*Stellaria media*	?	Reed 1970: 168–169
Chicory	*Cichorium intybus*	?	Reed 1970: 396–397
Cocklebur	*Xanthium strumarium var. canadense*	?	Reed 1970: 444–445
Corncockle	*Agrostemma githago*	?	Reed 1970: 154–155
Corn gromwell	*Buglossoides arvensis*	?	Reed 1970: 304–305
Crested wheatgrass	*Agropyron cristatum*	post–1935	Hitchcock 1935: 231
Curly dock	*Rumex crispus*	?	Reed 1970: 130–131
Dallasgrass	*Paspalum dilatatum*	post–1875	Reed 1970: 74–75; Hoover et al. 1948: 680
Dandelion	*Taraxacum officinale*	pre–1600?	Reed 1970: 438–439; Tierney 1983: 16
Field pennycress	*Thiaspi arvense*	?	Reed 1970: 214–215
Field sandbur	*Cenchrus carolinianus*	pre–1846	Reed 1970: 50–51
Foxtail millet	*Setaria italica*	Post–1849	Hoover et al. 1948: 691
Goatgrass	*Aegilops cylindrica*	pre–1950	Hitchock 1935: 243–246
Goathead	*Tribulus terrestris*	?	Reed 1970: 242–243
Goosegrass	*Eleusine indica*	pre–1935	Reed 1970: 62–63
Green fox-tail	*Setaria viridis*	?	Reed 1970: 85–86
Hedge bindweed	*Convolvulus sepium*	?	Reed 1970: 293–294
Henbit	*Lamium amplexicaule*	?	Reed 1970: 314–315
Hoarhound	*Marrubium vulgare*	pre–1600?	Wooton 1915: 556; Tierney 1983: 16
Italian ryegrass	*Lolium perenne* ssp. *multiflorum*	post–1820	Hoover et al. 1948: 676
Ivy leaf	*Ipomoea hederacea*	?	Reed 1970: 300–301
Japanese brome	*Bromus japonicus*	?	Reed 1970: 42–43
Johnsongrass	*Sorghum halepense*	post–1880	Reed 1970: 86–87
Kentucky bluegrass	*Poa pratensis*	post–1579	Gay and Dwyer 1970: 44
Lambsquarter	*Chenopodium album*	19th century?	Reed 1970: 132–133
Large crabgrass	*Digitaria sanguinalis*	?	Reed 1970: 58–59
Mallow	*Malva neglecta*	pre–1600?	Ford 1987: 75; Tierney 1983b: 16
Marijuana	*Cannabis sativa*	pre–1894	Bourke 1894: 143
Marshpepper	*Polyganum hydropiper*	?	Reed 1970: 122–123
Mayweed	*Anthemis cotula*	?	Reed 1970: 370–371
Meadow fescue	*Festuca pratensis*	19th century	Hoover et al. 1948: 672
Meadow foxtail	*Alopecurus pratensis*	?	Hoover et al. 1948: 649
Moth mullein	*Verbascum blattaria*	?	Reed 1970: 332–333
Mousear chickweed	*Cerastium fontanum*	?	Reed 1970: 158–159
Mullein	*Verbascum thapsus*	post–1800?	Haughton 1978: 227–228
Multiflora rose	*Rosa multiflora*	?	Reed 1970: 222–223
Mustard	*Sinapis arvensis*	?	Reed 1970: 192–193

continued on next page

Table 60—Introduced plants (continued).

Common name	Scientific name	Date of introduction	Source
Narrowleaf vetch	*Vicia sativa* ssp. *nigra*	?	Reed 1970: 238–239
Orchard grass	*Dactylis glomerata*	post–1760	Hoover et al. 1948: 664
Oxeye daisy	*Leucanthemum vulgare*	?	Reed 1970: 388–389
Pigweed	*Amaranthus albus*	?	Reed 1970: 142–144
Plantain	*Plantago* spp.	?	Reed 1970: 346–347
Poison hemlock	*Conium maculatum*	?	Reed 1970: 280–281
Prickly lettuce	*Lactuca serriola*	?	Reed 1970: 426–427
Prostrate knotweed	*Polygonum aviculare*	?	Reed 1970: 116–117
Purslane	*Portulaca oleracea*	pre–1600?	Reed 1970: 152–153; Tierney 1983: 16
Ragweed	*Ambrosia artemisiifolia*	?	Reed 1970: 364–369
	A. psilostachya	?	
	A. trifida	?	
Redroot pigweed	*Amaranthus retroflexus*	?	Reed 1970: 146–147
Redtop	*Agrostis gigantea*	?	Gay and Dwyer 1970: 8
Red (sheep) sorrel	*Rumex acetosella*	pre–1600?	Reed 1970: 128–129; Tierney 1983: 16
Rough cinquefoil	*Potentilla norvegica*	?	Reed 1970: 218–219
Russian knapweed	*Acroptilan repens*	?	Reed 1970: 384–385
Russian olive	*Elaeagnus angustifolia*	pre–1935	Freehling 1982: 100
Russian thistle	*Salsola kali*	post–1890	Wooton 1895; Bradfield 1974: 8
Rye Brome	*Bromus secalinus*	pre–1915	Hitchcock 1935: 48
Salsify	*Tragapogon dubius*	pre–1800	Fernald 1970: 1549; Camp et al. 1957: 137
Selfheal	*Prunella vulgaris*	?	Reed 1970: 316–317
Sheep fescue	*Festuca ovina*	1598?	de Buys 1985:225
Shepherd purse	*Capsella bursa-pastoris*	?	Reed 1970: 198–199
Siberian elm	*Ulmus pumila*	post–1919	Scurlock 1988a: 139
Smallflower	*Galinsoga parviflora*	?	Reed 1970: 410–411
Smallseed falseflax	*Camelina microcarpa*	?	Reed 1970: 190–197
Smooth brome	*Bromus inermis*	post–1884	Hitchock 1935: 658–660
Smooth crabgrass	*Digitaria ischaemum*	?	Reed 1970: 56–57
Sowthistle	*Sonchus arvensis*		
	S. asper	?	Reed 1970: 434–437
Stinging nettle	*Urtica dioica*	?	Reed 1970: 110–111
Sudan grass	*Sorghum bicolor* ssp. *drummondii*	post–1909	Hoover et al. 1948: 693
Sweetclover	*Melilotus officinalis*	pre–1915	Wooton 1915: 344; McKee 1948: 718
Tall buttercup	*Ranunculus acris*	?	Reed 1970: 186–187
Tall larkspur	*Delphinium barbeyi*	?	Reed 1970: 178–179
Tamarisk, salt cedar	*Tamarix ramosissima*	early 1900s	Robinson 1965: A6
Timothy	*Phleum pratense*	ca. 1747	Hoover et al. 1948: 684
Tree of heaven	*Ailanthus altissima*	post–1850	Haughton 1978: 388–389; Scurlock 1988a: 139
Tumble mustard	*Sisymbrium altissimum*	?	Reed 1970: 212–213
Watercress	*Rorippa nasturtium-aquaticum*	?	Reed 1970: 210–211
Weeping lovegrass	*Eragrostis curvula*	post–1934	Hoover et al. 1948: 670
Wild buckwheat	*Polygonum convolvulus*	?	Reed 1970: 120–121
Wild carrot	*Daucus carota*	?	Reed 1970: 282–283
Wild oat	*Avena fatua*	?	Reed 1970: 38–39
Wintercress	*Barbarea verna*	?	Fernald 1970: 716–717
Yellow foxtail	*Setaria pumila*	?	Reed 1970: 84–85
Yerba buena	*Mentha spicata*	?	Haughton 1978: 227–228

Terminology conforms to Soil Conservation Service 1994

Predator and rodent control by federal and state agencies continued into the 1940s–60s. A rodenticide known as 1080 was commonly used to control these species, followed by the use of a "cyanide gun" for control of coyotes (Brown 1983: 103; McDonald 1985: 12; Moyer 1979: 71). This device apparently had little impact on the overall population. More than 6,300 coyotes were poisoned or trapped in 1963 (Findley et al. 1975: 281–282).

In the Middle Valley, wildlife was adversely impacted by work of the Middle Rio Grande Conservancy District in the early to mid 1930s, especially species dependent on wetlands (Crawford et al. 1993: 39). As drainage canals were dug, the water table was lowered, draining the cienegas, charcos, and esteros. Populations of beaver, muskrat, mink, waterfowl, wading birds, and some reptiles and amphibians declined as a result. Subsistence and commercial hunting and trapping contributed to this decline as well (Crawford 1993: 39; Perrigo 1982: 62–63).

Mink were last reported in the Los Lunas area just prior to 1920, but a few individuals were present elsewhere in the Middle Valley until 1947 (Bailey 1971; Hink and Ohmart 1984, pt. I: 34; 324; Pillow and DeVaney 1947: 16). Minks were apparently the victim of trapping and habitat change. River otters were last observed at the northern boundary of the Middle Valley sometime before 1930 (Bailey 1971: 324). Never common, river otters also may have disappeared because of trapping, but increased temperature and sedimentation of the river were more likely causes.

The Norway rat was among the earliest introduced mammals that became naturalized (Table 61). This species was in the study region at least as early as 1851, and it was abundant in Albuquerque by 1888. Its high reproduction rate and ability to consume a considerable amount of a variety of foods has resulted in significant losses of field and stored agricultural produce. The Norway rat also carries diseases transmittable to humans, the best known being bubonic plague. This disease is still prevalent in the Middle Valley, where a number of cases are reported each year (Findley 1987: 107–108; Roots 1976: 43–44, 47, 52–53).

Another introduced rodent that has adapted to New Mexico's settlements and agricultural environments is the omnivorous house mouse. This species feeds on insects, agricultural produce, and other vegetative materials. It, too, carries the plague and a number of viral and fungal diseases, including harvest fever and typhus. A prolific breeder, house mouse populations can reach as high as 82,000 per acre. This species' impact on agricultural grains can be significant (Findley 1987: 109–110; Roots 1976: 54–56).

Wild horses and burros, although probably not as common as they were in the late 1800s and early 1900s, were present in the study region from the 1920s to the early 1940s (Findley 1987: 150; Table 61). They occurred in the Sangre de Cristo Mountains and the bajada of the Manzano Mountains and they were also recorded in the Jemez Mountains. By 1971 they had become a serious ecological problem at Bandelier National Monument due to their intensive grazing, which significantly increased soil erosion and damaged springs. They were subsequently removed by National Park Service personnel (deBuys 1985: 244; Rothman, 1992: 280–281; Speakman 1965: 31).

Four exotic and naturalized bird species occur in the study region (Table 61). Of these, the two most prominent are the rock dove or domestic pigeon (*Columbia livia*) and the European starling (*Sturnus vulgaris*). The starling has increased substantially since its mid 1930s arrival in the region. This aggressive bird consumes large quantities of grain and is considered a pest on farms. Well adapted to urban environments, where it displaces native species through competition for food and nest sites, the starling is equally disliked by city residents (Roots 1976: 132).

Another introduced and despised bird that has adapted to urban and farm environments is the house sparrow (*Passer domesticus*). It feeds on some agricultural fruit and vegetable crops and also carries a disease that kills poultry. Introduced on the east coast in the mid 1800s, this sparrow reached New Mexico by the late 1800s (Roots 1976: 122–128).

A common species of game bird in the Middle Rio Grande bosque and agricultural fields is the ring-necked pheasant (*Phasianus colchicus*), introduced in the late 1800s-early 1900s. Popular with hunters, the pheasant is generally not liked by farmers because of the crop damage it can inflict. This species also competes with native quail (Roots 1976: 163–166).

Other species, especially indigenous fish populations, have also been adversely affected by the increasing sedimentation, as well as lowered stream flows, construction of water control facilities, pollution, and competition with introduced species (Table 62). From 13 to 19 non-native fishes have been introduced in the middle reaches of the river. These species, such as the rainbow trout, common carp, yellow perch, and largemouth bass, have generally competed successfully with native fishes. Some have preyed on native fishes, and others have cross-bred with natives. This has contributed to the decline or extirpation of several indigenous species (Sublette et al. 1990: 2, 9–11, 331; Table 62).

"Louisiana" bullfrogs were probably introduced into the Middle Rio Grande in the early 1930s. Their population increased rapidly, and the bullfrog soon became the most common amphibian in the valley (Hink and Ohmart 1984: 83; Pillow and DeVaney 1947: 16). A closely related amphibian, the leopard frog, has declined sharply over the last 4 or 5 decades, probably due primarily to predation by bullfrogs (Hink and Ohmart 1984: 83).

At least four invertebrates have been introduced into the Middle Valley —a pillbug (*Armadillidium vulgare*), a woodlouse (*Procello laevis*), the European honeybee (*Apis meillifera*), and the common housefly (*Musca domestica*) (Table 61). Although these four species may have entered the region relatively early in the historic period, actual dates of introduction are not known.

Table 61—Introduced fauna.

Common name	Scientific name	Date of introduction
Mammals		
Norway rat	*Rattus norvegicus*	pre–1851
House mouse	*Mus musculus*	?
Burro	*Equus asinus*	1598
Horse	*Equus caballus*	1598
Oryx	*Oryx gazella*	1969
Domestic cat	*Felis domesticus*	pre–1910
Birds		
Ring–necked pheasant	*Phasianus colchicus*	late 1800s
Chukar	*Alectoris chukar*	1931
Rock dove	*Columbia livia*	pre–1850
Starling	*Sturnus vulgaris*	1935 or 36
House sparrow	*Passer domesticus*	pre–1900
Amphibians		
Bullfrog	*Rana catesbeiana*	early 1930s
Fish		
Brown trout	*Salmo trutta*	early 1900s
Rainbow trout	*Oncorhynchus mykiss*	1896
Eastern brook trout	*Salvelinus fontinalis*	pre–1900
Common carp	*Cyprinus carpio*	1883
Golden shiner	*Notemigonus crysoleucas*	pre–1957
Yellow bullhead	*Ictalurus natalis*	pre–1950
Smallmouth bass	*Micropterus dolomieu*	pre–1957
White crappie	*Pomoxis annulari*	pre–1957
Black crappie	*P. nigromaculatus*	pre–1957
Walleye	*Stizostedion vitreum*	pre–1957
Yellow perch	*Perca flavescens*	pre–1950
Crustacean Isopods		
Pillbug	*Armadillidium vulgare*	?
Woodlouse	*Porcello laevis*	?
Molluscs		
Asian fingernail clam	*Corbicula* sp.	?
Insects		
European honeybee	*Apis meillifera*	?
Common housefly	*Musca domestica*	pre–1950

Sources: Crawford et al. 1993; Findley 1987; Hubbard 1978; Koster 1957; Ligon 1961; Swain 1948; Sublette et al. 1990

Extirpated, Rare, Endangered, and Threatened Fauna

Historic and current populations of the species listed below have been extirpated by one or more human activities including habitat destruction (building, damming streams, overgrazing, logging, mining, farming, etc.); sport and commercial hunting, trapping, and specimen collecting; fire suppression; construction of roads and railways; pollution of surface and shallow ground waters; and introduction of exotic animals. Related environmental events such as soil erosion, siltation of streams and lakes, modification of stream and spring flows, water contamination, and perhaps acid rain have and are adversely impacting flora and fauna. Forty-five species of vertebrate animals are listed (Table 62) as extirpated, rare, endangered, or threatened in the Middle Rio Grande Basin by the U.S. Fish and Wildlife Service (1991) and the New Mexico Department of Game and Fish (1988, 1990).

SUMMARY

The ecosystems of the Middle and Upper Rio Grande basins have been impacted and changed by human activities for more than 10,000 years. These modifications were relatively minimal until the arrival of the Spaniards, who brought livestock, new tools, cultigens, ditch irrigation, and another world view. They also introduced sev-

Table 62—Extirpated, threatened, rare, and endangered fauna.

Common name	Scientific name	Extirpated	Endandered, Threatened, or Uncommon Species[b]
Mammals			
American elk	*Cervus elaphus*	X	
Grizzly bear	*Ursus arctos*	X	
Black bear	*Ursus americana*		X
Mountain lion	*Felis concolor*		X
Jaguar	*Felis onca*	X	
Gray wolf	*Canis lupis*	X	
Black-footed ferret	*Mustela nigripes*	X	
Mink	*Mustela vison*	X	
Bighorn sheep	*Ovis canadensis*		X
Otter	*Lutra canadensis*	X	
New Mexican jumping mouse	*Zapus hudsoniuslatens*		X
Birds			
Bald eagle	*Haliaeetus leucocephalus*		X
Golden eagle	*Aquila chrysaetos*		X
Peregrine falcon	*Falco peregrinus*		X
Common blackhawk	*Buteogallus anthracinus*		X
Northern goshawk	*Accipiter gentilis*		X
Mexican spotted owl	*Strix occidentalis lucida*	X	
Whooping crane	*Grus americana*[a]	X	
Rio Grande turkey	*Meleagris gallopavo*	X	
Western snowy plover	*Charadrius alexandrinus*	X	
Least tern	*Sterna antillarum*		X
Neotropic cormorant	*Phalacrocorax brasilianus*		X
Willow flycatcher	*Empidonas trailii*		X
Tundra swan	*Cygnus columbianus*		X
Bell's vireo	*Vireo bellii*		X
Grey vireo	*Vireo vicinior*		X
Baird's sparrow	*Ammodramus bairdii*		X
Fishes			
Rio Grande bluntnose shiner	*Notropis simus*	X	
Shovelnose sturgeon	*Scapirhynchus platorynchus*	X	
Longnose gar	*Lepisosteus ossurs*	X	
American eel	*Anguilla rostrata*		X
Golden shiner	*Notenigonus crysoleucas*	X	
Rio Grande silvery minnow	*Hybognathus amarus*		X
Speckled chub	*Extrarius aestivalis*	X	
Rio Grande shiner	*Notropis jemezanus*	X	
Spotted gar	*Lepisosteus latirostris*	X	
Phantom shiner	*Notropis orca*	X	
Rafinesque	*Aplodinotus grunniens*		X
Blue sucker	*Cycleptus elongatus*	X	
Freshwater drum	*Aplodinotus grunniens*	X	
Blue catfish	*Ictalurus furcatus*	X	
Gray redhorse	*Moxostoma congestum*	X	
Amphibians			
Jemez Mountains salamander	*Plethodon neomexicanus*		X
Leopard frog	*Rana pipiens*		X

[a] *Reintroduced in 1970s.*

Sources: Bailey 1971; Crawford et al. 1993: 140–144; Findley 1987; Hubbard 1978; Ligon 1961; Sublette et al. 1990: 216, 345–350; U.S. Fish and Wildlife Service 1995

[b] *Species determined to be threatened or endangered, species that have declined in the historic period, and species that have always been uncommon.*

eral infectious diseases that devastated Native American populations. Anglo American conquest and occupation began in 1846, and they, too, brought new tools, technologies, cultigens, and a view that resources, including the land and water, are commodities to be bought and sold for economic profit.

By the end of the 19th century, environmental problems had become so severe and widespread that the federal and territorial legislatures began to enact regulations related to the conservation of water, soils, grasslands, woodlands, and forests and their associated fauna. For various reasons, effective regulation did not really occur until the 1930s, followed by a vigorous environmental movement that generated far-reaching legislation and regulations in the 1960s and 1970s. This evolution from a time of unregulated land and water exploitation to recent control and management of these resources for future generations is the focus of Chapter 6.

CHRONOLOGY

1598–1630 With the construction of more irrigation systems and the introduction of livestock by the Spanish, the demand for surface water increased significantly (Meyer 1984: 50).

1598–1680 New Mexico's governors dominated the export trade in furs and skins, such as those of buffalo, antelope, elk, and deer (Weber 1971: 18–19).

1598 (post) A grass native to Eurasia, sheep fescue (*Festuca ovina*), may have been introduced to New Mexico via the fleece and droppings of domestic sheep brought by Onate (deBuys 1985: 225).

1600s (early?) Spanish cattle, carriers of brucellosis, probably infected bison, elk, and bighorn sheep, resulting in a decrease of these animal populations in the study region. Native Americans, as well as Spaniards, were affected by this in the form of undulant fever (Callenbach 1996: 134–135).

1600s (early) (to 1680) Pueblo residents were forced to collect firewood, salt, and pinyon nuts in large quantities, to prepare hides, and to manufacture cotton blankets, causing stress among the villagers (Snow 1981: 368).

1610 (post) According to Aldo Leopold, mountain meadows and foothills were overgrazed by Hispanic livestock (Brown and Carmony 1995: 230).

1660 Governor Lopez de Mendizabal shipped 1,350 deer skins and a number of buffalo hides to Parral to market. He sent two other large shipments of skins there during his term. Some 1,200 pronghorn skins and four bundles of elk skins were later found at his property in Santa Fe (Weber 1971: 20–21).

1661 Some 60 Pueblo laborers from Quarai were conscripted by the Spanish to harvest and transport loads of pinyon nuts. Nineteen Indians from Abo worked for 6 days carrying maize from Tabira and Las Humanas pueblos to the house of Captain Nicolas de Aguilar in the Salinas District. Also, some 40 Indians of Jemez Pueblo were forced by the Spanish to transport pinyon nuts to "depots" at Santa Fe, Cochiti, or San Felipe (Scholes 1937: 394–395).

1661 Pueblo Indians from Tabira collected salt at a nearby salt marsh and transported it to the Las Barrancas estancia of Sargento Mayor Francisco Gomez (Scholes 1937: 401).

1661 The mission livestock were moved from Las Humanas to Abo because the Pueblos exhausted themselves hauling water for the stock from deep wells to the west of the village (Scholes 1937: 401).

1692 (late August) The condition of the Camino Real was degraded following 12 years of little or no traffic. In many places, grasses, forbs, and shrubs had grown up in the road bed. Vargas sent the sheep, cattle, and horses ahead to trample the vegetation, providing a clearer and smoother road for the wagons and settlers in the caravan. In some places, the road was gullied due to water runoff, and Vargas had men ready to repair the road (Hendricks 1993: 81).

1700–1800 About 27,000 new acres were put into cultivation by the Spanish in the middle and upper Rio Grande valleys (Hedke 1925: 23).

1736 (early) Five Albuquerque farmers requested that the alcalde allow them to move their livestock back to the Isleta area, where better grazing conditions existed (Baxter 1987: 24).

1739 Some residents of Albuquerque, who were experiencing scarcity of wood, insufficient pasture for livestock, a scarcity of irrigation water, and encroachment of footpaths on their land, requested and received the Tome land grant (Ellis 1955: 91; Oppenheimer 1962: 16).

1700s (mid) Intensive livestock grazing and fuelwood cutting led to denudation and soil erosion along Abiquiu Creek. Water from the stream tasted and smelled like cattle manure (McDonald 1985: 120).

1750 By this year Albuquerque and nearby communities were experiencing some pressures of overpopulation. Suitable agricultural land was taken, and livestock overgrazed some pastures and outlying rangelands. By this year, the bajada between Albuquerque and the Sandia-Manzano mountains was virtually denuded of grass by livestock. Outmigration to "new" lands, such as the Rio Puerco-of-the-East, began (Simmons 1982: 106–107, 1988: 7).

1766 (August 12–13) Nicolas de Lafora passed the Senecu and San Pasqual pueblo ruins and found "plenty of pasture" in the area. From here to the Vueltos de Acomilla, he passed through "swampy ground with a great deal of coarse grass and reeds," which included the Bosque del Apache (Kinnaird 1967: 88).

1776 (pre) (late October or early November) A trade fair was held during this and previous years at Abiquiu. Utes brought deerskins to trade for horses; 15 to 20 good deerskins would get a horse. They also brought deer or buffalo meat, which they exchanged for corn or corn flour. Sometimes they brought young captives from other nomadic groups to trade with the Spanish (Adams and Chavez 1956: 252–253).

1776 An extensive cienega was located a short distance west of Taos Pueblo. Cattle were pastured there to graze the lush plants, and some sedge and grasses were cut as "hay" for other livestock. This marsh vegetation was burned each spring to foster vigorous growth of new plants (Adams and Chavez 1956: 111).

1779 The meadows south of Cochiti Pueblo were severely damaged by overgrazing of livestock (Lange 1959: 37).

1770s Albuquerque residents resorted to the use of horse manure as a fuel owing to the scarcity of wood in the area. Threat of attacks by Comanches or Navajos may have precluded their venturing from the village to collect firewood (Moorhead 1958: 24; Thomas 1932: 101).

1791 Grass for livestock was scarce around Belen (Espinosa and Chavez n.d.: 177).

1700s (late) Decimation of grasslands and fuelwood and total appropriation of water in the Santa Fe area caused the governor to recommend moving the capital to the confluence of the Santa Fe River and the Rio Grande (MacCameron 1994: 35).

1800 By this year residents of Abiquiu were traveling up to 20 miles to gather fuelwood (McDonald 1985: 121).

1812 Wild horses, or mustangs, were reported "in great abundance" in the province (Carroll and Haggard 1942: 100).

1817–80s Wood cutting was a common activity of Tijeras Canyon Hispanic settlers (Quintana and Kayser 1980: 48).

1820–30s Overgrazing, primarily due to sheep, was a problem in the Upper and Middle Rio Grande Basin (Fergusson 1935: 334).

1821 Most rangelands around settlements in the Rio Grande Basin had become overgrazed by this year. Some livestock owners sent their flocks to the llano east of the Pecos River (Rebolledo 1987: 100).

1821 The ruin of the Felipe Romero house was located south of Belen and about 200 yards east of the Rio Grande. By early 1897 the river shifted eastward, to within 5 yards of the ruin (Wilson 1977: 14).

1822–24 The first area to be intensively trapped was the southern Sangre de Cristo Mountains between Santa Fe and Taos (deBuys 1985: 93).

1822–26 Taos trappers virtually took all of the beaver in the Sangre de Cristo and Jemez mountains (Flores 1992: 8).

1824 Beaver populations in the Rio Grande and Pecos River basins were rapidly decreasing due to Anglo trapping (Weber 1965: 65).

1827 (February-September 1828) Two Hispanics and two Frenchmen trapped eight tercios (240 pelts) of beaver fur on the headwaters of the Rio Grande and the Conejos River (Weber 1971: 161).

1827 Anglo and Franco trappers virtually harvested all of the beaver in the Sangre de Cristo Range by this date (Ungnade 1972: 48).

1820s Local farmers began to notice formation of cienegas and esteros in the Middle Rio Grande Valley. These resulted from the dumping of excess water from irrigation ditches (Wozniak 1987).

1820s Trapper George Yount claimed to have seen 50 or 60 grizzly bears in a day. James Ohio Pattie claims to have observed 220 in a single day (Cleland 1950: 44).

1820s (late) (to early 1830s) Some "foreign" trappers told government authorities that they had purchased furs from Native Americans or Hispanic residents, when in fact they had trapped the animals. Then they sold them to Santa Fe Trail traders, who transported them back to Missouri (Weber 1971: 159).

1830 (late) (to spring 1831) Gervais Nolan led a trapping expedition from Taos to an unidentified area and returned with 50 pounds of beaver fur (Weber 1971: 183).

1831 (summer) William Sublette, a Santa Fe Trail trader, exchanged his merchandise for 55 packs of beaver pelts (1,705) and 800 buffalo robes, which he took back to Missouri (Weber 1971: 147).

1831 About $50,000 worth of beaver pelts and bison robes were shipped east over the Santa Fe Trail. Some $17,500 of these were harvested in New Mexico, amounting to 55 to 60 packs of beaver and 200 robes (Weber 1971: 206).

1831–33 Trading and trapping by Anglos and Hispanos resulted in the shipment of a substantial amount of beaver pelts east over the Santa Fe Trail (Weber 1971: 206).

1832 (fall) The Charles Bent and Company returned from Santa Fe with 13,182 pounds of beaver, representing at least 131 packs of pelts. These were taken over the past 2 years. There were also 355 buffalo robes included with this shipment (Weber 1971: 206–207).

1832 About 90 packs, or about 2,790 beaver pelts, went east over the trail from Santa Fe. About one-third of these were trapped in New Mexico (Weber 1971: 206–207).

1833 The city council of Santa Fe issued a proclamation with regulations requiring draining of stagnant pools, cleaning of streets, and removal of garbage. Throwing trash or dead animals into irrigation ditches or streams and burning of rubbish piles were prohibited (Simmons 1992: 224).

1836 The Rio Grande began cutting into its east bank at the village of Parida. By 1850 the settlement had moved some 1,000 yards eastward as the river continued to shift its channel (Hammond 1966: 25).

1836 One merchant transported 1,000 beaver skins and 1,000 buffalo robes over the Santa Fe Trail (Weber 1971: 219).

1836–50 The fields and vineyards at La Parida were being destroyed by the floodwaters of the Rio Grande. The village itself was moved about a thousand yards east of its original location to avoid total destruction (Hammond 1966: 25).

1837 Another Santa Fe trader carried 200 buffalo robes and two packs of beaver pelts to Missouri (Weber 1971: 219).

1838 A band of French trappers went into the Sangre de Cristo Mountains above Mora, but owing to prior trapping along the streams, they caught no beaver (deBuys 1985: 159).

1830s–40s Hispanic settlers, who were descendants of residents of San Jose de las Huertas, came from the Rio Grande to start a new village in the valley but found the old fields were no longer fertile and the creek flow had decreased (Batchen 1972: 86).

1843 Father Martinez of Taos reported that buffalo, deer, and other game were becoming more scarce due to increased hunting pressure, which in part was fostered by traders on the Southern Plains. He warned that extinction would eventually take place (Keleher 1982: 68–69).

1846 (September 2) South of Santa Fe, Emory reached the Galisteo River, "... which, at that time, was barely running. The bed of the creek is sand and pebbles of the primitive rock. . . . From this place to its mouth there is scarcely the sign of vegetation. At the dry mouth of the Galisteo. . ." (Calvin 1968: 62–63).

1846 (September 30) In the valley around Peralta, Emory recorded a considerable growth of cottonwood, "among which are found some signs of beaver" (Calvin 1968: 81).

1846 (October 3) Camped on the Rio Grande, near La Joya de Sevilleta, Emory (Calvin 1968: 82–83) described the river bank as "fringed with large cottonwoods growing at intervals."

1846 (October 7–8) Traveling down the Rio Grande, north of the Fray Cristobal range, Emory (Calvin 1968: 88–90) noted that the cottonwood was larger and denser and the grama grass adjacent to the floodplain taller.

1846 (early October) Below Socorro, Captain Turner noted that trees were much more abundant than upriver, and the grass remained good (Clarke 1966: 80–81).

1846 (fall) The U.S. military could find no cattle feed within 50 miles of Santa Fe. This was partly due to recent fires set by Indians (Frazer 1983: 11; Sunseri 1979: 75).

1846 (November-December) The large number of U.S. troops and Santa Fe Trail traders camped at Valverde almost exhausted the fuelwood, grass, and game in the area (Moorhead 1958: 167–168).

1849 (August 16) Colonel John M. Washington's troops found "good grass and water" and "sufficient fuel" at Agua Fria on the Santa Fe River (McNitt 1964: 7).

1849 Rangelands around Santa Fe, perhaps for up to 20 miles, had been denuded of grass by livestock of wagon trains. At nearby Galisteo, erosion, which began at this time, had cut deep arroyos, and the Galisteo Creek had eroded to a depth of 12 feet. The channel is about 200 feet wide; in 1849 a plank spanned the creek (deBuys 1985: 216–217).

1849–1931 Erosion, due in part to overgrazing, caused Galisteo Creek to cut a vertical-walled arroyo from 15 to 25 feet deep and from 50 to 200 feet wide (Cooperrider and Hendricks 1937: 16).

1851–52 The Territorial Legislature declared that the acequia alignments in use at the time should not be disturbed and should remain public, and their use for irrigation should take precedence over all other uses, such as grist mills (Wozniak 1987).

1852 (ca.) The El Tajo ditch was constructed to "relieve the high water overflows at Albuquerque." The de los Padillas acequia, on the other side of the river, was primarily used for flood control (Wozniak 1987).

1857 Santa Fe was described as "pleasantly situated on an extensive plateau" and produced "good crops of wheat, corn, beans, red pepper, and many of the vegetables ..." and "apples and the smaller fruits. . . ." The area around, "for miles," was destitute of trees. The "large growth" was reportedly "cut away, at an early date in the history of the place, for fuel and for better security against hostile Indians . . ." but "stunted cedars are very common." Pinyon was "the almost sole supply of fire-wood," which was "brought for miles on the backs of donkeys and sold by the load, in the plaza, at from twenty-five cents to one dollar. . . ." The "river-water is very extensively used for drinking purposes, and is excellent." Potable water was found by digging wells 10 to 40 feet deep (U.S. Surgeon-General's Office 1857).

1850s Santa Fe experienced critical water shortages, and a search for a new source was initiated. A dam was constructed at the headwaters of the Santa Fe River in 1866, but the resulting reservoir did not supply all of the needed water (Clark 1987: 33).

1862 (March 1) Confederate officer A.B. Peticolas (Alberts 1993: 56) noted that wood for fires was scarce in camp near Polvadera.

1862 (March 5) In the Padillas area there was a road on the floodplain along the west side of the Rio Grande; this road was "very sandy." Paralleling this one was an upland road, located along the edge of the floodplain. This was "a much better road for wagons" (Alberts 1993: 59).

1862 (April 14) The road, wrote Sergeant Peticolas, from the South Valley to Los Lunas, along the west side of the Rio Grande, was "very heavy with sand," and "the wagons could not travel very fast" (Alberts 1993: 102).

1862 (spring) The cottonwood bosque in the Peralta area provided protection for the Confederate troops being assaulted by Union forces (Cook 1993: 6).

1865–98 Owing to "ruthless destruction of free grass on public lands," grazing capacity of Southwestern rangelands was severely reduced. In the study region, some rangelands that supported one head of livestock on 2 to 5 acres in the early years of this period could only carry one head on 60 acres (Smith 1899: 9).

1866 (July 26) The first legislation affecting mineral lands, the Mining Act, was passed by Congress. This act declared that surveyed and unsurveyed public lands were to be open for exploration and the establishment of lode mines by all U.S. citizens or those intending to become citizens (Westphall 1965: 96).

1867 (April 3) Bell (1965: 241–242), traveling below Albuquerque, observed "The greater part of the valley is here almost entirely destitute of trees. This may be partly accounted for by the fact that the banks of the river are of a sandy, friable nature, and that the bed of the stream is always changing its position, sometimes to one, sometimes to the other; thus destroying fields of corn, irrigating canals, and villages. . . ."

1860s An estimated 18,000 acres of new irrigated land was developed in the Middle Valley (Wozniak 1987).

1860s–1912 The river bed at San Marcial aggraded between 12 and 14 feet due to the reduction of the Rio Grande's historic flow, which had previously scoured out the stream channel (Clark 1987: 205).

1870 By this year, silt and sand from arroyo runoff were adversely impacting irrigable lands on the end of the Galvan-Sanchez-Sandoval grant near San Ysidro. Some members of these families were forced to move due to the loss of these arable lands. The silt deposits probably resulted from intensive grazing of sheep and goats and resulting erosion on surrounding uplands (Swadesh 1978: 46–47).

1870–1900 Heavy overstocking of rangelands occurred and peaked in 1900; "only 2 grazable acres were available per animal-unit month" during that year (Dortignac 1956: 60).

1872 A traveler described the mesa above San Felipe Pueblo as "treeless" and grassless" (Beadle 1973: 486).

1874 (mid July) A flash flood along the Galisteo arroyo washed away a buckboard, mule, and driver. A road bridge in the area also was damaged (Carter 1953: 10).

1874–75 Severe arroyo cutting had begun by these years as a result of overgrazing and droughts (Harris et al. 1967: 11).

1874–98 Prairie dog and jack rabbit populations generally increased on regional rangelands due in part to the widespread killing of wolves and coyotes by ranchers, homesteaders, and government trappers. As rangelands were overgrazed, prairie dog and rabbit populations were forced to move onto previously unoccupied areas and compete with livestock for the grass there. Less desirable range plants, such as cactus and thorny shrubs, spread due to the overgrazing and drought (Smith 1899: 14–15).

1875 (March 3) The Right of Way Act provided for a 200-foot right-of-way for railroads and 20 acres for station grounds every 10 miles across public domain (Westphall 1965: 93–94).

1875 (September 10) The American Forestry Association was organized to publicly promote forestry and "timber culture" (Roberts 1963: 2).

1875–85 Siltation in the Middle Rio Grande Valley peaked (Hedke 1925: 28).

1878 J.W. Powell published a report in which he proposed a systematic classification of lands based on their potential "best use," for example, irrigation, timber, pasture, minerals. He also proposed grazing districts with boundaries drawn along contour lines (Barnes 1926: 35).

1879 (summer) The Rio Grande ceased flowing from Albuquerque to El Paso due to diversion from the river by farmers in southern Colorado (Miller 1989: 69).

1879 There were about 11 million board-feet of commercial lumber produced in the territory (Baker et al. 1988: 18).

1879–91 Some 24,550 acres were taken by railroads from the public domain in the territory. By 1891, 622,684 acres of public domain were granted to individuals under the land laws (Westphall 1965: 93–95).

1870s As El Paso's population increased significantly, using more and more water, the level of the Rio Grande began to fall. The major cause, discovered later, however, was the diversion of the river's waters by numerous new settlers in southern Colorado, who had been lured to the area by the Denver and Rio Grande Railroad (Sonnichsen 1968: 382).

1880 (pre) The flow of the Rio Grande was sufficient to scour sediment from its channel. After this year, the streambed began to aggrade due to continued decreasing flow and increasing silt load (Harper et al. 1943: 49).

1880 By this date, the flow of the Rio Grande had been so reduced by upstream use that irrigation systems and hundreds of acres in the Mesilla Valley-Las Cruces area were abandoned (Wozniak 1987).

1880 The bed of the Rio Grande began to aggrade, and subsequently the riverbed was 2–3 feet above the level of San Marcial (Calkins 1937: 9–10).

1880 The flow of the Santa Fe River had become insufficient for the needs of Santa Fe residents. Reservoirs had to be constructed and wells drilled in this century to meet community needs (Thomas et al. 1963: D–10).

1880 There were about 124,800 acres of land under irrigation in the Middle Rio Grande Valley (National Resources Committee 1938, pt. VI: 71).

1880–1925 This has been termed the period of "spoilation." "The grazing lands were stocked far beyond their capacity" (Roberts 1963: 7–8). Farming, mining, and other land uses also resulted in deterioration of land, which caused some settlements to be abandoned in the Middle Rio Grande Basin. The carrying capacity of rangelands decreased by 50 to 75 percent during this period (Kelly 1955: 308). Gullying was severe due to "an increase in intensity of summer storms and exceptionally heavy grazing by stock" (Leopold 1994: 17). The streambed of the Middle Rio Grande aggraded to the level that "raised high water flood flow at some places ten feet." Increasing volumes of silt were due to decreasing flows of the Rio Grande and overgrazing and subsequent erosion in the Upper and Middle River basins (Hedke 1925: 11, 23).

1880–1900 Lateral arroyos to the Rio Grande carried large quantities of silt into the acequia madre at San Pedro. An elevated canal siphon was constructed to preclude this problem (Marshall and Walt 1984: 284).

1880–1942 Overgrazing of the upper Rio Puerco watershed, coupled with droughts and periods of intense rains, caused increases in flood frequency and intensity. The river began to degrade, irrigation diversion dams were destroyed, and the water table dropped. Agriculture and livestock raising declined (Harper et al. 1943: 52).

1880–1955 Rabbitbrush (*Chrysothamnus* sp.), pingue (*Hymenoxys richardsonii*), and snakeweed (*Gutierrezia sarothrae*) increased markedly due to "heavy grazing pressure" and "deteriorated range conditions" (Dortignac 1956: 66).

1880 (ca. to 1928) The channel of the Rio Puerco changed from a depth of 8 to 40 feet at Cabezon during this period (Bryan 1928a: 274).

1880 (post) Extensive clear-cutting on the Rio Chama drainage, primarily on private lands, removed the ponderosa pine forest (Harper et al. 1943: 55).

1881 The Rio Puerco channel, south of the Santa Fe rail line, began deepening and shifting (Bryan 1928a: 277).

1881 The railroad extended rail construction across the Zuni reservation, and contract lumbermen built logging roads and cut "tens of millions of board-feet of lumber" on the Zuni River watershed (Hart 1991: II/3).

1882 A. Bandelier recorded the exotic *Ailanthus*, or tree-of-heaven, growing at the plaza of Ojos Calientes, 3 miles from Socorro (Lange and Riley 1966: 318).

1882–94 The Rio Puerco channel south of the Santa Fe Railroad continued to deepen, causing some area farming settlements to be abandoned (Bryan 1928a: 279).

1883 Texas cattleman W.C. Bishop concentrated his 3,000 cattle in Pajarito and Water canyons, which had perennial springs, on the Pajarito Plateau (Rothman 1992: 29).

1884 (April) The Central New Mexico Cattle Growers' Association was organized in Albuquerque (Hagy 1951: 11).

1884 (July 1) The main river channel at the Albuquerque bridge shifted some 500 feet to the west due to the flood flow (Carter 1953: 20).

1884 When the Rio Grande shifted its course west between Los Lentes and Los Lunas, the river cut the acequia madre and left it on the east side of the river. Three other ditches "moved" from west of the river to the east side in the area (Wozniak 1987).

1884 (post) Following the 1884 flood, public officials in New Mexico, for the first time, began to discuss seeking financial aid from Congress for the construction of levees along the Rio Grande (Carter 1953: 25).

1885 Congress passed a law forbidding ranchers to control public domain by "fencing and posting," but the practice continued until the Taylor Grazing Act passed 49 years later (Hagy 1951: 75–76).

1885–90 Owing to deep entrenchment, the Rio Puerco could no longer overbank flood in the Cabezon area. Wells in the area began to go dry also (Bryan 1928a: 274).

1885–1963 An estimated 600,000 to 800,000 acre-feet of sediment washed into the Rio Grande from the Rio Puerco basin (Dortignac 1963: 507).

1886 Dr. George Vasey of the U.S. Department of Agriculture, Division of Botany, Washington, D.C., attributed the enormous loss of cattle in the Southwest over the previous 3 years to overstocking of the ranges and adverse weather (Smith 1899: 5).

1887 (pre) Residents of Los Ranchos lost their acequia due to a "rise of the river." One individual, Guadalupe Gutierrez, stated that the high water table and wetlands had been caused by "surplus water from the acequias" (Wozniak 1987).

1887 The deepening channel of the Rio Puerco, 34 miles above its mouth, reached Los Cerros, causing abandonment of the village (Bryan 1928a: 279).

1887 The Rio Puerco channel at Guadalupe was about 3 feet deep and 30 feet wide (Bryan 1928a: 274–275).

1888 Recent droughts and blizzards caused the U.S. Congress to authorize surveys for irrigable lands and reservoir sites in the West by the U.S. Geological Survey (Wozniak 1987).

1888–1913 The channel of the Arroyo Hondo was "shifting" near the gauging station. The Rio Grande channel at the gauging station near Buckman was shifting as a result of "scour and fill of sand on lava boulders." The Rio Grande channel at the San Marcial gauging station was "sandy and very shifting" (Follansbee and Dean 1915: 120, 141, 435).

1889 The Territorial Legislature passed an act "limiting stock on public ranges to the number for which the user could furnish sufficient permanent water" (Clark 1987: 149).

1889 The Territorial Legislature established a Cattle Sanitary Board to work to prevent disease and to inspect animals (Hagy 1951: 95).

1880s Owing to overgrazing and logging in the Zuni Mountains, the upper Zuni watershed began to seriously erode (Hart 1991: II/3).

1890 By this year the pueblo of Santa Ana was unoccupied in the spring and summer owing to nonproductive lands along the Jemez River. Only one cottonwood tree was growing along the river in the area. Surrounding grazing lands had been abused and were virtually covered by wind-blown, shifting sands (White 1942: 29).

1890–91 On the east side of the river below Bernalillo and Belen, once productive fields were "alkali flats" caused by a "lack of drainage" (Powell 1891: 270).

1890–91 J.W. Powell (1891: 271) reported "From Albuquerque to San Marcial drainage of the lower of the Rio Grande Valley is exceedingly poor. Many ponds, some of them 8 or 10 acres in extent, are full of water during the early part of the year, and others show by the alkali coating on their sides and bottoms that the water has but recently left them." Low-lying ditches in the Tome-Los Lunas area were subject to "frequent overflow" and "being washed out or being filled with silt." According to Powell

(1891: 272), a number of houses in the low-lying areas of the valley south of Los Lunas "have fallen in by the sinking of the foundations. A large part of the valley ... is overgrown with cottonwood thickets or bosques, as they are called."

1890–1900 The deepening Rio Puerco channel became a serious problem for irrigation farmers in the Cabezon area (Bryan 1928a: 274).

1890–1904 In areas of rugged terrain, homesteaders herded goats, which resulted in the overgrazing of the steepest slopes (Brown 1985: 98).

1890–1940s During this period, the rangelands of the upper and middle Rio Puerco-of-the-East were overstocked, causing a degradation of plant cover. Russian thistle, snakeweed, and cacti populations (*Opuntia* spp.), plants of little or no grazing value, spread and sharply increased. The carrying capacity of these grasslands decreased. Sheet erosion and gullying followed (Widdison 1959: 272–273).

1892 (January) The Pecos River Forest Reserve was established by Presidential Proclamation (Tucker and Fitzpatrick 1972: 2).

1892–1906 Establishment of U.S. Forest Reserves (later designated National Forests) in northern New Mexico "had a tremendous effect upon the [Spanish] villages, some of which found themselves eventually completely surrounded by federalized lands.... Large numbers of Hispanos had to reorganize many aspects of their former economy and the way of life dependent upon that economy" (Gonzalez 1969: 122).

1893 By this year the exotic cheat grass had spread across much of the study region (Frome 1962: 253).

1894 (October) The first confirmed report of Russian thistle in New Mexico was made (Wooton 1895: 3).

1894–96 San Francisco and San Ignacio on the Montano grant in the Rio Puerco basin were abandoned (Bryan 1928a: 276).

1895 By this year virtually every acre of available grassland in the region was stocked with sheep or cattle. Rangelands that should have been stocked with one cow on every 40 acres were stocked with four animals (Barnes 1926: 7).

1896 (December 5) Because of dwindling irrigation water, the Secretary of the Interior placed an embargo on irrigation development in the Rio Grande Valley above El Paso (Wozniak 1987).

1896 There were about 105,000 acres of irrigated acreage in tributary drainages of the Rio Grande (Dortignac 1956: 30).

1896 (to mid 1930s) Trails, roadways, and irrigation ditches along the Rio Puerco drainage in the Cuba area "were converted into arroyos by runoff from surrounding slopes no longer protected by their plant cover" (Cooperrider and Hendricks 1937: 17).

1897 Grazing permits for horses on federal forest reserves were first issued (Eastman and Gray 1987: 36).

1897 The Santa Rosa de Cubero acequia, located between San Felipe and Santo Domingo pueblos, had disappeared due to a change in the course of the Rio Grande (Wozniak 1987).

1897–1909 Issues related to grazing regulation, grazing fees, and vegetation management for watersheds by the U.S. Forest Service were debated by Gifford Pinchot and the Secretary of Interior, U.S. Army Corps of Engineers, western stock growers, and some congressmen (Clark 1987: 141).

1899 A surveyor described a "new channel" of the Rio Puerco at Cabezon that was 198 feet wide. Seven years later the channel at the same location was 244 feet wide and 20 feet deep. These changes were attributed in part to land use activities by residents of the area (Bryan 1928a: 271–273).

1890s–1920s Large-scale, timber-cutting operations on the upper Chama River drainage resulted in excessive flooding and associated severe erosion (Cooperrider and Hendricks 1937: 77).

1800s (late) (to 1906) Some 210 sections of woodland, primarily ponderosa pine, were clearcut by commercial loggers (Phillipps 1907: 16–17).

1800s (late) (to early 1900s) "There was a drastic deterioration of ranges late in the last century and continuing into this century. . . . Some of the changes are undesirable and appear to be irreversible (e.g. in the arid Southwest where topsoil has been removed and grassland replaced by creosote bush . . .) . . . and other undesirable changes have unknown degrees of permanency (e.g. many alien species that are now established on certain rangelands)" (Branson 1985: 67).

1900 Extensive use of cottonwoods for fuel, construction, and livestock feed in the Middle Rio Grande Valley had subsided by this year (Dick-Peddie 1993: 151).

1900 The decrease in rangeland productivity in the Upper and Middle basins due to overstocking and overgrazing over the previous 4 decades began. The number of head of livestock continued to increase to a high of 177,000 animals in 1930. By 1935 the total had dropped to 54,000, but another increase began after the 1930s drought (Dortignac 1956: 59–60).

1900 Resident farmers were moving from Cabezon because they could no longer irrigate successfully from the deepening Rio Puerco (Bryan 1928a: 274).

1900 (post) The development of new canning processes and the introduction of refrigerator cars contributed significantly to a sharp increase in the large-scale production of vegetables and fruits (McWilliams 1961: 176).

1900–10 Continued overgrazing and logging on the Zuni River watershed accelerated soil erosion (Hart 1991: II/3).

1900–16 Non-Pueblo grazing and road building, as well as overgrazing and timber cutting on adjacent lands, damaged Santa Ana lands (Bayer et al. 1994: 183–185).

1900–26 Construction of railroads, bridges, and dikes and levees prevented the Middle Rio Grande channel from shifting (Rodey and Burkholder 1927: 15).

1900–34 As grazing regulations went into effect on national forest lands, many livestock raisers moved their herds onto the unregulated lower public domain, thereby increasing the grazing pressure (Box ca. 1978: 18).

1900–35 The total number of cattle in the Rio Grande watershed decreased by 60 percent, primarily due to depletion of range vegetation (Widdison 1959: 265–266).

1900–39 Spanish Americans lost about 70 percent of the land that they owned as private or community grants (Eastman and Gray 1987: 96).

1900–45 Alameda stock raisers were grazing their herds, primarily sheep, on common lands across the Rio Grande, west of the community, and on the east side of the railroad tracks (Gerow 1992: 49).

1900–50 The ponderosa forests on the east side of the Sandia Mountains disappeared due to logging and fire suppression (Baisan 1994: 2).

1900 (ca.) By this year, rapid deterioration of the physical environment in the upper Rio Puerco-of-the-East began. "The excessive numbers of stock which had been on the ranges, and which still continued to increase, had already sealed the doom of the area by destroying the ground cover on the dark, easily eroded soil.... The clear waters muddied; the Puerco and its tributaries began to cut into the ground. The river channel which had formerly carried water to the surrounding lands now began to drain them. Springs became wells. Settlements were abandoned, or moved to less damaged areas" (Maes and Fisher 1937: 16–17, 23).

1900 (ca.) Fire suppression began about this time, resulting in an increased proportion of Engelmann spruce and corkbark fir in the subalpine, coniferous forest zone, 9,500 to 12,000 feet elevation (Dick-Peddie 1993: 51, 56).

1900 (ca.) By this year the Pueblos had become economically dependent on the Anglo system, due in part to "alienation of land ... and the decreasing fertility of the increasingly smaller plots of land on which the Pueblos depended for a livelihood" (Dozier 1983: 9).

1900 (post) Pinyon-juniper woodlands spread, at lower elevation ecotone margins, onto grasslands during this century as a result of suppression of fires, livestock grazing, and other factors (Dick-Peddie 1993: 91–92).

1901 (September) Irrigation superintendent John B. Harper wrote that New Mexico's "desirable public land" was nearly all taken, but the "demand for agricultural land" was increasing (Bayer et al. 1994: 203, 353).

1902 Grazing permits for sheep on federal forest reserves were first issued (Eastman and Gray 1987: 36).

1903 By this year Russian olive had been introduced at Mesilla Park (Freehling 1982: 10).

1903 President T. Roosevelt created a commission to study the laws regulating settlement and grazing of public domain lands, with the view of their long-time conservation. This body concluded that most of the public domain was unsuitable for farming, and lack of government regulation and poor private stewardship had resulted in widespread degradation of rangelands due to overgrazing (Barnes 1926: 37–38).

1903 (and 1905, 1909) The Territorial Legislature passed acts authorizing counties to levy taxes to be used for paying bounty claims on predatory animals (Hagy 1951: 91).

1904 (pre) There was no bosque at Corrales except at one location (Eisenstadt 1980: 13).

1904–06 The Rio Grande carried an estimated, annual sediment load of 14,580 acre-feet. The USGS observed "The deposition of sand and silt in the erosion basins causes frequent changes in the course of the river, so that bayous, sloughs, and oxbow lakes are common in the bottom lands" (Lee 1907: 24).

1905–06 The number of grazing permits for national forests in New Mexico was 878 for 53,454 cattle and horses and 234 for 312,035 sheep and goats (Rowley 1985: 78).

1905–08 The freight road between Albuquerque and Cabezon traversed sand hills, clay soils, deep arroyos, and quicksands at fords. Some wagon ruts, especially on steeper grades, eroded into arroyos (Schmedding 1974: 78–79, 88–90).

1905–11 The U.S. Forest Service worked to organize a grazing program that would improve the value and use of the range (Roberts 1963: 115).

1905–35 Range forage on public and private lands declined dramatically due to intensive grazing. Some 84 percent of the public domain lands were "severely" or "extremely" depleted. Forest service ranges were overstocked by an estimated 43 percent in 1935 (Frederick and Sedjo 1991: 143–144).

1906 (June 11) The Forest Homestead Act opened national forest lands for agricultural settlement; after a residency period, settlers could receive free title to 160 acres (Rowley 1985: 81–82).

1906 "Cattle barons" were opposed to statehood because free grazing on the public domain would end, and they would be forced to make rental payments to the state fund. "Lumber barons" were opposed because large timber holdings were assessed at less than 10 percent of their value (Larson 1968: 243).

1906 A moderate earthquake caused severe damage to Socorro and the surrounding area (Northrop 1980: 85). The church of San Antonio de Aquinas was destroyed in an earthquake (Marshall and Walt 1984: 303).

1906 The Rio Puerco channel at San Luis was 20 feet deep (Tuan 1966: 589).

1907 Forest Service Director Gifford Pinchot stated "The connection between forest and river is like that between father and son. No forests, no rivers" (Clark 1987: 141).

1907–10 Snakeweed, *Gutierrezia* spp., had invaded the grasslands of the mesa and foothill zones (Watson 1912: 202).

1908 Most of the timberland in the Manzano National Forest had been cut for railroad ties and other construction materials (Baker et al. 1988: 78).

1909 The Forest Service allowed Native Americans to graze their livestock for free where animal numbers were low and meat and hides were consumed by the Indians (Rowley 1985: 86).

1909–11 Elliot Barker (1976: 10–11, 14) observed that sheep had damaged "high elevation slopes" in the Sangre de Cristo Mountains. This impact apparently occurred because of "close herding and trailing" and repeated bedding of the sheep at the same location.

1909–11 Botanist J.R. Watson (1912: 202), following his study of plant communities, wrote the following about the adjacent uplands of the Rio Grande: "This was undoubtedly originally a grassland, and is so yet where it has not been too seriously over-grazed. . . . Now thanks to lack of scientific control of grazing, it has been invaded by the composite *Gutierrezia* . . . as to merit being called a Gutierrezia formation."

1909–17 The successful trapping and hunting of predators on national forest lands led to an increase in prairie dog and other rodent populations. Livestock raisers complained that these animals were competing with their stock for grass and causing injury through their digging of burrows (Rowley 1985: 77).

1909–26 The riverbed at San Marcial aggraded about 12 feet. The rising riverbed caused a widening of the Rio Grande channel and encroachment on farmland from Belen south (Rodey and Burkholder 1927: 15).

1910 (pre) Farming was abandoned at La Ventana due to erosion, a deepening Puerco channel, and droughts (Widdison 1959: 282).

1910 (pre) Waterlogging, silting, and decreasing Rio Grande water flow caused a drop in irrigated acreage to 60,000, or a 57 percent decline (Dortignac 1956: 30).

1910 Many stockmen believed that grazing permits were a property right, subject to sale or transfer. The Forest Service held the position that they were "a personal privilege obtained from the Secretary of Agriculture, and only the secretary retained the right to grant, withhold, or revoke the permit at his discretion" (Rowley 1985: 89–90).

1910 Salt cedar was reported growing at Mesilla Park (Scurlock 1988a: 138).

1910–11 Young *Juniperus monosperma* plants were spreading into the lower grasslands of the Estancia Valley (Watson 1912: 206).

1910–12 Under legislative acts to prevent individuals or private companies from gaining exclusive use of extensive public lands or waters, the General Land Office withdrew such tracts and sources (Clark 1987: 145).

1910–18 Fifty-five new irrigation ditches went into operation in the Middle Rio Grande Valley (Hedke 1925: 22).

1910 (ca.) The waters of the Rio Grande commonly disappeared into its sandy bottom a short distance above Bernalillo (Harrington 1916: 101).

1911–12 Salt Cedar, or tamarisk, trees were being planted in Albuquerque as an ornamental. The species subsequently spread through the

Middle Rio Grande Valley (Scurlock 1988a: 136, 138).

1911 (post) Personnel from the State Engineer's Office constructed a levee to protect San Marcial from floods (Calkins 1937: 7–8).

1912 A soil survey in 1912 indicated that the water table in the Middle Rio Grande Valley stood at 6 inches to 6 feet, with an average of 23 inches. This waterlogging was due in part to long-term irrigation and a rising water table (Clark 1987: 205).

1912 Upon admission to the union, Congress gave all Sections 2, 16, 32, and 36 of the public domain to New Mexico for the aid and support of public schools. Other public lands were received by the state as well (Barnes 1926: 46).

1912–20s Access to common grazing lands previously used by La Tierra Amarilla land grantees was cut off as fencing by the Carson National Forest was initiated. The numbers of animals were reduced by implementation of permits and fees as well. This action was taken to help restore the overgrazed, eroding forest lands (Wilson and Kammer 1989: 53).

1913 Hewett et al. (1913: 20) wrote "The Rio Grande and many smaller streams show evidence of volume formerly much greater than at present."

1913 Vernon Bailey (1913: 74) described New Mexico's rangelands: "Many of the arid valleys in New Mexico have been for years so overstocked that the best grasses have been killed out and parts of the range rendered almost worthless. Some of the valleys show mile after mile of ground almost bare or overgrown with worthless vegetation that stock does not eat. Around most of the watering places the grass is killed for a long distance, often from 1 to 3 miles, the ground is trampled, and baked, and the little rain that falls runs down the trails and is wasted."

1913 The Rio Puerco channel at La Ventana was 15 feet deep (Dortignac 1962: 588).

1913 A USGS report pointed out the need to consider water in the disposal of the remaining public lands that it and must be appropriately managed (Clark 1987: 144).

1913–14 The Forest Service advertised 117 million board-feet to be harvested in the Carson National Forest, near La Madera, Rio Vallecitos, and in the higher Valle Grande area. A new sawmill was put into operation at La Madera, which had a capacity of 60,000 board-feet per day (Gjevre 1975: 37).

1914 (pre) The Santa Fe Railroad operated an average of 15 locomotives to pull its transcontinental trains. Each engine had a tender that held 7,500 to 10,000 gallons of water (Worley 1965: 37–38).

1914 William T. Hornaday, big-game hunter and director of the New York Zoological Park, wrote "Wherever found, the proper course with a wild gray wolf is to kill it as quickly as possible" (Brown and Carmony 1995: 228).

1914 Russian olive had been planted as an ornamental in various parts of the state, but none were reported in native riparian plant communities (Freehling 1982: 10).

1914 A firm purchased logging rights to 117 million board-feet of timber in the Carson National Forest. Ponderosa pine and Douglas fir were the two principal species harvested and sent to the company's sawmill at La Madera (Chappell 1971: 129–130).

1914 (late) (to April 1915) The New Mexico Cattle Growers' Association voted to pay a bounty of $25 for each hide of adult wolf or mountain lion taken on the ranges of its members. The organization also passed a resolution requesting Congress to provide funds to exterminate predators on public lands (Hagy 1951: 91).

1914–25 More than 200 rail car loads of apples were shipped annually from the Espanola area (Gjevre 1975: 18).

1914–26 The Rio Grande riverbed at San Marcial aggraded at an average rate of 0.08 feet per year (Dobson 1937: 2).

1915 Some 108 short-term grazing leases to non-Indians on 509 Jicarilla allotments at the southern part of the reservation were generally overgrazed (Tiller 1992: 112).

1915 The demand for beef and mutton increased sharply with the start of World War I, and grazing restrictions on the national forest reserves were relaxed (Brown 1985: 129–130).

1915 The Agriculture Appropriations Act, passed by Congress, provided for the establishment of summer homes, recreation sites, and campgrounds (Brown 1985: 130).

1915 (August) (to September 1916) The New Mexico Cattle Growers' Association paid bounties totalling $2,190.00 for 31 wolves, 47 mountain lions, 19 wolf pups, and 5 mountain lion kittens (Mortensen 1983: 71).

1915–16 The village of Paraje was condemned because of the construction of Elephant Butte Dam and was subsequently inundated by the reservoir (Marshall and Walt 1984: 279).

1916 (May 12) Construction on the Elephant Butte

Dam was completed, creating a reservoir 40 miles long and covering some 40,000 acres of land with 2,638,860 acre-feet of water (Clark 1987: 195; Workers of the Writers' Program 1940: 21).

1916 Congress passed the National Park Act, leading to the creation of the National Park Service (Udall 1963: 153).

1916 (late) (to 1917) The New Mexico Cattle Growers' Association lobbied the state and national legislatures to fund the taking of predators by the U.S. Bureau of Biological Survey operations in the state (Mortensen 1983: 71).

1916 The Enlarged Homestead Act provided for livestock driveways of not over one-fourth mile in width across public land (Hagy 1951: 78–79).

1916 The Stock-raising Homestead Act was passed by Congress; one of its provisions allowed for the substitution of range improvements and well drilling for cultivation; native grasses and topsoil would thus be protected, and small livestock growers would be protected from displacement (Clark 1987: 147). It also provided for a free section of grazing land when filed on (Oakes 1983: 27).

1916 With completion of the Elephant Butte Dam eels (*Anguilla rostrata*) could no longer return to the Upper Rio Grande (Koster 1957: 79).

1916 Owing to protests by cattlemen, the Forest Service raised grazing fees by 25 percent, rather than by 100 percent as the agency had proposed (Hagy 1951: 62).

1916–17 Ashley Pond founded a sportsmen's club that included a game preserve and hunting and camping areas at the north end of the Ramon Vigil land grant. The water source for this endeavor, a spring in Pajarito Canyon, dried up, and Pond abandoned the preserve (Ebright 1994: 244–245).

1916–18 When the United States joined the Allies in World War I, the Forest Service increased the number of permitted livestock on national forest lands. Conditions caused by previous overgrazing and logging worsened (deBuys 1985: 231).

1916–19 The U.S. Forest Service issued livestock grazing permits for the sacred Blue Lake area to non-Indians (Sando 1989: 83).

1916–23 The density of black grama grass on New Mexico ranges decreased during this dry period (Gatewood et al. 1964: B43).

1916–24 When available, pinyon nuts were shipped by rail from the Taos junction area. The average annual shipment was 10 carloads except for 1921, when there were 17 carloads (Gjevre 1975: 19).

1916–27 The riverbed at San Marcial aggraded about 12 feet (Rodey and Burkholder 1927: 15).

1916–20s The dense growth of tamarisk and other riparian vegetation increased the volume of silt deposition in Elephant Butte Reservoir (Calkins 1937: 10).

1916–47 The original capacity of 2.63 million acre-feet of Elephant Butte Reservoir was reduced 17 percent to 2.2 million acre-feet by deposition of sediments (Dortignac 1956: 40).

1917 The average depth of ground water on the floodplain of the Rio Grande in Socorro County was 2.37 feet (Bloodgood 1930: 52).

1917 Congress increased grazing fees on public lands, and politicians, ranchers, and others protested vigorously (Clark 1987: 146).

1917 The Forest Service increased grazing fees by 25 percent (Hagy 1951: 62).

1917 The Bureau of Biological Survey received $25,000 funding to control predatory animals and rodents in New Mexico. This amount was matched by the State (Hagy 1951: 93).

1917 (to April 1918) A number of New Mexico ranchers moved their cattle out of state because of the drought (Hagy 1951: 29).

1917–18 Maximum numbers of livestock were reached in New Mexico owing to the increased demand for food and wool during World War I (Donart 1984: 1240).

1917–18 Trespass livestock were common on Forest Service lands, which contributed to overgrazing (Roberts 1963: 120–121).

1917–18 The Sherwin-Williams Paint Company financed mining of lead and zinc in the Magdalena Mountains (Fergusson 1951: 307).

1917–22 About 845,930 acre-feet of water was consumed or lost in the Middle Rio Grande Valley through irrigation diversion, seepage, evaporation, and to swamps and ponds (Bloodgood 1930: 58).

1918 (fall) Spanish influenza struck New Mexico; there were 15,255 cases reported in the state and some 1,055 resulting deaths (Melzer 1982: 225).

1918 The width of the Rio Grande "flood channel" varied from 300 to 4,000 feet. The riverbed was aggrading at a high rate (Sullivan 1924: 6).

1918 Some 47,007 acres of farmland were being irrigated in the Middle Rio Grande Valley (Hedke 1925: 20).

1918 Aldo Leopold declared in a published paper that game management was as much a function of the Forest Service as were timber and range management (Brown and Carmony 1995: 85).

1918–45 Hundreds of burros that had been used by the military in World War I were released on rangeland west of Alameda, where they grazed until the population disappeared by the end of World War II (Gerow 1992: 49).

1918–93 Wetlands—salt grass meadows, marshes, and ponds—were reduced from 52,000 acres to about 3,700 acres, a 93 percent reduction (Crawford et al. 1993: 206).

1919 There were 48,795 acres of cultivated land, 51,977 acres of alkali and salt grass, 6,517 acres of "swamp," and 37,594 acres of bosque (Bloodgood 1930: 5).

1919–25 Sixty new irrigation ditches went into operation in the Middle Rio Grande Valley (Hedke 1925: 22).

1920 (pre) The last mink in the Los Lunas area were reported. This species historically occurred as far south as Elephant Butte (Hink and Ohmart 1984, pt. I: 34).

1920 (March) Private forester Stewart Edward White "criticized the Forest Service for allowing their forests to become overgrown with brush, and chastised it for not using light burning to prevent tree diseases and destructive conflagrations" (Brown and Carmony 1995: 143).

1920 (June 10) Congress passed the Federal Water Power Act; this legislation provided for the Federal Power Commission, which had authority to issue licenses for the construction, operation, and maintenance of power facilities on navigable waters and public lands (Clark 1987: 145–146).

1920 Following the flood, the State Engineer's Office again had to do more levee work (Calkins 1937: 7–8).

1920 The Forest Service adopted a policy of no light burning in ponderosa pine forest, based on the belief that fire every 2 to 3 years would prevent restocking of the trees (Pyne 1982: 522).

1920 The population of Cabezon was about 250 (Varney 1987: 35).

1920 (ca.) Erosion created a new arroyo, which cut Abo Creek and diverted most of the water, diminishing the stream flow (Clark 1987: 329).

1920 (ca.) Aldo Leopold planted a tamarisk in front of his house in Albuquerque (Robinson 1965: A5).

1900s (early) An agricultural field below Nambe Falls was abandoned and subsequently revegetated by prickly pear, cholla, juniper, pinyon, and unidentified shrubs (Ellis 1978: 62).

1900s (early) Intensive grazing, suppression of fire, and a "wet" period led to a "dramatic expansion of woody vegetation and a concomitant decay of the grass lands" (Pyne 1982: 524).

1900s (early) The Federal Government constructed reservoirs for pueblos that did not have a reliable water supply. These quickly began to silt up, resulting in a reduction of their capacities (Vlasich 1980: 28).

1900s (early) The introduced tamarisk formed dense stands, especially along riparian corridors, and became a fire hazard for cottonwood-willow bosques (Pyne 1982: 187).

1900s (early) A number of high runoff years in the Upper Basin probably accelerated soil erosion on a deteriorating watershed (Crawford et al. 1993: 24).

1900s (early) The American Lumber Company was established in Albuquerque. Logs for the mill came from the Zuni and San Mateo mountains north of Grants (Balcomb 1980: 56).

1900s (early) Bear Canyon on the west flank of the Sandia Mountains was a favorite recreational area for Albuquerque residents. The cold, pollution-free stream, lined by cottonwood and box elder, was the major attraction (Balcomb 1980: 63–64).

1921 Created by the State Legislature, the Rio Grande Survey Commission, in cooperation with the U.S. Reclamation Service, began to study environmental conditions in the Middle River Valley (Wozniak 1987).

1921 Aldo Leopold "presented a fully formed and brilliantly considered wilderness-preservation plan to the Forest Service" (Brown and Carmony 1995: 152).

1921–25 The Bluewater-Toltec Santa Cruz irrigation districts were formed (Clark 1987: 204).

1921 (post) Some ranchers supported creation of wilderness areas because their roadlessness would keep automobiles and their passengers off grazing leases (Brown and Carmony 1995: 154).

1922 (fall) Continuing drought conditions caused some ranchers to ship their cattle to Mexico for winter grazing (Hagy 1951: 32).

1922 The major crops, and their acreage, cultivated in the Middle Rio Grande Valley were corn (16,200), alfalfa (11,200), wheat (10,600), oats (3,700), and beans (1,800) (Bloodgood 1930: 12).

1922 There were 7,559,000 acres of public land under grazing lease and 1,500,000 acres under oil lease (Barnes 1926: 47).

1922 The grazing fee on state lands was reduced from five cents to three cents an acre (Hagy 1951: 82).

1922 The White Pine Lumber Co. was organized; included in the operation was a sawmill at Bernalillo and a rail line from the mill extending northward to the main logging camp in Guadalupe Canyon of the Jemez Mountains. By 1927 the sawmill was averaging an output of 145,000 board-feet of lumber a day which came from logs cut on the upper San Diego land grant (Glover 1990: 5–6; Scurlock 1981a: 148).

1920s (early) Much of the land previously farmed in the Middle Rio Grande Valley "had become either swamp or bosque (Kernodle et al. 1995: 21).

1923 About two-thirds of the Middle Rio Grande floodplain was waterlogged due to a high water table, flooding, and irrigation outflow (Burkholder 1928: 45–55).

1923 The State Legislature passed the Conservancy Act, creating a district with a governing board to initiate projects to prevent flooding, regulate stream flow, reclaim waterlogged lands, develop irrigation works, develop or reclaim sources of water, and generate electrical energy in the Middle Valley (Clark 1987: 207). The district structure was formed within 2 years. About 277,760 acres were included in the district (Scurlock 1988a: 136).

1923 The Reclamation Service was converted into the Bureau of Reclamation (Clark 1987: 189).

1923 Aldo Leopold astutely hypothesized that the drought caused a scarcity of quail in New Mexico (Brown and Carmony 1995: 108, 111).

1923 Tamarisk were observed growing along an irrigation canal but not along the Rio Grande west of Albuquerque's Old Town (Robinson 1965: A5).

1923–24 Robert Thompson purchased 55,000 acres of land, a tract that was the Alameda land grant. The headquarters was located on the north edge of Corrales. Some 3,000 to 5,000 herefords were grazed on the ranch (Eisenstadt 1980: 21–22).

1923–25 The blue, or scaled, quail population declined sharply due to drought and overgrazing (Ligon 1927: 134).

1924 (pre) The channel of the Galisteo deepened as a result of overgrazing and other abuse in its drainage. Due to this down cutting, water could no longer be delivered for irrigation (Brown and Carmony 1995: 169).

1924 (June 7) Congress passed the Pueblo Lands Act, which provided for the appointment of a commission to investigate Pueblo land titles and to litigate the thousands of non-Indian claims against Pueblo lands known as the Pueblo Lands Board. This commission was empowered to compensate Indians and non-Indians alike for lands lost via decisions (Brayer 1938: 29).

1924 Passage of the Pueblo Lands Act resulted in Hispanos acquiring legal title to about 18,200 acres of northern Pueblo land through adjudication. Most of this acreage was irrigable and water rights were appropriated with land title (Forrest 1989: 58).

1924 Wild horses on the Carson National Forest were contributing to an overgrazing problem. About 1,200 horses were rounded up; some were sold to residents surrounding the forest (Tucker and Fitzpatrick 1972: 79–80).

1924 Lack of grazing regulation on the public domain led to continuing overgrazing (Brown and Carmony 1995: 171).

1924 Aldo Leopold wrote "To a degree we are facing the question of whether we are here to found a permanent civilized community with room to grow and improve" (Brown and Carmony 1995: 170).

1924 Aldo Leopold's paper "Grass, brush, timber and fire in southern Arizona" was published. This article, the first detailed discussion of historical change in a Southwest landscape, identified overgrazing and fire suppression as the cause of the invasion of grasslands by shrubs and trees and erosion on National Forest lands. Erosion, he pointed out, was caused by allowing intensive grazing to reduce plant cover, which supposedly would decrease the incidents of fire (Brown and Carmony 1995: 188–192).

1924–32 Black grama grass density on New Mexico ranges increased until the drought in subsequent years reversed this process (Gatewood et al. 1964: B43).

1925 (spring-summer) Some 565,000 acre-feet of water was depleted for the year. A shortage of 200,000 acre-feet occurred at Buckman (Hedke 1925: 14).

1925 (August) There was a demand of 68,000 acre-feet in the Middle Rio Grande Valley (Hedke 1925: 32).

1925 The Middle Rio Grande Conservancy District was formed by this year. About 277,760 acres were included in the district. To alleviate flooding and subsequent waterlogging, dams, levees, and drainage canals were constructed over the next 5 decades (Scurlock 1988a: 136).

1925 Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta were incorporated into the Middle Rio Grande Conservancy District. These pueblos agreed to reorganize their irrigated land into larger, revenue-producing farms, but only Isleta and Sandia met the requirements of the agreement (Sando 1992: 123).

1925 Only about 55,000 acres of land were cultivatable in the Middle Rio Grande Valley because of a rising water table and silt deposits. Some 16,000 acres were not cultivated as a result of insufficient irrigation water, and about 8,000 acres were "swampy" due to a rising water table. Another 52,000 acres were covered with alkali deposits (Hedke 1925: 10).

1925 Rangelands included in the Atlantic and Pacific Railroad grant in west-central New Mexico generally had a carrying capacity of one cow per 50 acres (Barnes 1926: 40).

1925 The uplands on the Pedro Armendariz grant were fenced, causing the collapse of ranching, which had been the mainstay of the economy in the San Marcial area (Wozniak 1987).

1925 By this year there was only one large, roadless area (500,000 acres) in New Mexico. Fifteen years before there were six such areas (Flores 1992: 8).

1925 Thirty-four wolves were killed in the state, and only a few were left on the Jicarilla Apache Reservation and along the southern border (Brown 1983: 71).

1925 The last grizzly bear east of the Rio Grande was killed near Raton (Brown 1983: 150).

1926 (January 22) The U.S. Forest Service issued a memo "New Grazing Regulations on National Forests," which made three major concessions to livestock raisers: (1) 10-year grazing permits were given full status of a contract between the USFS and the stockmen and could only be revoked because of a violation of terms, (2) further distribution of grazing privileges was generally suspended, and (3) the role of local grazing boards was reemphasized, with one member representing the U.S. Department of Agriculture and the other members selected by the grazing permittees. These boards settled grazing disputes and gave advice in developing new grazing policies (Rowley 1985: 134–135).

1926 (August) A flood along the Galisteo drainage destroyed acequias at Colorado Plaza, Ortiz, Los Cerrillos, and Tijon (Cooperrider and Hendricks 1937: 15).

1926 Some Hispanic farmers in the Middle Valley expressed concern for the Middle Rio Grande Conservancy District program (Orona 1994).

1926 Some 8,300 acres at the south end of the Middle Rio Grande Conservancy District were excluded as a result of protest on behalf of the owners of the Bosque del Apache grant, the Victorio Land and Cattle Co., and 26 property owners in the Valverde-La Mesa area. This reduced the irrigable acreage to 123,267 (Clark 1987: 209).

1926 The U.S. Forest Service published *The Story of the Range* by Will C. Barnes, Assistant Forester and Chief of Grazing. This report documented grazing history and resulting impact on Great Plains and Southwest rangelands.

1926 The Achison, Topeka and Santa Fe Railroad contracted to provide 34,256 linear feet of trestle piling, 237,498 board-feet of native pine bridge timber, 81,610 board-feet of native pine box culvert timber, and 60,000 native pine track ties for construction of the Cuba Extension rail line, from San Ysidro to north of Cuba. The timber was cut in the Jemez Mountains (Glover 1990: 48).

1926 Large-scale development of mining operations at Willow Creek was begun by the American Metal Company (Northrop 1959: 39).

1926 or 27 The San Luis irrigation ditch on the Puerco was destroyed by a flood (Widdison 1959: 276–277).

1926–27 Salt cedar was widely planted by the Soil Conservation Service along the Rio Puerco and Rio Salado (Robinson 1965: A7).

1926–36 The average rate of sedimentation was about 975 acre-feet per year in the Rio Grande Valley near San Marcial (Happ 1944: 18).

1927 (pre) The sage grouse was extirpated from its native range in northern and northwestern New Mexico (Ligon 1927: 119).

1927 (March 16) The New Mexico groundwater law was passed, the first attempt by any western state to establish by statute and in relatively permanent form the basic principle governing the appropriation of ground water. All underground waters in the state were declared public waters, subject to appropriation for beneficial uses under the existing laws of the state relating to appropriation and beneficial uses of waters from surface streams, and to be supervised and controlled by the State Engineer. The act also authorized the state to determine sources and recharge of underground waters and to control their future development. The Middle and Upper Rio Grande was declared a groundwater basin (Clark 1987: 236–238).

1927 (fall) Some wolves entered north-central New Mexico from Colorado. They took a large number of young cattle along the Tusas River in the Tres Piedras Country (Brown 1983: 79).

1927 The Rio Puerco channel at La Ventana was about 40 feet deep (Bryan 1928a: 275; Dortignac 1962: 588).

1927 The Rio Puerco channel at San Luis was 22 feet deep (Tuan 1966: 589).

1927 The Rio Puerco channel south of the Santa Fe rail line was 40 feet deep, an increase of 22 feet since 1881 (Bryan 1928a: 277; Tuan 1966: 593).

1927 Predators, such as wolves, coyotes, bobcat, and mountain lions, were considered "the most serious enemy of game conservation in New Mexico" (Ligon 1927: 49–50).

1927 The last plains gray wolf in the state was exterminated by this year (Findley et al. 1975: 28).

1927 U.S. Biological Survey trappers Homer and Albert Pickens took seven gray wolves in the Canjilon Creek-upper Brazos drainages, the last of this species in the area (Pickens 1980: 11).

1927 Mule deer were rare or extinct "in the valleys, especially in the more settled parts" (Bailey 1971: 29).

1927 An estimated 2,950 pronghorns were found in the region (Ligon 1927: 25).

1927 Black bears received legal protection in New Mexico (Findley et al. 1975: 29).

1927 Wild turkey were surviving in only a few isolated areas (Ligon 1927: 114).

1927–36 Annually, the floodway aggraded an average of 0.09 feet, the riverbed 0.12 feet, and outside the floodway 0.02 feet. The floodway just below the mouth of the Rio Puerco aggraded 4 to 5 feet (Happ 1937: i, 3).

1928 The amount of irrigated lands in the Middle Valley decreased to about 6,000 acres (Dortignac 1956: 30).

1928 A plan for flood control, reclamation of land, and irrigation for the Middle Rio Grande Valley was completed by the Middle Rio Grande Conservancy District. Management of Indian lands, sediment control, and water supply were also part of this plan (Wozniak 1987).

1928 A new agreement between the Pueblos and Middle Rio Grande Conservancy District provided that the district would "provide conservation, irrigation, drainage, and flood control" for the Indians (Bayer et al. 1994: 240).

1928 The depth of the Rio Puerco channel at Cabezon was 40 feet (Bryan 1928a: 274).

1928 The McSweeny-McNary Forest Research Act, which called for the development of methods for protection of watersheds, was passed by Congress (Buchanan 1988: 32).

1928 The Cleary coal mine near Ventana produced 10,500 tons of coal during the year (Glover 1990: 51).

1928 Congress appropriated $150,000 for the U.S. Forest Service to "investigate the life histories and habits of forest animals, birds, and wildlife from the standpoint of injury to forest growth and as a supplemental economic resource" (Clark 1987: 266).

1928 An estimated 16 grizzly bears remained in New Mexico (Brown 1985: 153).

1928 The exotic rainbow trout was stocked in 187 rivers, creeks, and lakes across the state (Kuykendahl 1994: 3).

1928 or 29 Construction of drainage canals in Albuquerque's North Valley was begun by the Middle Rio Grande Conservancy District (Sargeant and Davis 1986: 103).

1928–31 The controversy over public grazing lands intensified, with violence caused by illegal fencing. Resulting siltation stemming from overgrazing and erosion threatened costly reclamation projects (Clark 1987: 253).

1928–54 Generally, eroded, overgrazed, and depleted rangelands in the region showed "marked improvement in range conditions" (Branson 1985: 64).

1929 (March 2) Congress passed an act authorizing New Mexico to negotiate specifically for the apportionment of the waters of the Rio Grande and the Pecos River with Texas (Clark 1987: 230).

1929 (September) The flood deposited so much clay and sand sediments over the valley from the head of the Elephant Butte Reservoir to about 11 miles above the mouth of the Rio Puerco that a recent soil survey of the floodplain had to be repeated (Cooperrider and Hendricks 1937: 36).

1929 (September) This damaging Rio Grande flood was caused by rainstorms that produced "destructive flash-flood waters," which "originated largely on impoverished rangelands" (Cooperrider and Hendricks 1937: 31).

1929 The Agricultural Appropriation Act was passed; $160,000 was provided for investigation of soil erosion and the means for its control (Clark 1987: 256).

1929 The state attorney general ruled that "unauthorized obstruction of any natural water course did become actionable for resulting damage" (Clark 1987: 335).

1929 Six pueblos—Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta—were incorporated into the Middle Rio Grande Conservancy District. Some 8,346 acres were under irrigation at the time, and the Pueblos had prior and paramount rights to water for this land. They did not, however, get such rights for 15,261 acres of land reclaimed as part of the project (Sando 1992: 123–124).

1929 (late) The new Middle Rio Grande Conservancy District promised to provide irrigation, drainage, flood control, and conservation for the Pueblos (Bayer et al. 1994: 242).

1929 (post) Following organization of the Middle Rio Grande Conservancy District, the Rio Grande Pueblos persuaded Congress to make a payment of $1,321,000 to the conservancy on their behalf because they could not maintain their subsistence economy if required to pay ongoing commercial charges (Harper et al. 1943: 24).

1929–30 A natural lake and marsh located along the meander of the Rio Grande at San Acacia was drained by the Bureau of Reclamation. This wetland reportedly supported a large population of fish and an array of wildlife species (Marshall and Walt 1984: 281).

1929–30 The major crops, in decreasing significance, for the Socorro-lower Rio Puerco areas, were wheat, alfalfa, corn, beans, chile, melon, cantaloupe, and onions. Alfalfa was the most important cash crop (Poulson and Fitzpatrick ca. 1930: 5–6).

1929, 31 Floods on the Rio Salado destroyed the Santa Rita ditch (Cooperrider and Hendricks 1937: 14–15).

1929–34 Several federal laws resulted in the purchase of more refuge lands; more wildlife conservation authority; studies of the economics of harvesting fish and game, wilderness recreation, and control of erosion and pollution; and creation of wildlife sanctuaries on the national forests (Clark 1987: 267).

1920s (late) Santa Ana Pueblo granted a right-of-way across their lands to the Santa Fe Northwestern Railroad. Construction damaged a flood control dike and caused erosion (Bayer et al. 1994: 238).

1920s (late) Jackrabbit populations increased significantly, and from the view of the livestock industry, they were an "acute problem" (Mortensen 1983: 73). This increase was probably due in part to the decimation of mammals such as wolves, coyotes, and bobcats, which preyed on this rabbit.

1920s Intensive grazing decimated plant cover, which resulted in severe erosion in the region (Forrest 1989: 140).

1920s Aldo Leopold recognized that overgrazing and fire suppression had profoundly altered the landscape and that they were interrelated (Pyne 1982: 520).

1920s Irrigated acreage in the Middle Rio Grande Valley was estimated at 48,750 acres, while some 58,000 acres were water-logged (Wozniak 1987).

1920s Alkali deposits covered much of Albuquerque's North Valley from Pueblo Road to Candelaria Road, except where there were many small lakes or ponds. Agriculture in this part of the valley was not practiced at this time. Also, fish, turtles, and frogs were found in some of the ponds, and mosquitos were a serious problem (Sargeant and Davis 1986: 100–101).

1920s A retail clothing store in Las Vegas sent two buyers to New Mexico and Arizona to buy furs, hides, and wool (Perrigo 1982: 62–63).

1920s Local bounties were paid for bobcats, and most sheep ranchers hunted them vigorously (Bailey 1971: 296).

1920s Wolves were virtually exterminated by trappers and hunters working for the Forest Service, U.S. Biological Survey, and ranchers (Brown 1983: 25).

1920s The Forest Service began to experiment with aerial control of forest fires (Pyne 1982: 523).

1920s–30s Some 1,110 men from 1,202 Hispanic families in the Tewa basin found wage labor outside their villages, but by 1937 only 157 men had found such work. Attempting to return to traditional farming and sheepherding failed due to "changes in the ecological balance, new laws, and competition with modern techniques," which "made it impossible for farming and sheepherding to support the existing population" (Gonzalez 1969: 123).

1920s–30s Several coal mines were operating in the La Ventana area. In 1930 the village had two general stores, a post office, hotel, and school. Owing to coal deposit depletion, loss of the rail line, and the depression, the town was abandoned (Widdison 1959: 283).

1930 (pre) Depressions and former channels of the Rio Grande and lower Rio Puerco-of-the-East in Socorro County became swamps. Much of the topsoils of their floodplains had become water saturated due to a high water table, which fluctuated with overflow and the rise and fall of the two streams (Poulson and Fitzpatrick ca. 1930: 2).

1930 (pre) The last river otter was recorded in the Middle Valley (Hink and Ohmart, 1984:pt.1, 34).

1930 By this year some of the agricultural land in the Middle Valley had been lost to a high water table and high saline content of the soil, which was caused by the aggradation of the Rio Grande streambed due to extensive silt deposits (New Mexico Historical Records Survey 1940: 23).

1930 By this year permits for grazing on the Santa Fe National Forest were reduced to correlate with carrying capacities (Rothman 1992: 159).

1930 By this year Frank Bond controlled the best grazing lands in the Jemez Mountains. He leased land for grazing his sheep from the Forest Service, and after 3 years of use, his forest grazing rights became permanent (Rothman 1992: 129).

1930 (spring) There were 527,000 acres of land under irrigation in New Mexico. About 15 percent of this acreage was irrigated with ground water (Clark 1987: 296).

1930 (spring) The Middle Rio Grande Conservancy District began construction of drainage canals in the Valencia area. High ground or mounds, some with old structures on top, were levelled (Otero 1989).

1930 (spring) As construction of various water control facilities began, armed conflicts broke out between conservancy employees and Hispanic farmers, who did not want their irrigation ditches destroyed at the start of the planting season. Several confrontational meetings between Middle Rio Grande Conservancy District officials and organized farmers, including some Anglos, who could not pay the heavy assessments imposed on their lands, occurred. Subsequently, the legislature passed legislation exempting payments on many tracts in the district for 5 years (Forrest 1989: 83–84).

1930 The State Engineer's Office approved the consolidation of 71 old diversions into six new permanent diversions by the Middle Rio Grande Conservancy District (Wozniak 1987).

1930 Irrigated acreage in the tributaries of the Rio Grande increased to 90,000 acres (Dortignac 1956: 30).

1930 The valley of the Rio Grande in the Socorro area supported dense stands of willow, tornillo, cottonwood, and rabbitbush. On waterlogged soils, vegetation was more sparse, and the open alkali flats were covered with salt grass. In wet depressions or around charcos, bullrush and sedge grasses were dominant. The adjacent, dry uplands supported mesquite, creosote bush, rabbitbush, and sparse bunch grasses. Livestock were grazed throughout the year on salt grass pastures and in the bosques of the Rio Grande and lower Rio Puerco in northern Socorro County (Poulson and Fitzpatrick ca. 1930: 7).

1930 The New Mexico Supreme Court ruled that underground waters are a public resource (Fergusson 1951: 362).

1930 The severity of overgrazing and other abusive land practices resulting in erosion was the focus of a USDA study by Hugh H. Bennett. This led to a comprehensive study of all factors causing erosion; the providing of labor, materials, and plants and seeds; and the acquiring of large blocks of marginal and submarginal land for conversion to grazing or forest reserves (Clark 1987: 256).

1930 The U.S. Census Bureau reported New Mexico's population as 423,317 (Workers of the Writer's Program 1940: 434).

1930 There were 11,144 persons living in Sandoval County and 423,317 in Bernalillo County (Levine et al. 1980: 51).

1930 About three-fourths of the human population in the Upper and Middle basins was classed as rural (Dortignac 1956: 72).

1930 (ca.) This was the last year that cotton was cultivated at Santa Clara Pueblo (Hill 1982: 33).

1930–36 Renovation of irrigation works in the Middle Valley was completed, including the construction of new diversion structures at Cochiti, Angostura, Isleta, and San Acacia, a siphon at Corrales, 767 miles of canals and laterals (including some rehabilitation), 342 miles of interior and riverside drains, and 180 miles of riverside levees (Wozniak 1987).

1930–40 Alluviation on the lower Rio Puerco below the Santa Fe rail line raised its channel 14 feet. This process occurred when so much sediment was carried from the upper course of the river and deposited along the lower course (Tuan 1966: 593).

1930–50 Droughts, floods, and overgrazing adversely impacted Santa Ana's livestock raising and crop production. The silting of farmlands was a continuing problem. Extensive sand dunes formed along the Jemez River, and ring muhly and broom snakeweed replaced native grasses in most of the rangeland (Bayer et al. 1994: 230–231).

1931 (pre) The vegetative cover of the upper drainage of the Santa Fe River was severely denuded due to overgrazing (Cooperrider and Hendricks 1937: 77).

1931 (pre) The Senorita Canyon area of the Santa Fe National Forest was overgrazed, and subsequently the canyon floor just outside the forest boundary was deeply trenched. Inside the fenced boundary "herbs, shrubs and small trees ... formed a dense cover between the old trees," and the "accelerated flow of the creek "had been checked" in recent years (Cooperrider and Hendricks 1937: 76).

1931 (pre) "Users of public lands never found it advantageous to protect or even conservatively graze any range they did not control.... Homesteaders who settled as groups or colonies on the most favorable of the remaining tracts of unreserved public domain also contributed to the impairment of rangelands.... For a time many of them believed that whatever was responsible for the untoward state of things was abnormal and that if they could produce enough to live on for another year, conditions would be better. They therefore grazed in common the surrounding public lands to the utmost, in the attempt to eke out subsistence" (Cooperrider and Hendricks 1937: 82).

1931 (March 2) Congress passed an act that provided $1 million to the Agriculture Department to completely eradicate predatory animals in the West over 10 years (Hagy 1951: 94).

1931 (September 1) The Laboratory of Anthropology was opened to the public (Workers of the Writer's Program 1940: 205).

1931 (September) Runoff from a rainstorm caused the banks of the Rio Puerco between Bernalillo and Cuba to slide, endangering the highway connecting the two settlements. Other roads and bridges in the Cuba Valley were damaged (Cooperrider and Hendricks 1937: 20, 76).

1931 On about 25 percent of the land in the Upper and Middle Rio Grande basins "normal soil erosion" was taking place. On about 35 percent of the lands accelerated erosion was occurring. On about 40 percent of the region rapid erosion was in progress (Cooperrider and Hendricks 1937: 86).

1931 At least 50 percent of the forage had been lost in the Upper and Middle Rio Grande drainages, primarily due to overgrazing and subsequent erosion (Cooperrider and Hendricks 1937: 72).

1931 Decimated and eroded rangelands with "low grazing capacity" had "high operating costs" because they "required" high investments per head of livestock in fences, watering places, and ranch equipment (Cooperrider and Hendricks 1937: 73).

1931 The forest on the upper Rio Cebolla in the Jemez Mountains was virgin. The plant cover within an "old cemetery" protected from grazing by an enclosure and located 2 miles southwest of Albuquerque was 85 percent grass species, 13 percent shrubs, and 2 percent weeds. Grasses on surrounding, extensive tracts were "practically extinct" due to overgrazing, and the total density of the present vegetation (weeds and half-shrubs) was "less than one-third of that within the enclosure." These lands had 50 percent less plant cover than the enclosed cemetery and other locations protected from grazing (Cooperrider and Hendricks 1937: 22, 84).

1931 Ongoing erosion was so severe in the Rio Puerco valley between La Ventana and Cuba that the railroad had to be abandoned (Cooperrider and Hendricks 1937: 11–12).

1931 The Soil Conservation Service initiated an erosion control program for the 11,500,000-acre watershed of Elephant Butte Reservoir, which was filling with sediment at a rapid rate (Clark 1987: 256).

1931 The U.S. Forest Service sold an estimated 207,900,000 board-feet of timber in the Rio de las Vacas watershed to the White Pine Lumber Company. This sale involved about 40,000 acres of land (Glover 1990: 26).

1931 The state declared that the waters of underground streams, channels, artesian basins, reservoirs, and lakes having reasonable, ascertainable boundaries are public waters subject to appropriation for beneficial use in accordance with the statutes and with rules and regulations formulated by the State Engineer of New Mexico (Erickson 1954: 81).

1931 The New Mexico Legislature passed a law giving the State Game Commission full regulatory powers to manage the wildlife of the state, including setting hunting seasons and bag limits (Barker 1970: 188; Flader 1978: 105).

1931 Under state game management, the pronghorn antelope population had increased to 5,000 animals (Barker 1976: 136).

1931–85 The total acreage of aspen stands and subalpine meadows decreased due primarily to fire suppression and cutting restrictions. Aspen stands decreased by more than 50 percent due primarily to the exclusion of fire. The mixed-conifer type and meadows increased by more than 81 percent due to the above and cutting restrictions (Johnson 1995: 2).

1932 (pre) "The plant cover of overgrazed cut-over savanna woodlands . . . declined as much as 70 percent, and dense woodlands [pinyon-juniper], 72 percent." Generally, rutted trails and roads made by woodcutters' livestock, carts, and wagons in the pinyon-juniper woodlands became deep gullies. Erosion was extreme on about 45 percent of these lands which had become severely eroded by 1931 (Cooperrider and Hendricks 1937: 60, 62).

1932 Acting under the authority of the Taylor Grazing Act, President Roosevelt reserved from entry all unreserved lands in 12 western states. This virtually ended homesteading in the region (Clark 1987: 254).

1932 The U.S. Forest Service suspended grazing fees because of the emergency conditions of the depression (Rowley 1985: 246).

1932 The last gray wolf in the Jemez Mountains was killed in the Valle Grande by a rancher (Scurlock 1981a: 148). One federal trapper took 36 mountain lions in the Jemez Mountains; 10 of these were trapped in Bandelier National Monument (Pickens 1980: 73).

1932–33 The Forest Service surveyed watershed conditions in the Rio Grande basin above Elephant Butte. Rapid deterioration of vegetation cover due to livestock overgrazing since the 1880s and subsequent accelerated erosion and gullying were documented. Increased sedimentation in the river had caused the loss of about 13 percent of Elephant Butte Reservoir's capacity (Clark 1987: 258).

1930s (early) Hispanics organized a farmers' association in the Los Lunas area over concern that their ditches might be lost to the Middle Rio Grande Conservancy District (Orona 1994).

1930s (early) Much of the Pueblo rangeland was overgrazed and overstocked (Aberle 1948: 17, 19).

1930s (early) More than 1,500 horses were removed from the Jemez River District of the Santa Fe National Forest (Tucker and Fitzpatrick 1972: 81).

1930s (early-mid) Tonque Arroyo had eroded 5 to 20 feet deep and from 20 to 50 feet wide. Formerly, the drainage consisted of a shallow depression (Cooperrider and Hendricks 1937: 12).

1930s (early-mid) Mountain streams in the upper Chama basin had lowered and widened their beds due to intensive logging and grazing. Their valleys had "drained through the formation of gullies and arroyos" and had "mostly iris and weeds, in contrast to dense growths of grasses and grasslike plants of valleys still in good condition" (Cooperrider and Hendricks 1937: 13–14).

1933 (early) President Franklin Roosevelt created the Civilian Conservation Corps (CCC). About 3 million persons, mostly young men, worked primarily on soil and water conservation projects until 1942 (Buchanan 1988: 32–33; Udall 1963: 140–141, 143).

1933 (spring) Eight young men from Placitas were called to a CCC camp in the Sandia National Forest (Batchen 1972: 4).

1933 (November-December) The road into Frijoles Canyon at Bandelier was constructed (Rothman 1992: 193).

1933 Unionization of coal miners and a tougher, comprehensive mining law reduced deaths due to mining accidents (Whiteside 1989: 183).

1933 The U.S. Forest Service declared the Pecos "high country" a primitive area (deBuys 1985: 285).

1933 Bighorn sheep from Banff National Park were released in the Sangre de Cristo Mountains (Barker 1953: 90).

1933 late (or early 1934) A gray wolf was killed between Ojo Caliente and Tres Piedras (Pickens 1980: 11).

1933–40 A range conservation program was carried out on Indian lands in the Middle Valley by the Soil Conservation Service (Harper et al. 1943: 89).

1933–40 New Deal agencies, and the Bureau of Indian Affairs, conducted a number of in-depth surveys of natural and human resources in the Middle and Upper Rio Grande valleys. Hispano, Native, and to a lesser extent, Anglo American, interrelationships with each other and their shared environment were first addressed by these studies (McWilliams 1961: 287).

1933–46 Livestock from Bernalillo trespassed on Santa Ana lands; non-Pueblo fishermen drove over pasture land, dumped trash, and cut firewood; and Frank Bond illegally allowed his sheep to graze rangelands (Bayer et al. 1994: 238).

1934 (June 18) The Indian Reorganization Act, giving Native Americans the right to govern themselves, was passed. Under this act, the

U.S. Government determined the organizational structure of Indian government. The act, in part, prohibited alienation of Pueblo lands (Simmons 1979b: 217).

1934 (June 28) The Taylor Grazing Act authorized the Secretary of the Interior to establish the Grazing Service, to control and manage grazing on the public lands, to rehabilitate overgrazed and eroded areas, and to construct improvements on federal lands (Hagy 1951: 75). In 1946 this agency was combined with the General Land Office to form the Bureau of Land Management (Clawson 1971: 34–38). The bulk of unappropriated grassland (80 million acres) was closed to further settlement by the act. These lands were to be kept as a grazing resource and managed by local livestock growers organized in districts and supervised by the Department of the Interior (Worster 1979: 190).

1934 (June 30) The National Resources Board, which sponsored ground and surface water studies, was created by executive order (Clark 1987: 250, 256).

1934 The governor created a State Planning Board made up of five major state agencies and presidents of the three major universities; they began a study of the state's natural resources, with emphasis on erosion problems and water conservation (Clark 1987: 269).

1934 The U.S. Government purchased the "badly overgrazed and eroded" Ojo del Espiritu Santo land grant and began a resource management program (Varney 1987: 35).

1934–35 The State Planning Board found that the public rangelands in the state were badly damaged due to overgrazing (Clark 1987: 255).

1934–42 The Grazing Service organized four districts embracing almost 1.5 million acres of grazing lands in the Middle Rio Grande Basin to regulate grazing (Harper et al. 1943: 88–89).

1934–44 The continuing overuse and deterioration of Pueblo land led to an accelerated land acquisition program. About 390,727 acres were purchased or assigned to Indian use on non-Pueblo lands. Another 199,255 acres of public land were under lease or permit from the state, the Forest Service, or the Taylor Grazing Service (Aberle 1948: 15–16).

1934–40s Livestock raisers "succeeded in mitigating the law's impact by formation of district and state advisory boards. These boards were elected by permitters and became the de facto governing boards." The U.S. Grazing Service generally followed the board's recommendations. As a result "range conditions improved very slowly" (Eastman and Gray 1987: 35).

1934–82 Peak flows of the Rio Puerco averaged 9,082 cfs, while those of the Rio Grande averaged 5,664 cfs (Crawford et al. 1993: 53).

1935 (May) The Rural Electrification Administration was created to make loans for the construction of electric power distribution systems and to improve telephone communication facilities in rural areas (Smith and Zurcher 1968: 328).

1935 (November) The starling was first recorded in New Mexico at Carlsbad, and the first birds of this species reached Albuquerque in November of the next year (Hubbard 1978: 68).

1935 There were 669,000 sheep and 212,000 cattle in the Middle and Upper Rio Grande basins (Harper et al. 1943: 49).

1935 Virtually all of the Tewa basin was described as "tragically overgrazed" (Weigle 1975: 36).

1935 Overgrazing of grant and public lands around El Rito resulted in reduction of livestock (Weigle 1975: 152).

1935 Deforestation 35 miles up the Rio En Medio and Chupadero watersheds by several lumber mill operations and local cutting for fuelwood resulted in severe soil erosion. Some 20 acres of farmland were lost near the Chupadero village (Weigle 1975: 66).

1935 Under the leadership of John Collier, a New Deal land reform program for Native Americans and Hispanics was implemented. Part of this program was aimed at restoring the fertility of severely eroded land (Forrest 1989: 129).

1935 Crested wheatgrass (*Agropyron cristatum*), a native of Eurasia, had been introduced in Colorado but not New Mexico (Hitchcock 1935: 231).

1935 The New Mexico Legislature passed the Oil Conservation Law, and state-supervised prorationing of oil began (Kinney 1950: 164).

1935 The average size of a Spanish farm along the Pojoaque River near El Rancho was 4.9 acres (Carlson 1969: 32).

1935 At El Rito the average family used six cords of fuelwood, primarily juniper and pinyon, per year (Weigle 1975: 153).

1935 CCC workers constructed a road from Los Alamos to Cuba via the Valle Grande (Scurlock 1981a: 148).

1935 The Historic Sites Act, requiring archeological investigation prior to the construction of a federal reservoir or a federally permitted reservoir, was passed by Congress (McGimsey n.d.: 16).

1935 The Office of Superintendent of State Parks and a Park Commission were created by the legislature (Clark 1987: 272).

1935 Depredation on livestock increased due in part to the drought (Brown 1985: 157).

1935 The Wilderness Society, led by Robert Marshall, was founded (Brown and Carmony 1995: 163).

1935–38 The Caballo Dam, located on the Rio Grande below Elephant Butte, was constructed to stabilize the international boundary, to impound water for irrigation and power generation during the winter months, and to control floods (Clark 1987: 252).

1935–39 Livestock numbers were reduced on Pueblo lands because of deterioration of rangelands due to overgrazing (Aberle 1948: 20).

1935–47 Salt cedar, or tamarisk, spread over about 24,500 acres of irrigable farmland in the Middle and Upper Rio Grande valleys (Hay 1972: 288).

1935–50 The average size of farms increased, but the irrigated land per farm remained between 15 and 16 acres due to a general decrease in irrigated acreage in the Upper and Middle Rio Grande basins (Dortignac 1956: 79).

1935–89 The middle Rio Grande channel area narrowed by approximately 50 percent. This resulted from the preclusion of periodic high discharge events, which maintain the channel capacity and geomorphology of the river, construction of dams, and increasing diversion of water (Crawford et al. 1993: 54).

1930s (mid) By this time, increased use of water, evaporation, and lowering of water tables resulted in a 50 percent decrease in flow of the Rio Grande since 1880 (Kelley 1982: 18).

1930s (mid) Most of the residents from the middle Rio Puerco-of-the-East valley moved upstream to the higher Cuba area, where agriculture was still relatively reliable (Calkins 1937b: 18–19).

1930s (mid to late) The Soil Conservation Service purchased the Ramon Vigil grant on the Pajarito Plateau from Frank Bond. This agency initiated soil and water protection plans for the grant, for San Ildefonso and Santa Clara lands, and for other lands on the Pajarito Plateau (Rothman 1992: 199).

1936 (April) The Grazing Service administered four grazing districts totalling almost 9 million acres (Clark 1987: 255).

1936 (October 1-October 1, 1941) The total suspended sediment load of the Rio Grande at San Marcial was 47,583,342 tons. This represented 2.07 tons per acre or 0.7 acre-feet per square mile annually. At least 90 percent of this total was probably derived from grazing land (Happ 1944: 17).

1936 The Middle Rio Grande Conservancy District completed construction of irrigation works for 118,000 acres of land. Completed work included the Cochiti, Angostura, Isleta, and San Acacia diversion dams, 180 miles of new canals, 294 miles of new laterals, and 200 miles of riverside levees. The valley water table was being lowered, and 59,159 acres of land were being irrigated (Clark 1987: 212; State Engineer Office 1956: 3).

1936 A new irrigation dam at San Luis, located about one-half mile above the site of the earlier structure, was completed by the Soil Conservation Service (Widdison 1959: 277).

1936 The Forest Service estimated that at least 75 percent of the Rio Grande watershed in southern Colorado and northern New Mexico was experiencing severe, accelerated erosion. This resulted primarily from removal of the plant cover through overgrazing and logging (deBuys 1985: 230–232).

1936 The New Mexico Lumber and Timber Co. of Bernalillo purchased the timber rights to the Baca No. 1 location in the Jemez Mountains. Here, and on nearby lands of the Santa Fe National Forest, there were an estimated 400 million board-feet of timber cut (Glover 1990: 36).

1936 The total stocking of the upper Rio Puerco valley was 14,500 cattle-units for the year; the grazing capacity was estimated to be 4,300 cattle-units (Maes and Fisher 1937: 34).

1936 Activities of nomadic stockmen, who had roamed the range with no base of operation, were stopped by the Division of Grazing (Clark 1987: 255).

1936 Salt cedar was scattered over 51,120 acres of valley land between Cochiti and Elephant Butte Reservoir (Lowry 1957: 4).

1936 By the end of this year some 61,294 acres of agricultural land were in cultivation (Wozniak 1987).

1936 Sixty Santa Ana Pueblo farmers harvested 6,200 bushels of corn, 3,250 bushels of wheat, 100 bushels of apples, and 4,000 bushels of grapes (Bayer et al. 1994: 229).

1936 Aldo Leopold called for the inventory and preservation of rare and threatened animals and plants (Brown and Carmony 1995: 199).

1936 (ca.) The juniper-pine-rock irrigation dam near Guadalupe, Sandoval County, burned, and local farmers could no longer receive adequate ditch water (Garcia 1992: 25, 27).

1936–37 Santa Ana's rangelands could support only 54 head of cattle or horses on a year-long basis. The Pueblo owned 634 cattle and several hundred horses, or 84 percent more animals than the carrying capacity of the grazing lands. Grazing leases and supplemental feeding prevented loss of their livestock. Fencing of their boundaries also kept out Bernalillo stock, which had contributed to the overgrazing problem (Bayer et al. 1994: 231, 233, 238).

1936–41 The average annual suspended sediment loads amounted to 39 million tons in the Upper and Middle Rio Grande. The mean annual suspended sediment load in the Middle Basin, by percent, was 21 for the Rio Chama, 10 for the Jemez River, 41 for the Rio Puerco, 10 for the Rio Salado, and 15 for minor tributaries. The river flow above the Chama contributed 3 percent. Gullying and arroyo trenching produced 65 percent of the total sediment load, sheet erosion 30 percent, and wind erosion 5 percent (Dortignac 1956: 48–49).

1936–41 An estimated 17,100 acre-feet per year of soil materials, the equivalent of 2 tons per year, eroded in the Middle Rio Grande Basin (Happ 1944: 17).

1936–47 Cottonwood, willow, and tamarisk cover increased from 38,400 to 51,120 acres in the Middle Rio Grande Valley (Lowry 1957: 4).

1937 (pre) An aggrading riverbed of the Rio Grande caused the water table to rise and waterlog fields in the Plaza Contadero. Former cultivated land was replaced with salt grass (Calkins 1937b: 20).

1937 (June 28) Congress formalized the Civilian Conservation Corps; personnel from this agency were to provide works "for the protection, restoration, regeneration, improvement, development, utilization, maintenance, or enjoyment of the natural resources of lands and waters, and the products thereof." Water development and conservation, improved range projects, and other projects were carried out with funding allocated to the National Park Service, U.S. Forest Service, Bureau of Reclamation, Soil Conservation Service, U.S. Fish and Wildlife Service, and state parks and forests. The CCC also contributed to wildlife and recreational programs. A special Indian Conservation Corps was also created. There were 43 camps in New Mexico; the program ended in 1942 (Clark 1987: 244–245).

1937 (August 26) The Small Reservoirs Act, which provided funding for constructing small water storage structures for isolated communities and groups of ranchers, was passed (Clark 1987: 263–264).

1937 Aldo Leopold wrote the following about the watersheds of northern Sierra Madre of Mexico compared to those in New Mexico's national forests: "But the watersheds are intact, whereas our own watersheds, sedulously protected from fire, but mercilessly grazed before the forests were created, and much too hard since, are a wreck" (Brown and Carmony 1995: 203).

1937 Some 8,000 individuals, almost all Hispanic, "lost their land titles because they were unable to pay taxes and assessments on the Middle Rio Grande Conservancy District Project . . ." (Gonzalez 1969: 52).

1937 Congress passed the Bankhead-Jones Farm Tenant Act, which authorized the Federal Government to purchase private lands of low production. These tracts were added to national forests, national parks, grazing districts, and other public land holdings (Levine et al. 1980: 53).

1937 There were 56,240 acres of public domain, 19,044 acres of U.S. Forest lands, and 75,431 acres of private lands being grazed in the Rio Puerco valley, from Regina-Cuba to Casa Salazar (Calkins 1937b: 6).

1937 The Forest Service released its report, *The Western Range*, which described "the critical deterioration in the condition of lands, regardless of ownership, prevailing in the public-land states" (Clark 1987: 274).

1937 About 85 percent of New Mexico's 77,488,536 acres were in a state of active erosion; some 46 million acres were losing topsoil at a high rate, and 41 million were already severely gullied. In response, the legislature created a soil conservation act (Clark 1987: 269).

1937 A soil conservation act was passed by the State Legislature, creating soil conservation districts to be assisted by other state and appropriate federal agencies. These districts were concerned with erosion control, water development, and land classification based on best use (Clark 1987: 270–271).

1937 Congress passed legislation creating soil conservation districts in the states (Batie 1985: 109).

1937 Three soil conservation grants totalling 174,000 acres were allocated to the Pueblos. These lands had a carrying capacity of 1,656 cattle. Three other such grants totalling 187,000 acres with a carrying capacity of 1,601 cattle were made to non-Indians, but primarily for Hispanic use (Forrest 1989: 141).

1937 All of Santa Ana's rangelands, except the mesa, were severely overgrazed and eroded. Extensive sand dune areas had formed along the Jemez River, siltation had ruined crops and clogged one of two wells, and desirable grasses had been replaced largely with ring muhly and snakeweed. The range agent reported that the rangelands "could support only 39 head of cattle and horses on a yearlong basis" (Bayer et al. 1994: 231, 233).

1937 The first state park, Bluewater Lake, was created (Clark 1987: 271).

1937 The Works Projects Administration, the Public Works Administration, and the National Youth Administration also provided employment for workers, who carried out conservation and reclamation projects for water and wildlife improvement (Clark 1987: 245).

1937 The Wildlife Restoration Act of 1937, also known as the Pittman-Robertson Act, created the Federal Aid to Wildlife Restoration Fund, required rivers and harbors appropriation to include funding for investigations and improvements of wildlife, and fostered closer cooperation between federal and state governments (Clark 1987: 268).

1937–38 The National Resources Committee and the Rio Grande Compact Commission conducted a comprehensive and detailed study of the land and water resources of the Rio Grande Basin north of Fort Quitman, Texas. The study addressed problems such as stream flow, apportionment of waters between the two states and Mexico, and flood and silt control (Clark 1987: 218–221).

1938 (August 20) The Pueblo and Spanish ruins of Abo were declared a state monument (Toulouse 1949: 1).

1938 (August) The Middle Rio Grande Conservancy District delegated 29 men to eradicate "gophers that threatened levee and irrigation ditch banks" from Alameda to Isleta Pueblo (Biebel 1986: 62).

1938 By this year Hispanic "community-owned" land grants were reduced to a total of 300,000 acres (Dortignac 1956: 72).

1938 A state game refuge was established on the east side of the Sandia Mountains (McDonald 1985: 12).

1938 A reservoir was built in the foothills west of Santa Clara Pueblo. Water from this impoundment was piped to within a few feet of each home (Hill 1982: 41).

1939 (February 1) Some 25,295 acres of the Ramon Vigil grant were transferred from the Soil Conservation Service to the Forest Service. The San Ildefonso sacred area within the grant was transferred to the Pueblo on September 18 (Rothman 1992: 204).

1939 By this year the Division of Grazing had built 585 check dams to control erosion and 31 reservoirs with an aggregate capacity of 17,500 acre-feet benefiting 75,000 acres of land (Clark 1987: 256).

1939 The first bridge for wagons and cars across the Jemez River was built (White 1962: 322).

1939 More than 5,500 acres of farmland were irrigated by 17 ditch systems in the Rio Puerco valley above Cuba (Dortignac 1960: 48).

1939 A resurvey of the Rio Puerco channel determined that the volume from below Cuba to its mouth was 267,000 acre-feet, an increase of 250,000 acre-feet over the last 55 years (Dortignac 1960: 47).

1939 There were 44 families living at San Luis, Sandoval County, and all but two were receiving government aid (Widdison 1959: 281).

1939 Legislation protecting the marten, mink, long-tailed weasel, and ermine was passed by the state (Sharpe 1983: 269).

1939 The Federal Aid to Wildlife Act was passed by Congress, and money became available to acquire habitat lands. Some 30,000 acres were purchased for this purpose in New Mexico (Barker 1976: 100–101).

1939 (late) New Mexico Game and Fish personnel released the first of a reintroduced herd of Rocky Mountain bighorn sheep from British Columbia into the Sandia Mountains (Pickens 1980: 83).

1939–64 Plant cover on five of six major vegetative communities on National Forest lands increased for protected and grazed plots. For grasslands the basal cover changed from 6 to 18 percent where protected and from 4 to 13 percent where grazed. In pinyon-juniper the increase was from 3 to 10 percent and 3 to 8 percent, respectively. For ponderosa pine it was 2 to 7 percent and 3 to 4 percent, respectively. In aspen stands the grass cover increased 22-fold under protection, an increase nearly three times greater than grazed plots (Potter and Krenetsky 1967).

1930s The Middle Rio Grande Conservancy District erected a concrete dam on the Rio Grande, about 3 miles north of Cochiti Pueblo. A major canal from each bank above the dam extended southward, delivering water to Cochiti, Santo Domingo, San Felipe, and Algodones. At Cochiti, floodwater farming was virtually abandoned, and irrigation farming increased greatly (Lange 1959: 38, 368).

1930s Some 300 farmers in the Albuquerque area erected a barricade in the North Valley to halt construction work by the Middle Rio Grande Conservancy District (Orona 1994).

1930s Following construction of the irrigation system at Cochiti, agricultural plots that had been dry-farmed previously were abandoned (Lange 1959: 38).

1930s Spanish livestock overgrazed the lands around Vadito, including locales on Picuris Pueblo land (Carlson 1979: 36).

1930s When the large, Hispanic livestock holders in the region were forced to reduce their herds, many young men whom they employed lost their jobs. Many of them sought work in Colorado and Utah (Gonzalez 1969: 127).

1930s Trucks replaced horses in logging operations (Glover 1990: 37).

1930s Wild horses, which grazed the Manzano Mountains bajada, grazed inside the Albuquerque airport boundaries, even after it was fenced (Speakman 1965: 31).

1930s Salt cedar, or tamarisk, began to invade the valley at Albuquerque (Scurlock 1988a: 138).

1930s Populations of small and large game species were decimated, some extirpated, in the Sandias due to intensive hunting and poaching (McDonald 1985: 12).

1930s Skiing became popular in northern New Mexico, and ski clubs were organized at Taos, Las Vegas, and Albuquerque (Nordhaus 1966).

1930s Electricity was introduced to the Valencia-Los Lunas area (Gallegos 1970: 75).

1930s (late) A shallow lake, bordering Albuquerque on the north and south, was drained by the Middle Rio Grande Conservancy District (Oppenheimer 1962: 36).

1930s (late) Crested wheat grass was introduced into New Mexico and adjacent mountain states by Agricultural Experiment Stations and the U.S. Forest Service (Hitchcock 1935: 231).

1930s (late) (to 1944) During this period the Pueblos doubled their land use base through an aggressive acquisition program and by procurement of permits or leases on neighboring federal or state land (Simmons 1979b: 216).

1930s–40s Horse traffic on the trail from the Seven Springs area in Tijeras Canyon to South Sandia Peak caused severe erosion. The trail was subsequently closed (McDonald 1985: 13).

1930s–40s Large herds of goats and sheep were grazed in the Los Pinos and Ladron mountains. This intensive grazing changed the floristic composition of rangeland on the Sevilleta land grant (Manthey 1977: 10–11).

1930s–60s Santa Ana Pueblos, through leases and permits, allowed non-Indian businesses to mine bentonite, sand, clay, gravel, pumice, and volcanic ash on their lands (Bayer et al. 1994: 229).

1940 (pre) "Louisiana" bullfrogs were released into Albuquerque's north valley (Sargeant and Davis 1986: 41).

1940 (January) The Upper Rio Grande Drainage Basin Committee held its first meeting. This group, made up of personnel from state and federal agencies, heard various parties discuss and protest against irrigation projects and possible loss of water rights to new development along the river (Vlasich 1980: 33).

1940 There were 255,800 cattle-units per year in the Middle and Upper Rio Grande basins, 116,000 units above carrying capacity (Harper et al. 1943: 50).

1940 More than 30 million acres, or about 39 percent of the total land area of the state, was used for agricultural and grazing activities. Included were 10 million acres in national forest, 16 million in public domain, 2.4 million Native American owned, and 3 million of railroad land (Culbert 1941: 162).

1940 The total farmland in the Middle and Upper Rio Grande valleys was 172,375 acres (Harper et al. 1943: 70).

1940 The U.S. Forest Service and Bureau of Land Management began to fence federal land in the Rio Puerco-of-the-East valley and traditional grazing lands on Mesa Prieta and the San Mateo Mountains, including Mount Taylor (Garcia 1992: 23).

1940 Several grizzly bears were reported on the Jemez District of the Santa Fe National Forest, the last such record for the state (Brown 1985: 160–161).

1940 Most wild horses had been removed from rangelands except on Indian reservations and "waste lands outside of the grazing districts and fenced areas" (Wyman 1945: 173).

1940 The Bureau of Fisheries and the U.S. Biological Survey were transferred and consolidated into the Fish and Wildlife Service, Department of the Interior (Clark 1987: 268).

1940 The population of Sandoval County was 13,898 (Levine et al. 1980: 54).

1940 About two-thirds of the human population in the Upper and Middle basins was classed as rural (Dortignac 1956: 72).

1940 (ca.) Elk from Wyoming, Wichita Mountains National Wildlife Refuge in Oklahoma, and the Philmont Boy Scout Ranch were transplanted on Mount Taylor, in the Jemez Mountains, and in the Hopewell and Tres Piedras areas of the Carson National Forest (Barker 1976: 109–110).

1940 (ca.) The La Joya State Waterfowl Refuge was established (Barker 1976: 104).

1940–41 Per an agreement with the Federal Government, Frank Bond removed many of his sheep from the upper Rio Puerco grazing precinct. He continued to graze sheep on the checkerboard railroad lands that he controlled, however, keeping grazing pressure on the area (Forrest 1989: 157–158).

1940–41 The Soil Conservation Service sponsored projects to control erosion on Santa Ana Pueblo land by erecting fences and windbreaks (Bayer et al. 1994: 228).

1940–42 Thirty-seven elk from Yellowstone National Park were released near Grass Mountain in the Sangre de Cristos (deBuys 1985: 356).

1940–44 Pueblo agricultural acreage increased by 15.3 percent, to a total of 21,855 acres. This increase was due to government assistance, part of the effort to increase food production during World War II (Vlasich 1980a: 40–41.

1941 (pre) Pronghorn antelope were hunted on the grasslands and savannahs near Santa Clara Pueblo. The surround technique was used by the hunting party, and 30 to 50 animals were killed on a successful hunt. A few pronghorns were allowed to escape to produce more animals (Hill 1982: 52).

1941 (pre) Various duck and goose species, sandhill cranes, wild turkey, blue grouse, scaled quail, band-tailed pigeon, mourning doves, "blackbirds," American robin, lazuli bunting, juncos, bluebirds, and Bullock's and Scott's orioles were hunted for food by residents of Santa Clara Pueblo. Eagles, hawks, vultures, roadrunners, flycatchers, Stellar's and pinyon jays, tanagers, warblers, billed magpies, orioles, and bluebirds were taken for their feathers (Hill 1982: 54–59).

1941 (pre) Residents of Santa Clara Pueblo caught carp, sucker, eel, catfish, and trout for food (Hill 1982: 59).

1941 There were seven districts with just under 16 million acres under the administration of the Division of Grazing (Clark 1987: 255).

1941 A water course was redefined as "a channel having definite banks and beds with visible evidence of the occasional flow of waters" (Clark 1987: 335).

1941 Five gray wolves and five or fewer grizzly bears were left in the Rio Grande National Forest, the entire population in Colorado (Warren 1942: 39, 92).

1941–43 Most commercial sheep and cattle ranchers were convinced that the severe soil erosion was simply a result of a natural aridity and that they and others were helpless in what they viewed as a natural and inevitable process (Forrest 1989: 160).

1941–43 Each family in the Rio Puerco-of-the-East was permitted to graze 15 head of sheep in its grazing precinct administered by the Grazing Service. This number of livestock was considered below the minimum needed for subsistence (Forrest 1989: 159).

1941–45 Corn, wheat, oats, alfalfa, beans, squash, chile, onions, cabbage, potatoes, watermelons, muskmelons, various other vegetables, peaches, apples, cherries, and grapes were being grown at Zia Pueblo (White 1962: 86–87).

1941–55 About one-fourth of the timber area in the Upper and Middle basins was in private ownership, while about two-thirds was in national forests. The remaining timber stands were on other federal, state, or Indian lands. For the national forests, about two-thirds of the land was ponderosa pine, one-fifth in spruce-fir, and the remainder in Douglas fir. About half of the ponderosa stands had been cut over, and less than 10 percent of the spruce-fir had been cut over. Some 5.4 billion board-feet of timber were in the national forests. An estimated 60 million board-feet were logged during the first year, and almost 70 million board-feet in 1950 (Dortignac 1956: 67–69).

1942 (June 6) Levees were strengthened and raised by the combined efforts of various governmental agencies. Cottonwood and other woody vegetation from bosque stands were used to construct mats for protection of levees at critical bends in the river (Happ ca. 1942: 2–5).

1942 The Pueblos owned about 20,700 acres of irrigable land in the Middle Rio Grande Basin; about 8,500 acres were in cultivation (Nelson 1946: 1).

1942 There were 14,972 acres under cultivation in the Rio Puerco basin (Harper et al. 1943: 11).

1942 The carrying capacity of over 12,100,000 acres of rangelands in the Middle Rio Grande Valley was estimated at 139,800 cattle-units or 699,000 sheep or goats per year. Some 255,800 cattle-units were actually on the range (Harper et al. 1943: 50).

1942 The "new" Santa Ana pueblo, now known as Santa Ana No. 1, east of old Highway 85, was described by Leslie White (1942: 32): "There are fertile lands on the east bank, which, of course, are under cultivation. On both sides of the river are sand bars, alkali flats, and some scrub woods (mostly cottonwoods)."

1942 A small pronghorn herd was observed grazing about 10 miles south of Santa Fe (Hewett and Dutton 1945: 108).

1942 Gross, Kelly, and Co. purchased a railroad car load of pinyon nuts and shipped them from Gallup to a Los Angeles business. Unknown to the owners, the nuts were wet from a snowstorm at the time they were picked, and once stored in the rail car, they became rancid (Kelly 1972: 175–176).

1942–56 The carrying capacity of grazing lands in New Mexico steadily decreased during this extended drought period (Gatewood et al. 1964: B43).

1940s (early) The excavation of Kuaua Pueblo was carried out on Santa Ana Pueblo land without their knowledge (Bayer et al. 1994: 236).

1943 April The All-Pueblo Council met and generally declared opposition to the Flood Control Act of 1941, which was passed after the major flood of that year. The council specifically opposed construction of proposed flood control dams at Otowi and San Felipe but generally supported flood control measures. The council also spoke out against any plans made for Pueblo lands without its input (Bayer et al. 1994: 242–243).

1943 An estimated 48 to 54 percent of the sediments accumulated in the Rio Grande between San Acacia and San Marcial came from the Rio Puerco drainage basin (Tuan 1966: 593).

1943 Because of continued flooding, water shortages for irrigation, stream bed aggradation, siltation of ditches, rising water tables, and financial difficulties, the Bureau of Reclamation and the Corps of Engineers began joint studies directed at protecting levees and property and at rehabilitating and further developing the land and water resources in the Middle Rio Grande (Crawford et al. 1993: 26).

1943 The pueblos of San Felipe, Santo Domingo, and Sandia "were growing excellent potatoes" (Vlasich 1980: 39).

1943–56 As climatic conditions became drier, the level of Elephant Butte Reservoir began to drop. By 1956 the lake was dry, the only time this has occurred (Hay 1963: 494–495).

1945 (July 16) The first atomic bomb was tested in the Jornada del Muerto (Northrop 1959: 41).

1945–49 The State Legislature passed a law that set up a predator control commission with annual funding of $50,000. The four members were from wildlife and livestock agencies. The New Mexico Livestock Growers' Association opposed the program and instead favored using the funds to pay professional hunters of predators (Mortensen 1983: 74).

1945–53 Increased recreational use occurred in the region, which increased water pollution, soil erosion, and accidental forest fires. Visitors to the Sandia District of the Cibola National Forest increased from 99,000 to 1,068,000 (Dortignac 1956: 85–86).

1940s (mid) The Pueblos complained to Congress that the Middle Rio Grande Conservancy District had not provided adequate water or maintenance of ditches as promised. Many claimed they had lost crops as a result (Bayer et al. 1994: 243).

1940s (mid) A road connecting Las Huertas Canyon to Sandia Crest was completed by this time (McDonald 1985: 11).

1946–56 The Bureau of Reclamation sprayed the herbicides 2,4-D and 2,4,5-T on tamarisk stands along the Rio Grande and tributaries in an attempt to control the spread of the exotic (Lowry 1957: 6, 7).

1947 By this year the original capacity of Elephant Butte Reservoir had been reduced by 17 percent due to sedimentation (Dortignac 1956: 2).

1947 The ditch rights of residents along the Santa Fe River from Agua Fria to Cienega were lost to the Compania de Agua de Santa Fe (Whitemore 1983: 186).

1947 Salt cedar had spread over 60,640 acres of the Rio Grande Valley, and these trees were consuming an estimated 238,700 acre-feet of water (Hay 1963: 491–498).

1947 Introduced bullfrogs were commonly harvested in the marshy areas of the Middle Rio Grande Valley (Pillow and De Vaney 1947: 16).

1947 A few mink were present in the Middle Rio Grande Valley. Overgrazing in the Jemez Reservoir site area had destroyed good quail habitat (Pillow and De Vaney 1947: 17).

1947 Four lakes in the San Marcial area provided good largemouth bass fishing. Good catches of crappie and channel catfish were also made (Pillow and DeVaney 1947: 10).

1947 The lower Rio Jemez provided no fishing owing to species depletion (Pillow and DeVaney 1947: 10).

1947 There was "a breeding colony of Brewster's and American egrets" (Pillow and DeVaney 1947: 19).

1948 Congress passed the Federal Water Pollution Control Act, the first such legislation for the United States (Clark 1987: 444).

1948 (ca.) A sawmill was built at Gilman just below the tunnels on the Guadalupe River in the Jemez Mountains (Glover 1990: 44).

1949 By this year, farming was no longer the primary occupation of the Pueblos (Furman 1975: 2).

1949 The Predatory Animal Control issued instructions and safety precautions for use of 1080, a highly lethal rodenticide, in the control of rodents and predators (Brown 1983: 103).

1949 An area of the Tres Piedras Ranger District, Carson National Forest, was reseeded with crested wheatgrass (Rowley 1985: following p. 192).

1940s (late) Los Alamos Laboratory began pumping water from wells up to 2,000 feet deep on the Pajarito Plateau for domestic and industrial use (Fergusson 1951: 363).

1940s Limits on the number of livestock that one owner could graze on the national forests were implemented. For the Santa Fe, 50 to 100 head of cattle per owner were permitted. These limitations were imposed because of heavy local demand. Also, attempts were made to reduce common use of forest ranges by constructing fences, developing more water, and reassigning individual allotments (Eastman and Gray 1987: 37).

1940s–66 A government hunter, who trapped or shot "problem" mountain lions and black bears in the Sandias, lived in Tijeras Canyon. Populations of these two species were virtually eradicated (McDonald 1985: 12).

1950 (pre) Water loss due to transpiration from salt cedar, surface water evaporation, wet sediments, and abandoned waterlogged lands was estimated at 75 percent of stream flow depletion (Dortignac 1956: 2).

1950 (pre) Yellow perch were introduced into the Rio Grande, Pecos, and San Juan drainages (Sublette et al. 1990: 331).

1950 There were 158,000 livestock units in the Middle and Upper basins (Dortignac 1956: 56).

1950 There were 55,000 to 90,000 acres of irrigated land in the Middle Valley (Dortignac 1956: 30).

1950 The estimated irrigated acreage for the Upper and Middle Rio Grande valleys was as follows: San Luis Valley to Otowi Bridge, 98,700 acres; Otowi Bridge to San Marcial, 98,700 acres (Sorensen and Linford 1967: 154).

1950 The irrigated acreage in the Middle Valley had declined to 3,500 acres (Dortignac 1956: 30).

1950 There were 712,000 acres of farmland under irrigation in New Mexico; 46 percent, or 320,000 acres, were irrigated with ground water (Clark 1987: 296).

1950 The population of the Middle and Upper basins was 275,000, of which about 15 percent were actively engaged in agriculture (Dortignac 1956: 77–78).

1950 The population of Sandoval County was 12,438 (Levine et al. 1980: 55).

1950 Cabezon was virtually abandoned (Varney 1987: 35).

1950–55 (spring-fall) Pinyon-juniper and sagebrush ranges were in "extremely poor condition and forage from these lands falls [fell] far short of needs, supplying only one-third of requirements during this time." This condition forced "livestock operators to hold animals longer on winter ranges or drive them to higher lying summer ranges." Spring and winter ranges were "overgrazed and the summer ranges are [were] often grazed too early, as a consequence" (Dortignac 1956: 64).

1951 (pre) The reach of the Rio Grande "between Bosque del Apache and the narrows of Elephant Butte Reservoir was almost a continuous swamp" (State Engineer Office 1956: 2).

1951 (March 25) Sagebrush was removed from 7,000 acres of overgrazed rangeland on Mesa Viejas, Canjilon Ranger District, Carson National Forest. Reseeding with crested wheatgrass followed (Rowley 1985: following p. 192).

1951 (July 24–25) A flash flood destroyed the San Luis irrigation dam on the Rio Puerco (Widdison 1959: 277).

1951–54 Channelization and floodplain clearing of 31 miles of the Rio Grande above Elephant Butte was completed (Lowry 1957: 12).

1951 (late) (to 1954) Channelization of the river, clearance of a floodway 1,000 to 1,400 feet wide of 31 miles of the Rio Grande, and construction of a low-flow channel, were carried out by the Bureau of Reclamation and the Corps of Engineers. Woody plants were tandem-disced and sprayed with 2,4-D and 2,4,5-T (Lowry 1957: 11–12).

1953 The New Mexico Legislature declared "that all underground waters of the State of New

Mexico are public waters subject to appropriation for beneficial use within the State" (Erickson 1954: 81).

1953 The Bureau of Reclamation began a channel modification of the Middle Rio Grande to maintain channel capacity for "safely passing high flows, reducing water losses while conveying water to downstream users, and moving sediments through the valley" (Crawford et al. 1993: 43–44).

1953 The "salt burden" in the Rio Grande at San Marcial exceeded one-half million tons during the year (Dortignac 1956: 38).

1954 The U.S. Government outlawed the indiscriminate use of poison to kill predators of livestock. Sheep ranchers turned to use of the "coyote getta," a "cyanide gun" stuck in the ground. Some ranchers also "controlled" predators by shooting from airplanes (Moyer 1979: 71).

1954–60 Annual sediment production on the San Luis watersheds in the Rio Puerco basin averaged about three-fourths of an acre-foot per square mile (Dortignac 1960: 49).

1955 The average, annual stream flow production in the Rio Grande above Elephant Butte was almost 3 million acre-feet. More than 900,000 acre-feet of water was consumed between the Colorado-New Mexico state line and Elephant Butte Dam. This was almost two-thirds of the water produced in this region. More than 400,000 acre-feet of the total was considered wasted or of nonbeneficial use (Dortignac 1956: 29).

1955 The aggrading bed of the Rio Grande was resulting in "increased frequency of floods by causing bank overflow under progressively smaller river discharges or water-flows," "increased channel meander due to nonuniformity of deposition," "reduced efficiency of drains" and "waterlogging," and "repeated inundation of railroads, highways, and bridges" (Dortignac 1956: 42).

1955 About 85 percent of the lands in the Middle and Upper basins were being grazed by livestock (Dortignac 1956: 55).

1955 Almost half of the Upper and Middle basin was "eroding at a "moderate rate" and over 40 percent at an excessive rate. Shallow gullies covered about 15 percent of the region (Dortignac 1956: 50).

1955 There were about 60,000 acres of vegetation dominated by salt cedar in the Middle Rio Grande. This phreatophyte species was consuming about 240,000 acre-feet of water annually, about twice the amount used by cultivated crops (Dortignac 1956: 47).

1955 There were an estimated 1,500 elk and 25,000 deer on national forests in the Upper and Middle basins (Dortignac 1956: 71).

1955 State legislation authorized change of the title "game warden" to "conservation officer" and authorized the director of Game and Fish "to appoint properly qualified persons as nonsalaried reserve conservation officers empowered to enforce the regulations of the State Game Commission and to perform such other duties with respect to wildlife management and conservation education as he might assign (Clark 1987: 370).

1955–60 Rural domestic use of water in New Mexico increased from 6.8 million gallons per day to 10.0 mgd (Hale et al. 1965: 52).

1950s (mid) More than 95 percent of the surface water produced in the Upper and Middle Rio Grande basins was used for farming, livestock raising, manufacturing and domestic purposes, or lost in transpiration (Dortignac 1956: 4).

1950s (mid) Most of the sedimentation in the Middle Rio Grande Basin was derived from gully and arroyo trenching and sheet erosion of lower elevation rangelands (Dortignac 1956: 2).

1950s (mid) The sediment load of the Rio Puerco began to decrease, probably due to "variations in climate/weather patterns, improved land management in the drainage, and cyclical geomorphic trends" (Crawford et al. 1993: 54).

1950s (mid) Only about half of the forage requirements were provided by native plant rangelands, even though livestock numbers had been substantially reduced. The native forage produced on pinyon-juniper and sagebrush rangelands was only about one-third of spring-fall requirements (Dortignac 1956: 3).

1950s (mid) There were between 30,000 and 40,000 sheep owned by residents of Laguna Pueblo (Eastman and Gray 1987: 98).

1950s (mid) There were about 60,000 acres of principally salt cedar in the valley from Otowi bridge to Elephant Butte Reservoir. Water consumption by this species was estimated to be twice that of cultivated crops (Dortignac 1956: 47).

1956 (March) The Sandia Conservancy District, petitioned for by a group of landowners, was created to control flash flood waters originating along the west face of the Sandia Mountains (Clark 1987: 355).

1956 A system of levees along both banks of the Rio Grande, from the North Valley to below Albuquerque, was constructed by the Corps of Engineers (Alberts 1976: 100).

1956–59 Channelization of the Middle Rio Grande, with clearing of all obstructions, was completed by the Bureau of Reclamation. Kellner jetties also were installed along the inside of the levee system to "train the river channel in the floodway to an approximate width of 600 feet..." (State Engineer Office 1956: 5).

1957 A paved road into Taos Pueblo was strongly opposed by the conservative faction of the village (Wood 1989: 103).

1958–60 Average annual yields of Russian thistle were 279 pounds/acre and of all grasses 224 pounds/acre on the Cornfield Wash drainage, a tributary of the Rio Puerco-of-the-East (Branson 1985: 39).

1959 The Rio Puerco channel at La Ventana was about 50 feet deep (Dortignac 1960: 47).

1959 The Ideal Cement plant opened in Tijeras Canyon (Oppenheimer 1962: A–16).

1959 Cochiti Pueblos lost their claim to the La Bajada land grant. The Pueblos also asked the Corps of Engineers to change the location of the proposed Cochiti Dam and Reservoir, but the agency refused (Welsh 1987: 145).

1959 The channelization project on the Rio Grande at San Marcial was completed (Jenkins and Schroeder 1974: 77).

1959 Peggy Pond Church, daughter of Ashley Pond, who founded the Los Alamos Ranch School, wrote of her father's feeling for the Pajarito Plateau: ". . . there are certain places in the earth where the great powers that move between earth and sky are much closer and more available than others, and ... this region, this stretch of valley, plateau and circling mountain, was one of them" (Church 1959: 18).

1950s The Bureau of Land Management was criticized for primarily focusing on leasing public lands to livestock raisers and overlooking other public values and uses for these lands. A special concern of some groups was the protection of watersheds and "marginal lands" from overgrazing (Clark 1987: 590).

1950s Timber sales and logging occurred in the Capulin Springs area in the Sandia Mountains. Logging was "camouflaged" because of complaints of local residents and visitors. Firewood cutting was common (McDonald 1985: 11).

1950s The Sandia ski area was expanded (McDonald 1985: 12).

1960 Congress passed the Flood Control Act, which in part authorized construction of the Galisteo Dam (Welsh 1987: 149).

1960 The Acequia de La Cienega flowed at 650 gallons per minute. In 1993 it flowed at 133 gpm, primarily due to the increase in wells in the area (Selcraig 1993: 10).

1960 By this year, Russian olive had become a major understory component of the Middle Rio Grande bosque (Freehling 1982: 10).

1960 The population of Sandoval County was 14,201 (Levine et al. 1980: 55).

1960–92 Groundwater levels in the Santa Fe Group aquifer system under east Albuquerque declined 140 feet. This represented an estimated withdrawal of 994,000 acre-feet of ground water (Kernolde et al. 1995: 1).

1961 (February) President Kennedy delivered a "natural resources" message advising Congress that he had instructed the Secretary of the Interior to initiate a three-part offensive against public land abuse. This included making an "inventory and evaluation of unreserved public lands," developing a "balanced use program," and an "accelerated soil and water conservation program, including a rehabilitation program of depleted rangelands" (Clark 1987: 590–591).

1962 (pre) Pinyon was the preferred fuelwood at Santa Clara Pueblo, followed by juniper and pine (ponderosa?) (Hill 1982: 41).

1962 (pre) Some Santa Clara Pueblo residents stated that Gambel's quail was a recent introduction (arrival?) into the area (Hill 1982: 56).

1962 The maximum depth of the Rio Puerco channel at La Ventana was about 55 feet (Dortignac 1962: 588).

1962 Sagebrush (*Artemisia* spp.) made up 3 to 4 percent of the vegetative cover on the Rio Puerco watershed (Dortignac 1963: 508).

1963 (May) The cattle egret, a native of Africa, was first recorded in New Mexico at the Bosque del Apache National Wildlife Refuge (Hubbard 1978: 4).

1963 Over 6,300 coyotes were trapped or poisoned by federal and state trappers without causing a noticeable decrease in the overall population (Findley et al. 1975: 281–282).

1963 Kokanee salmon were introduced in northern New Mexico (Sublette et al. 1990: 67).

1963–75 Personnel at the Laboratory of Tree-Ring Research in Tucson were unable to match species of living trees to those in the archeological chronology due to "changed dendrochronological characteristics of certain species as a consequence of logging which has destroyed the lower forest border in the northern Rio Grande Valley" (Dean and Robinson 1978: 4).

1964 The Rio Puerco channel at San Luis was 36 feet deep (Tuan 1966: 589).

1964 The depth of the Rio Puerco channel at Poblazon was 43 feet (Tuan 1966: 589).

1964 The depth of the Rio Puerco channel at San Ignacio was 36 feet (Tuan 1966: 589).

1964 Irrigated farm plots per capita among the Pueblo ranged from one-half acre at Laguna to 12 acres at Sandia (Stevens 1964: 39–40).

1964 Congress passed the Land Classification and Multiple Use Act, which directed the Secretary of the Interior "to develop criteria for determining which BLM lands should be classified for disposal and which should remain in federal ownership." These lands would also be "managed for the protection of public values" (Clark 1987: 591).

1964 Congress passed the Wilderness Act, establishing the national wilderness system (Clark 1987: 584).

1964 The 41,132-acre San Pedro Parks Wilderness Area was designated in the Santa Fe National Forest (Rothman 1992: 271).

1964 The Pecos Wilderness, some 167,416 acres, was created in the Santa Fe National Forest (Rothman 1992: 271). The area, including Pecos Baldy and Truchas Peaks, was restocked with Rocky Mountain bighorn sheep (deBuys 1985: 289).

1965 The State Legislature declared that "the State of New Mexico claims the right to all moisture in the atmosphere which would fall so as to become part of the natural streams or percolated water of New Mexico, for use in accordance with its laws." The Weather Control and Cloud Modification Commission was also created "to oversee attempts to alter weather conditions" (Clark 1987: 373).

1965 The Water Resources Planning Act created a national water commission to work with the National Resources Council and public and private agencies "in isolating major problems and suggesting alternative solutions which would assure an ample supply of clear water for the future." A final report, *Water Policies for the Future*, was produced, with emphasis on the economics of water (Clark 1987: 378–380).

1965 Congress passed the Water Resources Research Act, which was directed at supplementing, rather than duplicating, ongoing research, with special emphasis on state problems that had only a small chance of being funded. A Water Resources Research Institute was established in New Mexico, partially with funding authorized by this federal act (Clark 1987: 380–381).

1965 Logging by the New Mexico Timber Co. ended on the Canon de San Diego land grant. Most of the grant was deeded by the U.S. Forest Service, but some land was developed as vacation properties (Glover 1990: 44).

1965–66 The State Planning Office and the State Engineer Office carried out an in-depth report and inventory of the state's water resources (Clark 1987: 374).

1960s (mid) The Forest Service proposed to construct a road from Sandia Crest to Placitas. Because of protests from several environmental groups, the agency moved the road to a lower elevation and secretly cleared the right-of-way. Increasing protests caused the Forest Service to terminate the project (McDonald 1985: 12–13).

1966 Congress passed the Historic Preservation Act, setting up the National Register program (McGimsey n.d.: 17).

1967 A fire that started in or near the Juan Tabo picnic grounds burned up to the ridge of the Sandia Mountains over 3 days (McDonald 1985: 12).

1968 (September 26) The Rio Grande, extending south from the Colorado state line to Highway 96, was declared a National Wild and Scenic River (Baker et al. 1988: 72).

1968 The estimated carrying capacity for rangelands in the Santa Fe and Albuquerque areas was less than one-half that of 1827 (Gonzalez 1969: 44).

1969 Congress passed the National Environmental Policy Act (Clark 1987: 450–451).

1960s The riverside diversions at Corrales and Atrisco were replaced by inverted siphons, which ran under the river from riverside drains that were converted seasonally into conveyance channels (Kernodle et al. 1995: 19).

1960s Northern pike were introduced into several large reservoirs (Sublette et al. 1990: 77).

1970 (December 15) President Richard Nixon signed a bill placing 48,000 acres of Carson National Forest, including their sacred Blue Lake, in trust for the sole use of Taos Pueblos (Keegan 1991: 50).

1970 President Nixon set up the Environmental Protection Agency (Clark 1987: 452).

1971 The Wild Horse and Burro Act, which complicated the management of these two animals on Bureau of Land Management and U.S. Forest Service lands, was passed. Populations increased on most areas, and burros moved into Bandelier National Monument. Partly due to their intensive grazing, soil erosion on the monument increased to an estimated 36 tons per year (Rothman 1992: 280–281).

1972 The Forest Service issued *The Nation's Range Resources*, which reported that much of Southwestern rangelands, public and private, were in a deteriorating condition (Rowley 1985: 238).

1970s (early) Water deficiency, present or future, and pollution were serious problems as identified by 8 of the 10 Middle Rio Grande pueblos (Furman 1975: 5).

1971 (post) The descendants of Pecos Pueblos requested that the state Game and Fish Department transfer to them ownership of the cave at Tererro, a sacred place (Kessell 1979: 471).

1975–76 The condition of most of the public domain was considered only bad to fair. The Bureau of Land Management reported that only 17 percent of the rangelands they administered were in good or excellent condition (Box ca. 1978: 18).

1980 The Cochiti Pueblo Council filed suit against the Corps of Engineers, Albuquerque District, for causing the "waterlogging" of 320 acres of traditional Cochiti farmland below the Cochiti Dam, which the Corps had constructed in 1967–70 (Welsh 1987: 162).

CHAPTER 6

OVERVIEW OF EARLY SCIENTIFIC WORK, RESOURCE DATA COLLECTION, MANAGEMENT, AND CONSERVATION 1812–1982

Historic Native American and Hispanic resource use and conservation prior to the Anglo occupation and domination of the Middle Rio Grande Basin was documented in Chapters 3–5. Various Indian groups exploited water and a range of faunal and floral resources, arable soil, and rock materials. They developed strategies, in some instances, for sustained use of these resources on a subsistence basis. Their relatively low populations and low levels of technology generally ensured an ongoing relative abundance of most of these resources. In rare situations where intensive local use or climatic events depleted a needed resource, Native Americans moved to a new area or traded for the scarce commodity. In the colonial period, the Spanish generally interrupted such strategies.

Hispanics brought not only an array of new technologies, which enabled them to exploit eco-cultural resources more extensively and intensively than the indigenous populations, but they also brought a new attitude regarding environmental use. The Spanish, unlike Native Americans, saw themselves as separate from nature and viewed natural disasters as acts of God over which they had no control (Weber 1992: 29). Although most residents maintained basic subsistence lifestyles, some resources were exported to Mexico by wealthier private individuals or government officials. By the late 18th century, in spite of some governmental regulation, there were some local water shortages and contamination, decimation or depletion of forage, and soil erosion. By the time of the arrival of the U.S. Army and early Anglo settlers in the mid- to late-1840s, grass and wood supplies were in decline or nearly exhausted around the Rio Grande Valley from above Cochiti Pueblo to below Socorro.

Anglo Americans also brought new technologies and, more important, a new attitude toward the environment. Like that of the Spaniards, Anglos' attitudes emanated from a religious background that viewed humans as separate from the natural environment. Also related to this philosophy was a resource exploitation strategy based on maximum harvest of resources for maximum profit. To promote primarily Anglo settlement and development of the region, the Federal Government passed many natural resource laws, created numerous agencies, and appropriated many millions of dollars. Initially, virtually all federal and territorial laws promulgated intensive use of the environment. This led to various forms of environmental degradation that subsequently were addressed in ever-increasing degrees by governmental agencies.

Most notable is the characteristic evolution from virtually unregulated resource use on the frontier, especially on the public domain. Driven and supported by federal and local legislative acts, policies, agencies, and monetary remuneration, the pattern shifted to a relatively well-regulated and reasonably balanced resource management system emphasizing self-sustainable and wise use programs and policies, involving an array of public agencies and "watchdog" environmental groups. A few legislative acts from the early exploitation period, such as the 1872 Mining Act, remain in effect. The 104th Congress has attempted to modify many resource management laws created in recent decades.

The following overview includes (1) a discussion of the early naturalists and environmental scientists and their work, (2) a chronological narrative about conservation and management of land and water resources by public agencies, (3) significant resource management legislation, and (4) a discussion of important private organizations' effect on management and preservation of the region's environmental resources during the territorial and statehood (to 1982) periods. A chronology of landmark events, the work of naturalists, scientists, government agencies, and environmental organizations and resource legislation follows.

EARLY NATURALISTS AND ENVIRONMENTAL SCIENTISTS IN THE STUDY REGION, 1831–1924

Various Native American groups, who have lived in the region for more than 10,000 years, might be called the first "naturalists." Over thousands of years, knowledge of geography, surface waters, rocks and minerals, plants and animals—their distribution, seasonal or annual occurrences, and uses—was gained through observation, study, and experimentation. Native Americans passed this knowledge orally from one generation to the next. They shared non-sacred aspects of this information with Hispanics who began settling in New Mexico at the end of the 16th century. Hispanics brought new plants, animals, and associated knowledge, which in turn they shared with Native Americans.

Native Americans also had considerable knowledge of astronomical phenomena and extensive knowledge of the geography of the region. Early Spanish explorers relied on Indian guides for travel directions, locations of water, and food sources. This kind of information was also made available to Spanish Colonial New Mexico's Hispanic and later Anglo explorers and settlers. Chronicles from early Spanish expeditions (Hammond and Rey 1966, 1967; Hodge 1946; and Schroeder and Matson 1965) contain the first written descriptions, albeit sketchy, of the land, water, biotic components, and indigenous peoples.

The best known map maker in Spanish Colonial New Mexico was Captain Don Bernardo Miera y Pacheco. After his arrival in Santa Fe in 1756, he produced several maps, including perhaps his best known map, prepared in 1779 (Fig. 74). This map shows, with relative accuracy, streams and rivers, mountain ranges, place names, and settlements. He died in Santa Fe in 1785 (Adams and Chavez 1956: 2–4, 161; Chavez 1975: 229–230).

The most comprehensive work on the geography, agriculture, and human populations of colonial New Mexico was produced by Fray Francisco Atanasio Dominguez, a Franciscan priest who traveled across the region in 1776 (Adams and Chavez 1956). He carefully recorded his observations on the landscape and settlements, which resulted in a large manuscript discovered in Mexico City in 1928 and first published 28 years later. Several other religious figures and government officials, such as Benavides (Ayer 1965), Morfi (Simmons 1977), Chacon (Simmons 1985), and Pino, Barreiro, and Escudero (Carroll and Haggard 1942), authored manuscripts that contain less comprehensive and detailed, but nonetheless useful, environmental history data on the period.

The first scientific studies of the region were carried out by Anglo naturalists from the midwestern or eastern United States, some of whom were actually trained as medical doctors. They primarily collected plants and animals that were sent back east for study and naming. They were followed by geologists, paleontologists, botanists, zoologists, and ornithologists, who were generally part of military expeditions or railroad surveys. Early photographers, artists, and map makers, also part of the same kind of field parties, provided basic imagery of the land and its people. These collected specimens, associated scientific data, and photographs and maps composed a body of knowledge that was subsequently utilized by early conservationists and resource managers, as well as private organizations and politicians, in determining needs, developing programs, and enacting legislation related to the environment.

Although not trained as a naturalist, early Anglo explorer and trader Josiah Gregg (Fig. 75) was a good observer and student of the region's geography, fauna, flora, and eco-cultures. His observations, made from 1831 to 1841, were published in the now classic *Commerce of the Prairies*, which has gone through several reprintings since first issued in 1844. A few other Anglos of the mid 19th century, such as W.H.H. Davis (1982), wrote rather detailed accounts of land use along the Middle Rio Grande Valley.

The first individuals trained in the physical or biological sciences to work in the study region were botanists. Two East Coast botanists, John Torrey of Columbia and Asa Gray of Harvard, collected, classified, and named plants for a botanical study of North America in the 1840s. Thomas Nuttall, a prominent Philadelphia botanist, and George Engelmann, a St. Louis physician and expert on cacti, assisted in this ambitious project (Dickerman 1985: 159; Goetzmann 1966: 321). These plant and zoological collections resulted in descriptive catalogs and inventories that organized large amounts of data for use by later, more theoretically oriented biologists. Scientists forwarded faunal specimens to the Smithsonian Institution, where they were cataloged and classified under the direct supervision of Spencer F. Baird, a student of John James Audubon (Goetzmann 1966: 322–323).

Collecting in New Mexico began in 1841, when William Gambel, a protege of Nuttall, arrived in Santa Fe in July. He collected botanical and zoological specimens in the nearby Rio Grande Valley and Sangre de Cristo Range. The Gambel oak was later named in his honor (Dickerman 1985: 159, 163–164).

In 1846 another plant collector, Frederick A. Wislizenus (1969), came to New Mexico just prior to the U.S. Army's invasion. During his relatively brief passage through the region and into Chihuahua, Wislizenus collected five new species, including pinyon and ponderosa pines, walking-stick cholla, a yucca, and an echinocactus (Dickerman 1985: 164–166).

Later in 1846, Lt. William Emory of the U.S. Corps of Topographical Engineers collected botanical specimens along the Santa Fe and Chihuahua trails. Two of the plants he collected, an oak and a mesquite, were later named for him (Dickerman 1985: 167–168). Emory also produced the first detailed maps of the region.

Another topographical engineer, Lt. James W. Abert (1962), was interested in the flora, fauna, and geology of New Mexico. Under Emory's command, Abert described the plants and animals on his route of travel along the Rio Grande Valley as far south as Valverde, west to the Rio Puerco, Laguna, and Acoma, and east to the edge of the Estancia Valley. He collected and recorded various bird specimens during his exploration. He also collected the first fossil specimens from the territory; some of these were illustrated in his subsequent report to the U.S. Senate.

The U.S. Corps of Topographical Engineers had been created in 1838 and was responsible for conducting a general survey of the plants, animals, geology, and Native Americans of the West. Most of the engineers, like Emory and Abert, were educated at West Point and were trained and advised by the best scientists and learned societies in America. Their recording and collecting of natural his-

Figure 74—Miera y Pacheco's map of the Middle Rio Grande Basin, 1779.

tory specimens were major contributions to the basic work of science. At the beginning of the Civil War in 1861, the Corps began to disintegrate. In early 1863 it merged with the Corps of Engineers (Goetzmann 1991: 6–21, 430–432).

Various topographical engineers also made relatively careful observations of the weather representing the first scientific meteorological data recorded in the state. These data were used primarily to determine feasibility of road and railroad construction and settlement in the region (Goetzmann 1991: 331).

Augustus Fendler, who had extensive experience collecting plant specimens, arrived in New Mexico with a contingent of American troops in the fall of 1846. The following spring and summer he collected 1,026 specimens along the Santa Fe River and surrounding uplands. One of the plants he collected, Fendlerbush, was subsequently named in his honor (Dickerman 1985: 168–169).

Capt. Lorenzo Sitgreaves led an expedition from Santo Domingo Pueblo west to Zuni and the Colorado River via Acoma and El Morro in 1854. Included in the party were naturalist and physician Dr. S.W. Woodhouse, Lt. J.G. Parke, and artist R.J. Kern. Woodhouse collected and described mammals, birds, reptiles, and amphibians. Among the birds were White-Throated Swifts, the first time this species was collected scientifically. He later survived a bite on the hand by a rattlesnake near the Zuni River (Eifert 1962: 180–182; Ligon 1961: 7).

Cartographer Richard Kern, while living in Santa Fe in late 1850, assembled a large botanical and entomological collection. He sent the collection east, probably to the Academy of Natural Sciences of Philadelphia. Early in 1852 Kern personally gave a number of insect specimens and a coyote skull from New Mexico to the academy (Weber 1985: 134–135).

Still another U.S. topographical engineer, Lt. A.W. Whipple, followed the 35th parallel across New Mexico Territory in 1853. Surveying for a possible railroad route to the Pacific, he was accompanied by Dr. C.B.R. Kennerly, a physician and naturalist; Dr. J.M. Bigelow, also a medical doctor and naturalist; Jules Marcou, a celebrated geologist; and H.B. Molhausen, a German artist and topographer. In addition to collecting mammals, birds, and fish, Bigelow wrote an essay on the distribution of plants along their survey route and the distribution of specific tree species found in forests. Five men trained in meteorological observation were also members of the expedition (Goetzmann 1991: 287-288, 328).

As noted above, Bigelow, with the Whipple expedition, collected the first fish specimens in the region in 1853. C. Girard, a member of the Capt. John Williams Gunnison expedition, surveying the 38th parallel as another potential railroad route, collected fish in the Upper Rio Grande Basin in southern Colorado. These specimens, and those collected by other early surveys, went to the U.S. National Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology at Harvard University for curation (Goetzmann 1966: 286–287; Sublette et al. 1990: 1, 370).

Figure 75—Santa Fe Trail trader Josiah Gregg. Courtesy Museum of New Mexico Photo Archives, Santa Fe (negative no. 9896).

In 1857–59 John Strong Newberry, a member of military surveys for railroad routes, studied the geology of northern and northeastern New Mexico. He wrote detailed descriptions of stratigraphy, gathered considerable paleontological information, and provided a good interpretation of the regional geology (Goetzmann 1966: 308–309; Kues 1985: 117).

A number of army surgeons stationed at frontier outposts made early weather observations. Their data “represented a comprehensive picture of far-western weather conditions,” that was useful not only to the military but also to early settlers in the region (Goetzmann 1991: 331).

Several military doctors contributed to early ornithological research in New Mexico. Perhaps the best known, Lt. Col. Thomas Carlton Henry, was stationed at forts Fillmore and Thorn in 1852–55. He collected a large number of bird specimens and published his observations on these, as well as those made in the field, in 1856 (Henry 1856; Hume 1942: 207–218; Ligon 1961: 7–8).

Dr. Caleb Burwell Kennerly accompanied Lt. Joseph C. Ives up the Rio Grande to Albuquerque in 1853, making extensive observations on birds and collecting a relatively large number of specimens. He joined the Whipple expedition and continued his work as the group moved west across the Rio Puerco, along the San Jose, and on to El Morro and Zuni Pueblo (Ligon 1961: 8).

At Cantonment Burgwyn (later referred to as Fort Burgwyn) in the 1850s, post doctor W.W. Anderson discovered a new species of warbler, which he collected and sent to Professor Baird. Baird subsequently named the bird Virginia's Warbler, in honor of Anderson's wife (Eifert 1962: 183). Another new species of warbler, Grace's Warbler, was collected by U.S. Army surgeon Dr. Elliott Coues near the site of old Fort Wingate in July 1864. He was one of the best known 19th-century ornithologists in the Southwest, as well as a noted historian. Coues' two-volume *Key to North American Birds* (1884) was perhaps his most important ornithological publication (Eifert 1962: 175-176, 183–184; Ligon 1961: 9).

While at Camp or Cantonment Burgwyn in 1872, Major Charles Emil Bendire became interested in birds and egg collecting. He continued this pursuit at posts in southern Arizona, eventually collecting some 8,000 eggs, which he donated to the U.S. National Museum. His two-volume *Life Histories of North American Birds* (1892-1895) was a highly respected work (Ligon 1961: 9).

In 1869 the U.S. Geological Survey of the Territories was formed in the Department of the Interior, primarily to conduct land classification and resource explorations ahead of the land surveyors and first settlers. The first outstanding geologist to work for the USGS was F.V. Hayden who conducted a major survey from Denver over Raton Pass, south to Santa Fe, then back north through Taos and the San Luis valley in 1869. With Hayden were zoologist E. C. Carrington, entomologist Cyrus Thomas, and artist Henry W. Elliot. The expedition collected large numbers of fossils. On a later survey, 1873–75, Hayden also sent ethnologist William H. Holmes and photographer W.H. Jackson on a survey of Indian ruins from Mesa Verde to the San Juan to Chaco Canyon, Pueblo Pintado, and Canyon de Chelly. Their detailed report, with numerous illustrations, was an early landmark in Southwestern archeology (Goetzmann 1966: 489, 497–498, 521–526).

Beginning in 1871, Lt. George M. Wheeler led the geographical surveys of the territories of the United States west of the 100th meridian. The main objectives of the surveys were to gather topographical knowledge of the region; prepare accurate maps; gather information on routes for rail or wagon roads; survey the mineral resources, geological formations, vegetation, agricultural suitability, and weather; and gather information on Native Americans. Key members of the expedition included E.D. Cope, who discovered Eocene fossil beds with their early mammal remains in northern New Mexico. He and Dr. Oscar Loew also explored new Indian ruins along the San Juan River in 1874. The surveying and mapping of north-central and northwestern New Mexico occurred in 1877–78. Ornithologist Henry W. Henshaw conducted extensive field work in central and northern New Mexico in 1873–74. Zoologist Elliot Coues and photographer Timothy O'Sullivan also contributed outstanding work for the project. By the end of the project in 1878, seven large volumes of final reports on geography, geology, paleontology, astronomy, zoology, botany, archeology, and history were completed. Also produced were 71 maps, including a geological, as well as a topographical, atlas and seven land-use maps. Some 43,759 natural history specimens were collected and sent to the Smithsonian (Goetzmann 1966: 467–470, 482–483, 485–487; Goetzmann 1991: 42).

Other important work of the Wheeler group was performed by Cope and H.C. Yarrow, who collected fish in the region (Sublette et al. 1990: 345, 365–366). Ornithologist Henry Wetherbee Henshaw, who emphasized observing and recording birds rather than collecting, worked in the northern part of the territory in 1873–74. U.S. Army botanist Joseph T. Rothrock also collected here in 1874 (Ligon 1961: 10).

Two of the best known naturalists who worked in New Mexico were Florence Merriam, an orinthologist, and Vernon Bailey, a naturalist. They collected and observed across the territory-state from 1889 to 1924. Some have called Merriam the greatest American woman ornithologist; she authored the *Handbook of Birds of the Western United States* (1917 rev. ed.) and *Birds of New Mexico* (1928). Vernon Bailey was Chief Naturalist of the U.S. Bureau of Biological Survey for years and published *Life Zones and Crop Zones of New Mexico* (1913) and *Mammals of New Mexico* (1932) (Ligon 1961: 11; Norwood 1993: 43–46).

New Mexico's best known early anthropologist was Adolph F. Bandelier, who worked over much of the territory between late 1880 and early 1892. Perhaps Bandelier's most important contribution was his pioneering effort in multidisciplinary approaches, especially using ethnological data in the interpretation of archeological remains. Until 1886, funding for most of his fieldwork came from the Archaeological Institute of America and after that date from AIA and the Hemenway Expedition (Lange and Riley 1966: 1–5, 24–56, 66–67).

As indicated, artists and photographers accompanied many of the earliest scientific expeditions to the region. Their images of the historical landscape, plants, animals, historical structures, and indigenous peoples are still valuable today. In addition to those previously mentioned, there was illustrator and cartographer Edward Kern, who was with the Col. John M. Washington expedition in 1849. His brother Richard was also on this expedition, which followed a circular route from Santa Fe through Navajo country, via Chaco Canyon, Canyon de Chelly, and Zuni, and back to the capital. Edward's fine map was the first detailed map of this region. He also made meteorological observations and sketches of animal and plant life. Richard prepared several sketches of landscapes and Navajo leaders, which became part of Col. Washington's report to the U.S. Senate (McNitt 1964: ix, xxxii, l-lii).

Some early photographers included J.G. Gaige, who worked out of Santa Fe and at military posts, 1862–66; Nicolas Brown, who photographed around Santa Fe and Albuquerque and worked the Rio Abajo 1866–72; Alexander Gardner, who accompanied a private railroad survey across central New Mexico in 1867–68; H.T. Heister, who photographed from his Santa Fe studio and while making a boat trip down the Rio Grande in 1874; and George C. Bennett, who photographed at Acoma, Cochiti, and Frijoles Canyon, where he worked with Adolph Bandelier, 1880–83 (Rudisill 1973: 13–14, 16, 28-29, 33). Another group worked in the 1880s: Ben Wittick, who worked for the Atlantic and Pacific Railroad in 1881–82 and around the territory until he died of snakebite in 1903; John Hillers, who accompanied Col. James Stevenson in a study of prehistoric archeological sites and extant pueblos in 1879–80; independents George C. Bennet and William H. Brown, who photographed the Santa Fe and Cerrillos areas and the Rio Grande Valley around San Juan Pueblo and Potrero Viejo in 1880; William H. Rau, a visiting landscape photographer, 1881; Charles Lummis, who lived at Isleta and other pueblos in 1888–1890s and teamed with Adolph Bandelier and photographed the Cochiti-Jemez country during this period; Henry A. Schmidt, who worked the area around his resident town of Chloride, but photographed as far north as Cabezon, 1882–1924; William Henry Cobb, who worked out of Albuquerque and Santa Fe, 1880–1890s; and Philip Embury Harroun, who photographed irrigation and bridge projects, 1881–92 (Coke 1979: 4–21; Olivas 1971, 1975; Rudisill 1973: 5–11, 33, 54). Starting their work slightly later were Christian G. Kaadt, who was employed a short time by the Santa Fe Central Railroad and later ran a curio shop in Santa Fe, 1893–1905; Erwin E. Smith, who photographed at many of New Mexico's larger ranches in the early 1900s; and John K. Stauffer, who photographed along "El Camino Real" in 1905 (Rudisill 1973: 38, 54–55). A number of other photographers captured historic scenes in the Middle Rio Grande Basin (Fig. 76).

RESOURCE CONSERVATION AND MANAGEMENT

At the time of Anglo military invasion-occupation in 1846, administration of public lands was the responsibility of the U.S. General Land Office, an agency understaffed and inadequately funded. Combined with general public apathy toward natural resources, there was little regulation of timber cutting, mining, and other resource exploitation (Udall 1962: 1; 1963: 58–59, 73). Three years later, however, on March 3, Congress enacted a law establishing the Department of the Interior to administer these lands and resources. The previously established General Land Office and Office of Indian Affairs were transferred to this new department (Dale 1949: 6; Smith and Zurcher 1968: 112; Udall 1962: 2).

To protect forests on public lands, timber agents were appointed by the Secretary of the Interior in 1850. This marked the first organized federal program for managing public timber. Five years later these employees were placed under the direct jurisdiction of the Commissioner of the General Land Office, which issued a circular with general directions and instructions for protecting this forest resource (Udall 1962: 2).

In an attempt to better regulate timber harvesting on public lands, a Bureau of Forestry was created in the Department of Agriculture, which was established in 1862. However, virtually unregulated timber cutting continued. Conservation of the public forests began with the 1875 creation of the American Forestry Association. Efforts of Secretary of the Interior Carl Schurz and forest agent Dr. Franklin B. Hough in the Department of Agriculture also brought about federal protection for timber on public lands. Regulation remained hampered, however, by protests from the timber industry and the actions of unscrupulous federal employees, especially in the General Land Office (Bergoffen 1976: 11; Roberts 1963: 2; Udall 1963: 86–87).

New Mexico had achieved territorial status in 1850, and the first laws related to water were subsequently passed by the Legislative Assembly in 1851. These laws confirmed Spanish-Mexican law in that the use of water for the irrigation of the fields should be preferable to all others and the course of ditches or acequias already established should not be disturbed. Furthermore, the owner of livestock that trespassed onto unfenced fields owned by others was liable for damages. Also in 1851, the Territorial Assembly petitioned the U.S. Congress to reserve all salt lakes, salt mines, and springs to prevent these resources from passing into private ownership. Other laws passed over the next several years strengthened the "institution of the community acequia" (Clark 1987: 25–27, 32).

Three years later, on July 22, 1854, Congress passed the Donation Act, which created the office of the Surveyor General of New Mexico and granted 160 acres of surveyed land to every qualifying "white male citizen" over the age of 21. Other individuals meeting specific requirements of residency in the territory could qualify as well. To secure a donation, the claimant had to demonstrate continuous residence and cultivation for 4 years or more (Westphall 1965: 1, 37).

The first Surveyor General arrived in the territory in December 1854 to begin the public land surveys. The

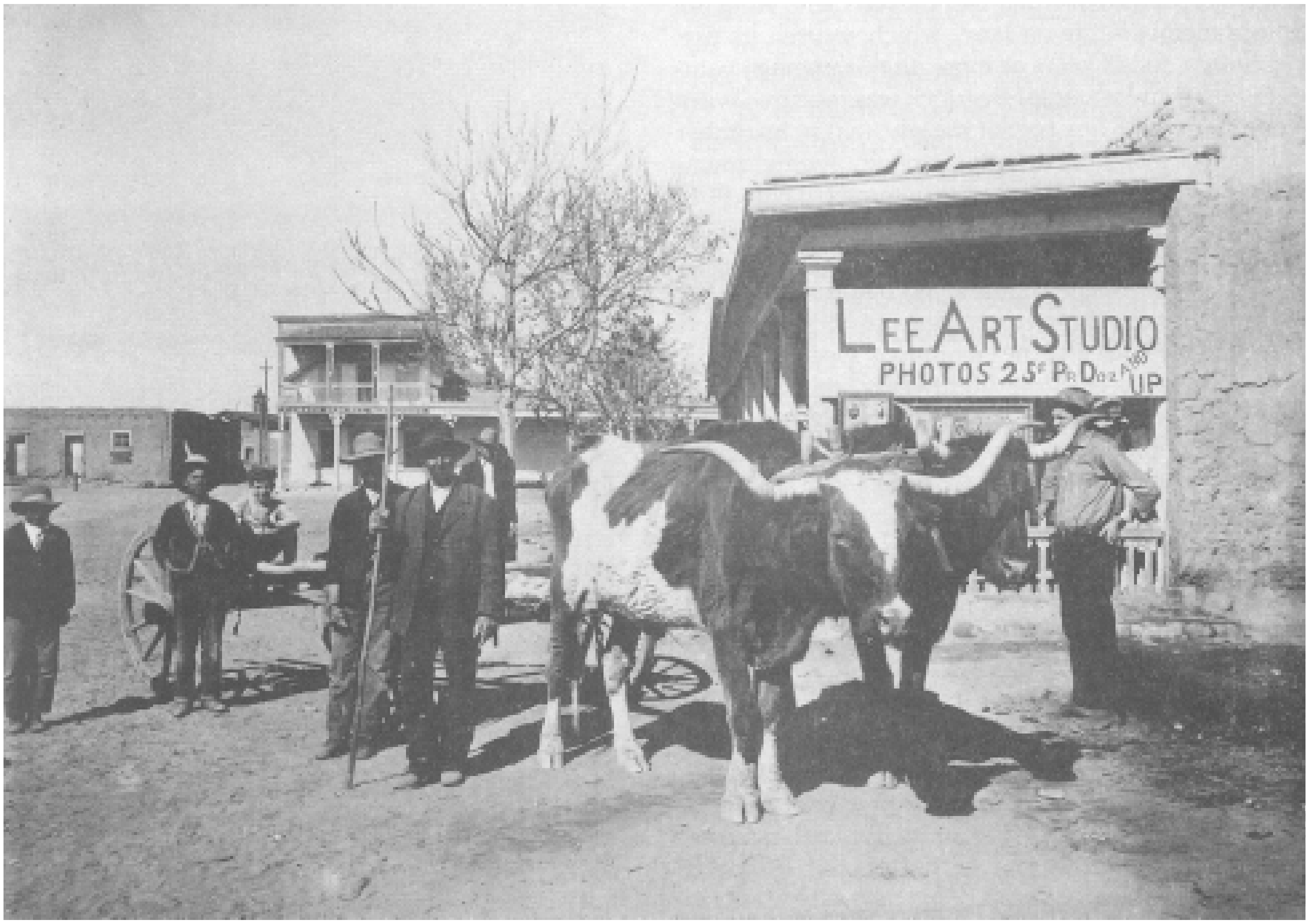

Figure 76—Socorro residents with team of oxen hitched to wagon bed at the Lee Art Studio, ca. 1890. Courtesy New Mexico Bureau of Mines Photo Archives, Socorro.

policy of his office was to survey only arable or agricultural land. His first effort was the survey of the principal meridian, from near the Jemez Mountains, south to the border, and a base line for 24 miles on either side of the principal meridian (Westphall 1965: 1, 4, 5, 17, 37).

On March 12, 1860, Congress passed the Pre-emption Act, giving free public land to New Mexico. Two years later, this body passed the Homestead Act, which allowed individuals to claim 160 acres of public domain. A patent to the land could be obtained by living on the tract for 4 years or by commuting it through payment of cash within 6 months (Clark 1987: 44–45; Westphall 1965: 42–43).

Surveyed or unsurveyed public lands, which could be explored or mined for minerals, were opened by the Mining Act of 1866 to all citizens or individuals intending to become citizens (Limerick 1987: 65; Westphall 1965: 96). This legislation and its updating in 1872 were based on the view that mining "was the most important, if not the only reasonable, use of public land." Under either act an individual could stake out as many claims as wanted, and a claim remained valid as long as the miner recovered a minimum of $100 annually from working a placer or lode mine. A patent on the claim could be obtained through survey and meeting other provisions of the act and making payment of $2.50 or $5.00 per acre (Clawson 1971: 123–124; Utely and Mackintosh 1989: 27). More than a year prior to the federal Mining Act of 1866, the Territorial Assembly passed a bill providing a legal basis for mining development and supported local rules of miners (Christiansen 1974: 87).

In the 1870s, Congress enacted several other federal laws affording individuals the right to acquire public land for the purpose of harvesting resources, including the Timber Culture Act of 1873, the Desert Land Act of 1877, and the Timber and Stone Act of 1878. The first two laws were abused, and the third did not apply to New Mexico. An example of one abuse of the Timber Culture Act involved some cattle corporations that had persons who were not corporate members file on land, which secured its use, free of charge, for 13 years or more. In this manner, valuable grassland and water for livestock was procured without complying with any part of the law; that is, no timber was planted or maintained. By this strategy "entire" townships were dominated by large cattle interests (Baydo 1970: 156; Clark 1987: 46-47; Oakes 1983: 27; Westphall 1965: 43, 72–74, 76).

The first government action at the federal level that would later influence resource management on protected lands in New Mexico was the creation of Yosemite Valley as a "scenic reserve" in 1864. Eight years later, Congress established Yellowstone National Park in Wyoming, the first such use of public land not only for the United States but also for the world (Wild 1979: 40-41, 60; Udall 1963: 112).

One of the earliest efforts to bring about government resource management and conservation in the Southwest was John Wesley Powell's *A Report on the Lands of the Arid Region of the U.S.* issued in 1879. In the plan, Powell, head of a Department of the Interior survey, proposed a systematic classification of lands based on their potential "best use"—irrigation, logging, grazing, mining, and so forth. Powell also recommended ending the homestead and pre-emption programs. These would be replaced, he suggested, by small irrigated farms no larger than 80 acres and all part of irrigation districts, or by livestock ranches no larger than 2,560 acres and part of grazing districts. While Powell was clearly ahead of his time, Congress rejected virtually all of his plan. One recommendation, that a geological survey be created to compile data on which sensible resource planning could be based, was adopted (Barnes 1926: 35; Swift 1958: 45; Udall 1963: 88–94; Worster 1994: 13).

A year later Congress created the Public Lands Commission, and Powell was appointed director. The purpose of the commission was to codify public land laws, develop a system of public land classification, and make recommendations for the "wise disposal" and management of the remaining public lands (Udall 1962: 5; Utely and Mackintosh 1989: 9–10; Worster 1994: 9).

The U.S. Geological Survey (USGS) was created by Congress in 1879, and Powell was named its first director. Since establishment, this agency has produced thousands of detailed maps, studies on surface and ground waters, studies of physical and historical geology, and more recently, aerial imagery (Udall 1963: 94–95; Fig. 77).

Figure 77—U.S. Geological Survey geologist R. H. Chapman in the Rio Grande. Photo courtesy of U.S. Geological Survey, Denver. Photo Archives

Albuquerque's board of aldermen in 1863 passed perhaps the first ordinances dealing with nonwater environmental problems in the territorial period. These laws applied to animal and traffic control, sanitation, public works, and zoning (Simmons 1982: 195–196). Territorial legislation related to flooding was passed on January 18, 1866. This statute provided for the right to move an irrigation ditch destroyed by rain or runoff water. Construction of a new ditch was permitted if the damaged ditch was impossible to rebuild and if most of those who would furnish the labor so consented (Clark 1987: 26). The Assembly addressed flooding some 10 years later when it created a five-member board of commissioners, who would be responsible for raising money for use in flood prevention by taxing residents living within 5 miles of the Rio Grande (Clark 1987: 31).

The Territorial Organic Act of 1878 specified that any timber cut on public lands and exported from New Mexico was liable to seizure by the U.S. Government (Ritch 1968). Another territorial act, this one to control water pollution, was passed on February 12, 1880. This legislation declared

> . . . every person who shall foul the water of any stream in the Territory of New Mexico, or throw into any ditch, river or spring of flowing water any dead or pestiferous animal or other filth, dirty vessels, or other impurities that might injure the general health of the inhabitants of any town or settlement of this Territory, on conviction thereof, would be fined not less than one nor more than ten dollars (Clark 1987: 31).

In this same year the Territorial Assembly also passed two laws to protect wildlife. One, to prevent the extinction of the buffalo, came as the last members of this species in the territory were about to be killed. Furthermore, enforcement of the law would have been virtually impossible (Gard 1960: 216). The other, a fish law, declared that operators of mills or factories could not discharge any waste harmful to trout. Another provision made the taking of fish by the use of drugs, explosives, or artificial obstructions a misdemeanor. Additionally, trout could be taken only by hook-and-line, and commercial sale of fish was limited (Clark 1987: 32).

Five years later, in 1885, a significant event affecting wildlife occurred. The Federal Bureau of Biological Survey, whose primary role was protecting game animals and controlling predators and rodents, was created in the U.S. Department of Agriculture, partly due to pressure from the livestock industry. Employees of this bureau began to study methods of poisoning rodents and "pest" birds and trapping or poisoning predators. By 1890 agency field personnel were aggressively killing wolves, coyotes, grizzly bears, mountain lions, bobcats, and prairie dogs (Brown 1983: 1–2, 41–43; Udall 1962: 6).

Concern for grass and water led Congress to pass a law in 1885 forbidding ranchers to control public domain by fencing and posting, but the practice generally continued until the Taylor Grazing Act was enacted 49 years later. The federal law opened the public domain to all comers, which, in some instances, resulted in overgrazing (Clark 1987: 54, 136; Hagy 1951: 75-76).

In 1889 the New Mexico Territorial Assembly supplemented the Federal fencing act by passing a law declaring that an individual or corporation could only graze the number of livestock that he or it had enough water to maintain (Clark 1987: 54, 149; Hagy 1951: 75). Two years later the legislature enacted a stricter fencing law, making it a felony to cut fences on private land or to fence to the detriment of others land that was not legally owned or used (Clark 1987: 54).

Recent droughts and the need to better manage water in the West also prompted Congress to pass the Hatch Act in 1887, creating agricultural experiment stations to conduct scientific research and disseminate findings through the land grant colleges. Also, Congress authorized surveys by the USGS for irrigable lands and reservoir sites in the West. This agency soon began to place streamflow gauging stations at appropriate locations, with the first being established on the Rio Grande at Embudo in 1889 (Bullard and Wells 1992: 12; Clark 1987: 131; Wozniak 1987).

In February 1887 the Territorial Assembly enacted legislation authorizing the incorporation of companies to supply water for mining and milling, as well as irrigation. The U.S. Congress, in the following year, passed legislation providing for the withdrawal of irrigable land from entry. As a result, some 39 reservoir sites amounting to over 40,000 acres were selected in New Mexico. In early 1891 the Territorial Assembly petitioned Congress generally criticizing its embargo on development of water necessary for the reclamation of arid lands. These withdrawals were soon repealed by Congress (Clark 1987: 65, 66, 132; Westphall 1965: 84).

The Territorial Assembly continued to legislate water matters, when in 1888, the first groundwater supply studies were authorized. In 1891, it passed a statute requiring "all persons, associations, or corporations who . . . constructed or enlarged any ditch, canal, or reservoir taking waters from a natural stream to make a sworn written statement of such diversion, to be filed with the county probate court within ninety days after commencement of the work." Construction had to be completed within 5 years of commencement (Clark 1987: 117; Hale et al. 1965: 7).

Outside of New Mexico, concern for wildlife and wilderness led to formation of two conservation groups on opposite coasts, the American Ornithologists' Union (1883), parent organization to the National Audubon Society in New York and the Sierra Club (1892) in California (Matthiessen 1987: 167; Udall 1963: 116). Both evolved into major national environmental organizations with chapters in New Mexico.

The Territorial Assembly displayed a concern for fish conservation, passing a law in 1889 that created fish wardens in every county to assist sheriffs and commissioners in enforcing an 1880 fish and game law. The law included a closed season of fishing except for members of needy families, the construction of sluices for passage of fish at all dams or other obstructive facilities constructed for purposes other than irrigation, and the prohibition of waste discharge harmful to trout by mills or factories into any stream (Clark 1987: 32).

In 1889 the Territorial Assembly also established a Cattle Sanitary Board, whose main efforts were to prevent disease and to inspect animals (Hagy 1951: 95). Protection of cattle from predators, such as the wolf, was also addressed. In 1893 the legislature passed the Territorial Bounty Act, allowing counties to appropriate funds for payment to individuals taking wolves, grizzly bears, mountain lions, and coyotes (Fig. 78). This act led to a rapid decline of wolves and bears over the next 20 or so years (Brown 1983: 43). Legislators who opposed this legislation considered bounties a kind of "rural welfare"; that is, ranchers were responsible for controlling predators on their land. Some ranchers even paid bounties to professional hunters who would take wolves on their land (Brown 1983: 43–44; Burbank 1990: 98).

Wolves were also targeted because of their predation on deer, the most important meat animal taken by private and commercial hunters. Deer population declines were due in large part to hunting, however, so the Territorial Assembly passed a law in 1897 regulating hunting of deer and other game (Findley et al. 1975: 329).

Interest in the climate grew among the livestock and farming industries and the federal and territorial governments during this period. Weather records had been kept

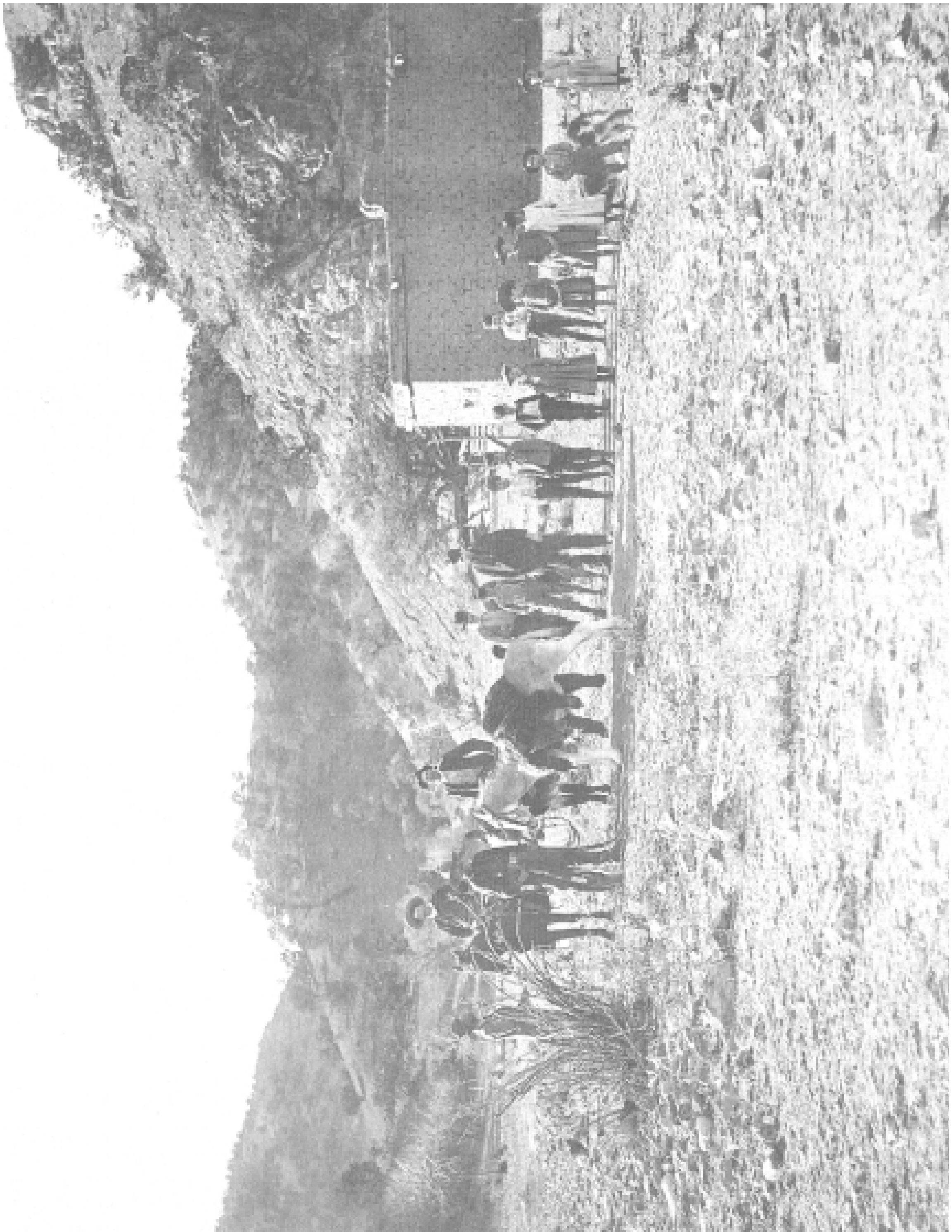

Figure 78—Hunters and onlookers with dead grizzly bear, 1880s. Courtesy Museum of New Mexico Photo Archives, Santa Fe (negative no. 12241).

by the U.S. military over the past 4 decades. This responsibility was transferred to the U.S. Weather Bureau, established in the Agriculture Department in 1891 (Bradley 1976: 12). Four years later the Territorial Assembly passed legislation enabling the publication of a *Monthly Weather Review*, which disseminated climatic data collected by the Weather Bureau. Volunteer observers collected most of the field information at this time (Tuan et al. 1973: 12).

The Territorial Assembly also passed an important law affecting irrigation. This measure defined community ditches (acequias) and detailed their legal status. The multiple owners of ditches were considered to be "corporations" or bodies corporate, with power to sue and be sued as such (Clark 1987: 30).

On March 16, 1899, the legislature responded positively to the federal Fergusson Act, which authorized the transfer of federal public lands to the territory for schools and certain other public institutions. About 500,000 acres were designated as sites for irrigation reservoirs and 100,000 acres for "improving the Rio Grande and increasing its surface flow in New Mexico." To lease, sell, and manage these lands, the Territorial Assembly created the office of Commissioner of Public Lands and a Board of Public Lands in March of 1899 (Clark 1987: 84). That same year, the legislature authorized towns of the "first class" to issue bonds for construction of embankments, drainage ditches, and other facilities to prevent flood damage to or destruction of municipal property (Clark 1987: 31–32).

Some of the most significant events in natural resource legislation and management during the 1890s were forest related. Congress and other officials in Washington were increasingly concerned about illegal and wasteful timber cutting. Congressional action in 1888 forbade trespass timber harvesting on Indian reservations, and Congress repealed the unsuccessful Timber Culture Act in 1891 (Clark 1987: 62; Udall 1962: 6). Also in 1891, the General Land Law Revision Act, commonly known as the Creative Act, was passed; it authorized the establishment of national forest reserves from public domain lands by presidential action. These reserves would later be redesignated national forests. Their administration was assigned to the Department of Interior, rather than Agriculture (Baker et al. 1988: 25; Clark 1987: 71; Utely and Mackintosh 1989: 19).

In January 1892 the President created the Pecos River Forest Reserve, the first "national forest" in New Mexico (Fig. 79; Table 63). The cutting of timber up to $100 in value, per year, on the reserves was allowed in the fiscal year of 1893 (Baker et al. 1988: 25, 79; Tucker and Fitzpatrick 1972: 1; Udall 1963: 100–101). This reserve subsequently became part of the Santa Fe National Forest.

Congress passed the Organic Act for national forests in June 1897. This legislation established standards for the use and protection of national forest reserves. Furthermore, this act embodied the concept of multiple-use of resources in conformity with state laws and federal rules and regulations. Management of grazing, including the use of grazing fees for cattle, sheep, and horses, was authorized. The act also authorized sale of timber on national forest reserves (Baker et al. 1988: 39, 79; Brown 1978: 254; Clark 1987: 140; Eastman and Gray 1987: 36).

Probably the most important figure in the history of national forests, Gifford Pinchot, was appointed Chief Forester in the Department of Agriculture in 1898. An activist and friend of Theodore Roosevelt, he already had a plan and program for the systematic management of the forests. Owing to Pinchot's influence, Roosevelt, who became president in 1901, declared that "forest and water problems are perhaps the most vital internal questions of the United States" in his first state-of-the-union message (Udall 1963: 101–103). A Forestry Division was created in the General Land Office in 1901, but four years later management was transferred to Agriculture (Udall 1962: 9–10).

Management of wildlife in the national forests was, as yet, not a concern, although a federal law, the Lacey Act, passed in 1900, made market hunting and importation of foreign wildlife illegal (Borland 1975: 122). Interest in wildlife at the territory level was evidenced by the introduction of brook trout into the Rio San Jose near Laguna at this time, followed by other releases in other drainages of the Rio Grande in the early 1900s (Sublette et al. 1990: 72).

Over the first decade of the 20th century, Pinchot effectively debated vegetation management for watersheds and grazing regulation, including fees, with the Secretary of the Interior and Army Corps of Engineers, western stock growers, and various congressmen. The Department of Agriculture actually had promoted management of water through management of the forest reserves. In 1900, the General Land Office opened these lands to limited fee grazing. Preference was given to livestock raisers with land within or adjacent to the reserves (Clark 1987: 72, 141).

Another management policy for the forests implemented at this time was fire suppression. Aggressively pursued to the present, this strategy, combined with livestock grazing, has caused significant change in the composition of plant communities in the national forests (Dick-Peddie 1993: 51, 56, 91–92).

Owing primarily to predation on livestock by wolves, grizzly bears, and other carnivores, the program to exterminate these predatory animals was continued with an act in 1903 to authorize counties to levy taxes for use in paying bounty claims. In the following year, the legislature created the New Mexico Department of Game and Fish (Borland 1975: 122; Hagy 1951: 91; Sublette et al. 1990: 72).

Water quality was a concern at the federal level as Congress passed the Rivers and Harbors Appropriation Act of 1899. Also known as the Refuse Act, this legislation authorized the Corps of Engineers to regulate all sources of effluents into navigable streams. Polluters could be

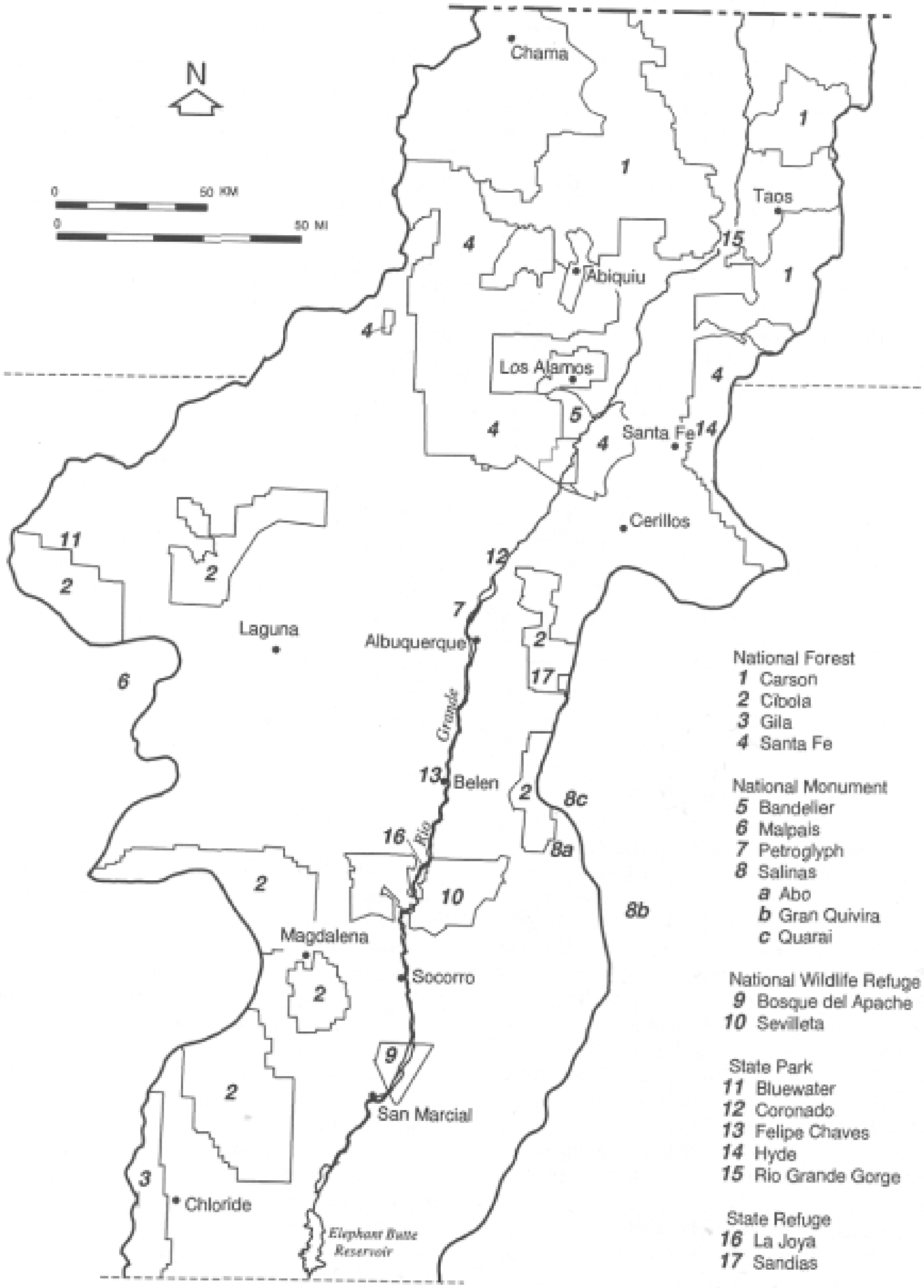

Figure 79—National forests, parks and monuments, national wildlife refuges, and major state parks.

Table 63—National and state forests, wildernesses, wild rivers, parks, monuments, and refuges.

Name	Date established	Name	Date established
National preserves/forests (NF)		Apache Kid WA	1980
Santa Fe NF		Withington WA	1980
Pecos River	1892	Rio Grande Wild and Scenic River	1970
Jemez	1905	National monuments (NM)	
Pecos River NF changed to Pecos NF	1908	Gran Quivira National Monument	1909
Jemez and Pecos NFs consolidated	1915	Salinas NM (Gran Quivira NM, Abo and	
Carson NF		Quarai State Parks combined)	1981
Taos Forest Reserve (FR)	1906	Bandelier NM	1916
Taos, Carson, and part of Jemez NF combined	1908		
Cibola NF		National wildlife refuges (NWR)	
Mt. Taylor	1906	Bosque del Apache NWR	1939
San Mateo	1906	Sevilleta NWR	1972
Manzano	1906		
Magdalena FR	1906	State parks (SP)	
Mt. Taylor NF and Manzano NF combined	1908	Bluewater Lake SP	1937
Datil NF	1908	Quarai and Abo Ruins SP	1937
San Mateo NF added to Magdalena NF	1908	Hyde SP	1939
Zuni NF and Manzano combined	1914	Rio Grande Gorge SP	1959
		Rio Bravo SP	1982
Wilderness areas (WA)		Coronado State Monument	1935
San Pedro Parks WA	1964		
Pecos WA	1964	State Game Refuges (SGR)	
Wheeler Peak WA	1965	Sandia Mountains SGR	1938
Bosque del Apache WA	1975	La Joya SGR	1928
Bandelier WA	1978		
North Sandia Peak WA	1978	State waterflow areas (SWA)	
South Sandia Peak WA	1978	Belen SWA	1958
Manzano Mountains WA	1978	Bernardo SWA	1971
Chama River Basin WA	1978	Casa Colorada SWA	1981
Cruces Basin WA	1980	La Joya SWA	1930
Basin Latir WA	1980		

Sources: Baker et al. 1988; Barker 1970; Crawford et al. 1993: 13; Grover and Musick 1989; McDonald 1985; Tucker 1992.

charged with a misdemeanor for such discharges, which did not include waste from “properly supervised” public works or waste in “liquid state” from streets or sewers (Clark 1987: 268; Welsh 1987: 202).

Water management to enhance availability was also addressed. In June 1902 Congress created the U.S. Reclamation Service, which was organized within the USGS. Its major responsibility was to construct irrigation works for the reclamation of arid lands. Users of these facilities would repay construction costs over a 10-year period, and small farmers could irrigate 160 acres or less with water from federal irrigation works. The collected monies would be placed in a reclamation fund, which would be used to build dams and canals in the region. In 1907 the service became a separate Bureau of Interior agency (Utely and Mackintosh 1989: 19).

At the direction of Congress, the Bureau of Mines was created within the Interior Department in 1907. This bureau promoted minerals technology and mine safety (Utely and Mackintosh 1989: 27). Concerned for the safety of miners, the Territorial Assembly passed a law governing operators, supervisors, and miners. Basic ventilation was set at 100 cubic feet of air per man per minute and 300 cfa for each animal (Whiteside 1989: 174).

President Roosevelt remained active in raising Americans’ collective awareness of environmental problems and the need to widely use or preserve resources. In 1908 he convened the Governors’ Conference on Conservation and told the participants “Facts which I cannot gainsay force me to believe that the conservation of our natural resources is the most weighty question now before the people of the United States.” Before the National Conservation Commission, which he assembled in Washington the following year, the President challenged the participants “to make the nation’s future as great as its present. That is what the conservation of our resources means” (Swift 1958: v; Worster 1994: 20–21).

In 1903 Roosevelt created a commission to study the laws regulating settlement and grazing of public domain lands, with the view of long-time "conservation,” a term coined by Pinchot and forester Overton Price. These men and other commission members concluded that most of the grasslands on public domain were unsuitable for farming, and lack of government regulation and poor private stewardship had resulted in widespread degradation of rangelands due to overgrazing. Nevertheless, the heavy stocking on national forests was believed to be desirable in that removal of grass and other understory plants would reduce fuels for fires. Fire suppression was now a primary objective of the Forest Service (Baker et al. 1988: 56; Barnes 1926: 37–38; Brown 1985: 124; Udall 1963: 105–106).

As early as 1905, the U.S. Forest Service was developing a grazing program that would improve the value and use of rangelands. However, the service made inaccurate counts of livestock numbers and miscalculated carrying capacities, which led to continued overgrazing. The same problem occurred on lands considered unfit for timber that were settled by individuals under the June 11, 1906, Forest Homestead Act. Erosion of farm plots by runoff water on these claims occurred frequently (Roberts 1963: 115; Rowley 1985: 55, 63, 81–82).

On June 25, 1906, Congress amended the Fergusson Act permitting the Secretary of the Interior to approve grazing leases in excess of the 640-acre limit on public lands. Following passage of this legislation, grazing leases became the primary source of revenue from territorial lands (Clark 1987: 85). Four years later, an "Indian Forest Service" was formed in the Department of the Interior. It became known as the "Branch of Forestry" of the Bureau of Indian Affairs (Udall 1962: 13).

The Forest Service grazing fees, which went into effect in 1906, averaged 4.7 cents per animal unit month. Some ranchers challenged the agency's legal authority to charge for grazing, as well as to implement other regulations. After lengthy litigation, the Supreme Court upheld the Forest Service's right to carry on this management of resources (Baker et al. 1988: 98; Clawson 1970: 171-172; Rowley 1985: 86). There were 131,621 cattle and horses permitted to graze on national forests in New Mexico in 1909. The same year, the service allowed Native Americans to graze low numbers of livestock free if the meat of these animals was eaten and the hides used.

Between October 5, 1906, and July 2, 1908, President Roosevelt created a number of national forests in the study region (Table 63). These included Mt. Taylor, San Mateo, and Magdalena, all of which later became part of Cibola; Taos, which later became part of Carson; Jemez and Pecos, which were combined in 1915 and became part of the Santa Fe National Forest (Fig. 79). Most of these forests included not only traditional grazing lands of Hispanos and Pueblos in the region, but also Pueblo religious sites and shrines such as Taos' sacred Blue Lake. It would be many years later before the sacred Blue Lake and other important religious areas were restored to the Pueblos (Baker et al. 1988: 25, 42; Sando 1989: 83; Tucker 1992: 107, 109, 112–114; Wood 1989: 74).

A late prehistoric-historic Pueblo ruin and associated Spanish mission churches were established as Gran Quivira National Monument by President William Howard Taft in 1909 (Table 63). His authority to do so came from the Antiquities Act, passed by Congress in 1906, enabling presidents to preserve significant "historic landmarks . . . and other objects of scientific interest" (Carroll 1991: 1; Udall 1963: 132). Also in 1909, a branch of the Department of Agriculture, the Bureau of Soils, warned that topsoil is the one resource that Americans must not exhaust (Worster 1993a: 73).

In the first decade of this century, the Territorial Assembly was focused on water. In 1905 an act creating the River Commission, with responsibility for flood control on the Rio Grande, was passed. Burros, or dikes, were built at Valencia and Tome to protect against a major flood that year. Also passed was an act declaring natural waters as belonging to the "public," and all New Mexico citizens had the right to appropriate them for beneficial use. A territorial engineer, a water code, and a reconstituted Board of Water Commissioners were enacted by the assembly 2 years later. Hydrographic surveys were soon begun by the engineer (Clark 1987: 117–123; Ellis and Baca 1957: 17). Finally, 55 new irrigation ditches went into operation in the Middle Rio Grande Valley from 1905 to 1912 (Hedke 1925: 22).

In 1909 two types of voluntary water organizations were authorized by the territory—water users' associations and irrigation districts. For the latter, irrigation systems could be constructed for the members. Another provision was also passed by county commissioners authorizing drainage of seepage in unincorporated towns and villages. This provision had to be petitioned by a majority of a community's residents and investigated by the county surveyor, who had to concur, before this action could be implemented (Clark 1987: 110, 112).

Also, in 1909, Congress passed the Enlarged Homestead Act, which authorized the classification and entry of semiarid lands. Qualified entry men could occupy 320 acres of "nonmineral, untimbered, nonirrigable, unreserved, and surveyed but unappropriated" public land in the territory. One-eighth of the land had to be continuously cultivated for crops, other than native grasses, by the end of the second year and one-quarter within the third year (Clark 1987: 136–137).

During this general period the Forest Service began to hire trappers to kill wolves to protect livestock on national forest grazing lands (Dunlap 1984: 143). Also, the territory continued its program to exterminate grizzly bears and wolves. Bounties of $20 and $15, respectively, were paid in 1908-09 for these animals, and up to $50 could be obtained for grizzly bear hides. At the same time, the effort to reintroduce elk into the region was begun by the owner of Vermejo Park. Because of the low numbers of pronghorn, the legislature enacted a law to take them off the list of legally hunted animals. In 1912, the last indigenous sage grouse was killed near

Chama (Barker 1953: 93, 153; Burbank 1990: 98; Matthiessen 1959: 283).

More than 900 permits to take beavers were issued to individuals who claimed damages to their property in 1910–11. Conversely, the Santa Fe Water Company was offering $50 for each pair of live beavers to transplant in upper Santa Fe Canyon, where they would help save water (Bailey 1971: 219).

Management concerns for public grazing lands and water use continued on the federal level. In 1910 the USFS established the Office of Grazing Studies, and the following year offices were organized at Denver and Albuquerque. Many stockmen believed that grazing permits were a property right, subject to sale or transfer. The Forest Service took the position that they were "a personal privilege obtained from the secretary of agriculture [sic], and only the secretary retained the right to grant, withhold, or revoke the permit at his discretion" (Price 1976: 7; Rowley 1985: 89–90, 99).

Under legislative acts to prevent individuals or private companies from gaining exclusive use of extensive public lands or waters, the General Land Office withdrew such tracts and sources (Clark 1987: 145). In 1911 Congress passed another act, the Weeks Law, which authorized funds for acquisition of forest lands to protect stream watersheds. This legislation also called for a cooperative fire protection plan between the Forest Service and participating states (Otis et al. 1986: 5). A 1913 USGS report addressed the need to consider water in the disposal of the remaining public lands and that this resource must be properly managed (Clark 1987: 144).

In 1912 the new State Legislature passed the Game and Fish Act, establishing a Game Protective Fund, codifying territorial wildlife laws, and making it a misdemeanor to pollute waters with sawdust or other materials that would kill or drive away fish (Clark 1987: 272).

Upon admission to the Union in 1912, Congress gave all sections 2, 16, 32, and 36 to New Mexico for the aid of public schools. Other public lands were received by the state as well (Barnes 1926: 46).

Also in 1912 the Forest Service began to manage grazing to protect rangelands, watersheds, and wildlife by reducing the numbers of livestock in the forests (Roberts 1963: 115–116). The Jornada Range Reserve, created by Executive Order in 1912, was managed by the USDA Bureau of Plant Industry. Researchers at the reserve, which is located just south of the study region, studied methods of improving and maintaining desert grassland for sustained use and for protection of livestock (Price 1976: 17).

The federal and state effort to control predators was accelerated in 1914–15. In a Congressional act on June 30, 1914, the Predatory Animal and Rodent Control (PARC) was formed within the U.S. Biological Survey. This branch was responsible for experiments and demonstrations in destroying wolves, grizzly bears, and other predators of livestock. J. Stokely Ligon was made head of the wolf eradication program and was subsequently joined by Aldo Leopold of the Forest Service, who later reversed his view of predators, especially wolves (Fig. 80). In the first year of operation, 69 wolves were trapped, poisoned, or shot in the state. In 1916, 117 wolves were taken in the national forests (Bailey 1971: 311; Brown 1983: 52, 1985: 126–127; Burbank 1990: 101, 107–108; Leopold 1949: 129–133).

Besides livestock, the Forest Service was concerned about the loss of large game animals to various predators. The prevailing view of wildlife managers at this time was that populations of elk, mule deer, and pronghorn had been extirpated or severely reduced primarily by predation. Intensive hunting was also considered a contributing factor. To correct this, the Forest Service released 37 elk from Yellowstone National Park into the Pecos District of the Santa Fe National Forest in 1915. In less than 20 years this small herd had increased to about 300 animals, and hunting was permitted within a short time. Mule deer populations had been severely reduced in the valley and the foothills of the region before 1920. The pronghorn population, reduced to 1,200 animals in 1915, increased to 2,957 head by 1926 owing to protection from hunting (Bailey 1971: 29; Barker 1953: 94–95, 163; Findley et al. 1975: 334).

In 1915 Congress passed the Agriculture Appropriations Act, which in part provided for the establishment of summer homes, recreation sites, and campgrounds in the national forests. Within the Santa Fe National Forest, President Woodrow Wilson created the 22,400-acre Bandelier National Monument in February 1916. Near the monument, Ashly Pond, founder of the Los Alamos Ranch School, founded a sportsman's club, which included a game preserve with hunting and camping areas, at the north end of the Ramón Vigil land grant. When the spring went dry, the source of water was lost, and he abandoned the project (Church and Church 1974: 9; Ebright 1994: 244–245; Rothman 1992: 122). On August 25 of the same year, Congress passed the National Park Act, which led to the creation of the National Park Service (Udall 1963: 153).

Also in 1916, the U.S. Bureau of Reclamation completed construction of Elephant Butte Dam, and the reservoir soon began filling. This dam and reservoir system was constructed to control floods and to store irrigation water. Floods were also an ongoing concern of the State Legislature. In this same year the legislature created the Rio Grande Commission, whose purpose was to address drainage, water storage, river rectification, river-bank protection, diversion dams, and canals, as well as flood control (Clark 1987: 195, 198, 205, 206, 217–218).

The management of livestock dominated the efforts of Federal regulatory agencies in the years 1916–18. The Stock-Raising Homestead Act of 1916, passed by Congress, allowed the substitution of range improvements and well

Figure 80—Aldo Leopold (left), Ira Yarnell, and Harry C. Hall in the Carson National Forest, 1911. Courtesy University of Wisconsin Photo Archives (X25 123).

drilling for cultivation. Also, a free section of grazing was provided when the applicant filed a claim. Another provision allowed for livestock driveways of not more than one-fourth mile wide across public land (Clark 1987: 147; Hagy 1951: 78–79; Oakes 1983: 27).

The Forest Service raised grazing fees by 25 percent in 1916, rather than the 100 percent it had proposed. Nevertheless, ranchers, in general, and some politicians, protested vigorously. In another management decision, the service issued livestock grazing permits to non-Indians for the sacred Blue Lake area. Grazing permits on all of the region's national forests were increased owing to increased demand for beef and wool during World War I. This overgrazing and a drought resulted in erosion. Trespass livestock on Forest Service lands was common at this time, which also contributed to the overgrazing (Clark 1987: 146; de Buys 1985: 231; Donart 1984: 1240; Hagy 1951: 62; Roberts 1963: 120–121; Sanchez 1992: 2; Sando 1989: 83).

With the demand for beef generated by the war, Ligon and Leopold used the situation to justify an intensified predator control effort. In 1917 the Biological Survey received $25,000 to control predators and rodents in the state. Some 93 adult wolves and 30 pups were killed by PARC and New Mexico A&M College (now New Mexico State University) employees in 1918. By 1920 the estimated wolf population of 300 had been reduced to 60 or less. The poisoning of grizzly bears was also initiated by PARC the same year, and 28 animals were taken (Brown 1983: 57–58, 64, 137; Flader 1978: 60; Hagy 1951: 93; Roberts 1963: 120–121).

Early in 1920 private forester Stewart Edward White criticized the Forest Service for its no burn policy of ponderosa stands. He maintained that light burning would preclude development of understory brush, which would lead to destructive fires, and would prevent tree diseases. The Forest Service's program was based on the belief that fire every 2 to 3 years would prevent restocking of the tree (Brown and Carmony 1995: 143; Pyne 1982: 522).

Aldo Leopold "presented a fully formed and brilliantly considered wilderness-preservation plan to the Forest Service" in 1921 (Brown and Carmony 1995: 152). The plan was well received by most of his supervisors. Within a year he presented a proposal for a Gila Wilderness area, which was created 2 years later, the first official U.S. wilderness area. During this period, some ranchers supported wilderness areas because their roadlessness would keep automobiles and their passengers off grazing leases (Brown and Carmony 1995: 153–154).

In March 1922 Congress passed the General Forest Exchange Act, authorizing the Forest Service to consolidate forest lands and to make exchanges to acquire private inholdings within national forest boundaries. This law was amended 6 years later to authorize the exchange of grants lands adjacent to the Carson, Santa Fe, and Manzano national forests for the use of Forest Service land and timber (Baker et al. 1988: 27).

In 1922 there were 7,559,000 acres of public land under grazing lease and 1,500,000 under oil lease. Two years before, Congress had passed the Minerals Leasing Act, enabling the General Land Office to lease lands with fossil fuels and other critical mineral resources to private producers. Also in 1922, the state reduced grazing fees on its lands from 5 cents to 3 cents an acre (Barnes 1926: 47; Hagy 1951: 82; Utely and Mackintosh 1989: 27).

On June 10, 1920, Congress passed the Federal Water Power Act, which provided for the establishment of a Federal Power Commission. The commission was authorized "to issue licenses for the construction, operation, and maintenance of power facilities on navigable waters and public lands" (Clark 1987: 145–146).

In the 1920s the federal and state governments began to address adverse environmental conditions in the Middle Rio Grande Valley. The Rio Grande Survey Commission, in cooperation with the U.S. Reclamation Service, initiated a study of these conditions in 1921. Two years later the service's name was changed to the Bureau of Reclamation. In 1923 the State Legislature passed the first Conservancy Act, which created a district for the Middle Valley with a governing board to initiate projects to prevent flooding, regulate stream flow, reclaim waterlogged lands, develop irrigation works, develop or reclaim sources of water, and generate electrical energy. Within 2 years the district structure was formed, and construction subsequently began on dams, levees, and drainage canals (Clark 1987: 189, 206, 207; Scurlock 1988a: 136; Wozniak 1987).

The Federal Government and the Middle Rio Grande Conservancy District provided assistance to the Pueblos relative to land and water issues in the region during this period. In June 1924 Congress passed the Pueblo Lands Act, which provided for the appointment of a commission to investigate Pueblo land titles and to litigate the thousands of non-Indian claims against their lands. A commission was established to compensate Indians and non-Indians for lands lost via court decisions. For Pueblos that did not have a reliable water supply, reservoirs were constructed (Brayer 1938: 28–29; Vlasich 1980: 26).

In 1925 Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta were incorporated into the Middle Rio Grande Conservancy District, agreeing to reorganize their irrigated land "into larger, revenue-producing farms." To date, only Isleta and Sandia have lived up to the requirements of the agreement (Sando 1992: 123).

In 1928–29 the district agreed to "provide conservation, irrigation, drainage, and flood control" for the Pueblo (Bayer et al. 1994: 240). When the MRGCD was organized after 1929 the Pueblo persuaded Congress to make a payment of $1,321,000 to the district on their behalf because they could not maintain their subsistence economy if required to pay ongoing charges for irrigation facilities and water (Harper et al. 1943: 24).

The late 1920s-early 1930s were marked by loss of Pueblo land and trespass by non-Indians. Santa Ana Pueblo is an example of some of these problems. In the earlier period Santa Ana granted a railroad right-of-way across its lands. Construction of the line damaged a flood control dike and caused erosion (Forrest 1989). Livestock owned by non-Pueblos were illegally grazed on Santa Ana lands, and outsiders also dumped trash and cut firewood (Bayer et al. 1994: 238).

Overgrazing of the public domain continued into the 1920s, especially that caused by wild horses on the national forests. With the assistance of local ranchers, U.S. Forest Service rangers rounded up thousands of these animals from 1924–25. The following year the Forest Service published *The Story of the Range*, which documented grazing history and resulting impact on Southwest rangelands. The Forest Service also released a memo entitled "New Grazing Regulations on National Forests"; in this document three major concessions to the livestock industry were made: (1) 10-year grazing permits were given full status of a contract between the Forest Service and the stockmen and could only be revoked because of a violation of terms, (2) further distribution of grazing privileges was generally suspended, and (3) the role of local grazing boards was reemphasized, with one member representing the Department of Agriculture and the other members selected by the grazing permittees. These boards settled grazing disputes and gave advice in developing new grazing policies (Brown and Carmony 1995: 171; Rowley 1985: 134–135; Tucker and Fitzpatrick 1972: 79–80; Wyman 1945: 159–160).

The Story of the Range, and Aldo Leopold's 1924 article on the effects of intensive grazing and fire suppression, helped lead to the McSweeney-McNary Act of 1928, which called for the development of methods to protect watersheds. This act also authorized experiments in range management at 12 regional forest research stations, including the Rocky Mountain Forest and Range Experiment Station at Fort Collins, Colorado. A branch station was opened subsequently in Albuquerque (Bergoffen 1976: 61; Buchanan 1988: 32; Price 1976: 19). Largely due to Leopold's efforts, the first wilderness area ever created was the Gila, established in the Gila National Forest in 1924 (Baker et al. 1988: 47).

The U.S. Biological Survey and cooperating ranchers put out 103,000 strychnine-poisoned baits to control predators in 1923. Wolves, grizzly bears, and coyotes were targeted; populations of the first two animals were virtually extinct. Local bounties were paid for bobcats, and sheep ranchers hunted them vigorously. Game species such as deer and pronghorn were at an all-time low the following year. But mule deer numbers in the national forests increased rapidly with the virtual elimination of predators and hunting regulation. By the late 1920s, they were abundant. Black bears, whose numbers were low, were also given legal protection (Bailey 1971: 296; Brown 1985: 142; Brown and Carmony 1995: 127; Findley et al. 1975: 29; Ligon 1927: 15).

From 1929 to 1934 several federal laws were passed that appropriated funds for the creation of wildlife sanctuaries on national forests; authorized the purchase of additional refuge lands; authorized studies of economics of harvesting fish, game, and wilderness recreation; and expanded the wildlife conservation authority. Congress also appropriated $150,000 for the Forest Service to "investigate the life histories and habits of forest animals, birds, and wildlife from the standpoint of injury to forest growth and as a supplemental economic resource" (Clark 1987: 266–267).

On March 16, 1927, the State Legislature passed a groundwater law for New Mexico, the first such law of its kind among the western states. In this act, all underground waters in the state were declared public waters, "subject to appropriation for beneficial uses" under relevant existing state laws. Use was to be administered by the State Engineer. Additionally, the Middle and Upper Rio Grande was declared a groundwater basin (Clark 1987: 236–238).

Surface water conservation and management continued as a priority on the national and state levels. In 1927 Congress authorized the Corps of Engineers to conduct surveys for flood protection and hydropower facilities in all U.S. waterways. In 1928 Congress also authorized the Secretary of the Interior to enter into a contract with the Middle Rio Grande Conservancy District for participation in its $10 million program of drainage, flood control, rehabilitation of irrigation systems and farmland, and general conservation. Furthermore, in 1929 Congress enabled New Mexico to negotiate specifically with Texas for the apportionment of the waters of the Rio Grande and the Pecos River. In 1929 Congress passed the Flood Control Act, allowing the Corps of Engineers to locate water sources for domestic supplies, irrigation, and hydroelectric power (Clark 1987: 230; Strauss 1947: 133–134; Welsh 1987: 22, 109).

That same year the state attorney general ruled that "unauthorized obstruction of any natural water course did become actionable for resulting damage" (Clark 1987: 25). The state also declared that the waters of underground streams, channels, artesian basins, reservoirs, and lakes "with reasonably ascertainable boundaries are public waters subject to appropriation for beneficial use in accordance with the statutes and regulations formulated by the State Engineer of New Mexico" (Erickson 1954: 81).

The Middle Rio Grande Conservancy District completed construction of major water control facilities, including El Vado dam and reservoir on the Chama River, between 1930 and 1934. Levees, drainage canals, and new irrigation ditches were also constructed in the Rio Grande Basin (Harper et al. 1943: 53; Fig. 81).

Most ranchers and homesteaders continued to overgraze public and private lands, and resulting soil erosion continued as a serious problem across the region. Conservationists urged Congress to control grazing on federal lands by establishing regulations to be administered by the Department of Agriculture. By 1930, grazing permits on the Santa Fe National Forest had been reduced to correlate with carrying capacities (Cooperrider and Hendricks 1937: 82; Rothman 1992: 159; Stout 1970: 323). In 1930–31 the Forestry Division, Bureau of Indian Affairs, assumed responsibility for the protection and administration of grazing on Indian lands. A grazing policy for the reservations was formulated and implemented (Udall 1962: 17).

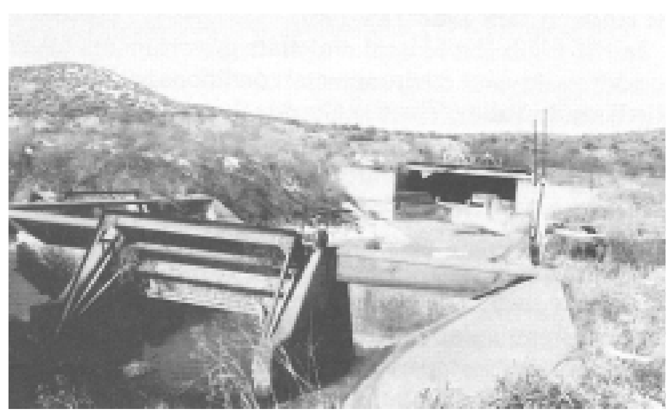

Figure 81—Middle Rio Grande Conservancy District water control facility south of Isleta Pueblo. Photo by author.

A forestry research area of 10,000 acres was established in 1930 on the Santa Fe National Forest for use by the University of New Mexico (Baker et al. 1988: 29). Three years later, the Forest Service made the Pecos High Country a "Primitive Area" (deBuys 1985: 285). The Wilderness Society, an advocacy group for wilderness areas, was organized in 1934 and would soon bring pressure on the government to create wilderness areas (Udall 1963: 154).

In November 1931, the National Conference on Land Utilization met in Chicago and recommended that in order to obtain conservation and rehabilitation of the grazing ranges of the public domain these lands be organized into public ranges to be administered by a Federal agency in a manner similar to and in coordination with the national forests. The group also recommended "that lands valuable for watershed protection should be administered under the supervision of the Federal Government." Subsequently, the Secretary of the Interior approved federal regulation of grazing on the public domain to protect these lands (Clark 1987: 252–253). Also, the Soil Erosion Service was established as a temporary agency in the Department of the Interior in 1933. Two years later it was transferred to the Department of Agriculture under the National Soil Conservation Act. In 1935 this agency implemented an erosion control program for the 11,500,000-acre watershed of Elephant Butte Reservoir, which was filling with sediment at a rapid rate (Clark 1987: 256; Udall 1962: 18).

The emergency conditions of the Depression took precedence, in general, over erosion caused by overgrazing as the Forest Service suspended grazing fees in 1932. To accommodate the increased grazing pressure, the agency removed more than 1,500 horses from the Jemez River District of the Santa Fe National Forest. Grazing fees for grazing on national forests were reinstated in 1933 by the Secretary of Agriculture. These fees were based on an appraisal of each range area and varied from year to year in proportion to changes in livestock prices (Clawson 1971: 172–173; Rowley 1985: 246).

Several programs to aid economic recovery during the Depression were authorized by Congress and the President. The National Industrial Recovery Act enabled the Forest Service to develop a code of business practices for the timber industry. Included in this code was commitment to "conservation, selective cutting, sustained yield, reforestation and a program to prevent forest fires" (Baker et al. 1988: 53).

President Roosevelt created the Civilian Conservation Corps (CCC) in 1933, a program that, until 1942, put about three million persons to work, primarily on soil and water conservation projects. Some 17 CCC camps were established on national forests in New Mexico; there were four camps established on the Santa Fe, including one at Bandelier and two on the Cibola. Workers erected boundary fences; built roads, trails, and bridges; constructed erosion control features; improved timber stands; replanted areas; and built residences and other structures (Baker et al. 1988: 53; Buchanan 1988: 32–33; Rothman 1992: 183–184).

An Indian branch of the CCC was organized in 1933, and several irrigation projects were completed. From this year until 1940, a range conservation program was conducted on Indian lands in the Middle Valley by the Soil Conservation Service (Harper et al. 1943: 89; Hughes 1983: 126). In addition to the CCC, the Work Projects Administration, the Public Works Administration, and the National Youth Administration provided employment for workers who carried out conservation and reclamation projects for water and wildlife improvement beginning in 1937 (Clark 1987: 244–245).

Congress passed the Indian Reorganization Act on June 18, 1934, giving Native Americans the right to govern themselves, prohibiting alienation of Pueblo lands, and defining the Secretary of the Interior's responsibility for conservation and economic development of resources on Indian lands. In this same period, the BIA and New Deal agencies conducted a number of in-depth surveys of natural and human resources in the region. The interrelationships between Native, Hispano, and Anglo Americans, and each with the environment, were first addressed in these studies (McWilliams 1961: 287; Simmons 1979b: 217; Utely and Mackintosh 1989: 32).

The drought year of 1934, exacerbated by the Dust Bowl conditions located just to the east of the study region, was a time of focusing on grazing and related erosion. The governor created a planning board made up of individuals from five major state resource agencies and presidents of the three major universities. They initiated a study of the region's natural resources with an emphasis on erosion problems and water conservation (Clark 1987: 269). The Federal government began buying cattle on overgrazed, drought-stricken rangelands (Limerick 1987: 88).

On June 28 of the same year, Congress passed the Taylor Grazing Act, authorizing the Secretary of the Interior to rehabilitate overgrazed and eroded areas and to control and manage grazing on the public lands. Under the act, the U.S. Grazing Service was organized within the Interior Department. In 1946 this agency was combined with the General Land Office to form the Bureau of Land Management (Clawson 1971: 34–38; Hagy 1951: 75). Also under the act, the bulk of unappropriated grassland (80 million acres) was closed to further settlement. These lands were to be kept as a grazing resource and managed by local livestock raisers organized into four districts within the 1.5 million acres in the Middle Rio Grande Basin. These districts were supervised by the Interior Department. State and district advisory boards were formed; their members were elected by permittees. Through these boards, livestock raisers, who had strongly opposed passage of the

Taylor Grazing act, were able to mitigate the impact of the law. As a result, "range conditions improved very slowly" (Clawson 1971: 34–38; Eastman and Gray 1987: 35; Hagy 1951: 75; Harper et al. 1943: 88–89; Stout 1970: 314, 318; Worster 1979: 190).

A 1934–35 study by the New Mexico State Planning Board found that the public rangelands were badly damaged due to overgrazing. Pueblo grazing lands were also in poor condition, primarily as a result of a long history of intensive grazing. This led to the U.S. Government's establishment of an accelerated land acquisition and management program for Native Americans. About 390,727 acres were purchased or assigned to Indian use on non-Pueblo lands. One such large tract was the badly overgrazed and eroded Ojo del Espiritu Santo land grant, where, following purchase, a resource management program was initiated (Varney 1987: 35).

Under the Taylor Grazing Act, the Pueblos received grazing permits on public lands (Aberle 1948: 15–16). This removed some grazing pressure from Pueblo lands, but range grasses continued to deteriorate and soil erosion continued. The Indian Service, now the Bureau of Indian Affairs, "assumed an advisory and supervisory responsibility for the range" (Aberle 1948: 19).

In 1935 a New Deal land reform for Native Americans and Hispanics was implemented under the leadership of John Collier. One aspect of this program was the restoration of the fertility of severely eroded land (Aberle 1948: 20; Forrest 1989: 129; Table 64). Land deterioration continued, however, due partly to overstocking, wild horses, and generally dry conditions after 1941. Government programs to control erosion on Pueblo lands continued into the 1940s (Bayer et al. 1994: 228; Harper et al. 1943: 50; Wyman 1945: 173).

After 1935 the range management division of the United Pueblos Agency determined the carrying capacity of the land. As a result, a livestock reduction program on Pueblo lands was implemented; this was an extremely unpopular program. Also, water control structures, such as small reservoirs, were constructed at some of the pueblos (Table 64). A concrete dam was erected on the Rio Grande, about 3 miles north of Cochiti Pueblo, to deliver irrigation water to Cochiti, Santo Domingo, San Felipe, and Algodones. At the first pueblo, the practice of dry farming was discontinued owing to this new water supply (Aberle 1948: 20; Bayer et al. 1994: 231, 233, 238; Hill 1982: 41; Lange 1959: 38, 368). Irrigation projects were completed at Santa Ana, Sandia, and Isleta pueblos (Table 65).

During the Depression and drought of the mid 1930s, predator control continued, and the federal attempt to eradicate all gray wolves and grizzly bears was successful (Hagy 1951: 54). At the state level, the legislature passed an act in 1931 giving full regulatory powers to the State Game Commission in managing wildlife, including hunting seasons and bag limits. By this year the pronghorn population had increased to about 5,000 animals. Rocky Mountain bighorn sheep were transported from Banff National Park, Canada, to the Sangre de Cristo Mountains, where they were released in 1933 (Barker 1953: 90, 1970: 188; Flader 1978: 105).

In 1936 the director of the Grazing Division established four grazing districts totalling 9 million acres. These districts were concerned with erosion control, water development, and land classification based on "best use" (Batie 1985: 109; Clark 1987: 270–271). Each district had advisory boards across the state, made up of ranchers, a local sportsmen's club member, and an employee of the division. Grazing fees were set at 5 cents per animal unit month. This agency also reduced livestock numbers on public lands and stopped nomadic stockmen, who roamed the range with no base of operation, from further grazing.

Table 64—Conservation improvements on Pueblo lands, 1935–1944.

Improvement	Quantity
Roads and trails	318 miles
Stock trails and driveways	95 miles
Small and large bridges	57
Cattle guards	56
Boundary and cross-fencing	1,325 miles
Corrals	35
Contour furrows	5,685 acres
Terraces	16 miles
Water control structures	1,085 gullies or arroyos
Shallow and deep wells	56
Spring development	122
Stock tanks	119
Impoundment, spreader, or diversion dams	263
Range grass planted	584 acres
Chamisa planted	6,732 acres
Trees planted	20,000

Source: Aberle 1948

Table 65—Rio Grande Pueblo irrigation projects, ca. 1940.

Pueblo	Population	Reservation area acres	Irrigated acres	Diversion acres
Cochiti	353	22,766	1,867	9,335
Santo Domingo	1,020	66,235	4,278	21,390
San Felipe	700	43,376	3,836	19,180
Santa Ana	274	19,139	1,114	5,570
Sandia	136	22,885	3,418	17,090
Isleta	1,336	205,331	6,183	30,915
Total	3,819	379,732	20,696	103,480

Source: Nelson 1946

The Forest Service and Soil Conservation Service implemented new grazing and soil stabilization management programs on severely eroded lands and actually purchased some of these lands. To deal with overgrazing and other land use problems on the national forests, Congress, in 1935, had appropriated funds for establishment of the Rocky Mountain Forest and Range Experiment Station (Clark 1987: 255; Clawson 1971: 149, 173, 1985: 230–232; Price 1976: 19; Rothman 1992: 199).

On the severely degraded Pueblo lands in the Middle Basin, a number of U.S. Government agencies financed and directed construction of conservation improvements from 1935 to 1944, including stock trails and driveways, fencing, contour furrows, terraces, water control structures, and revegetation of areas (Aberle 1948: 15–18).

The Forest Service released its report *The Western Range* in 1937, which described the severe deterioration of public grazing lands in the western states (Clark 1987: 274). By 1936, the agency estimated that at least 75 percent of the Rio Grande watershed in southern Colorado and northern New Mexico was experiencing severe, accelerated erosion, primarily due to overgrazing and intensive logging (deBuys 1985: 230–232). This same year the Forest Service received authorization and funding for the reserving of certain unappropriated waters in New Mexico to carry out the protection and improvement of national forest lands through water conservation (Clark 1987: 274). Also in 1937, Congress passed the Bankhead-Jones Farm Tenant Act, authorizing the Federal Government to purchase private lands of “low production.” These tracts were added to national forests and parks, grazing districts, and other public land holdings (Levine et al. 1980: 53).

During the 1930s drought, significant federal water legislation continued to be passed and management programs implemented. In 1934, the President created by Executive Order the National Resources Board, which sponsored ground and surface water studies. Two years later the Flood Control Act was passed. This law declared that the Federal Government was responsible for controlling floods on navigable rivers and runoff-caused erosion on smaller streams. The act "established for the first time an integrated flood-control policy" and laid the foundation for the greatest public works program ever undertaken by the U.S. Government (Clark 1987: 250, 256, 259–261).

The drought also spurred the establishment of the comprehensive Rio Grande Joint Investigation in 1936 involving a number of federal, state, and area governmental agencies and organizations, as well as private agencies and educational institutions. Their final report, issued in June 1937, provided the foundation for the Rio Grande Compact of the next year. This agreement, between New Mexico, Colorado, and Texas, apportioned the over-appropriated waters of the river to the three states (Clark 1987: 219–220; Harper et al. 1943: 53; Thomas 1963: H16).

Meanwhile, water users in southern New Mexico brought a suit against the state and the Middle Rio Grande Conservancy District for impairment of their water rights below Elephant Butte Reservoir through storage and diversion of Rio Grande watershed waters upstream. The suit reached the Supreme Court and a special master was appointed to hear the arguments and to make a final report. This and other problems were considered in the Joint Investigation study, which became the foundation for negotiating the Rio Grande Compact of March 18, 1938 (Clark 1987: 218–219). This compact delineated the tri-state division of Rio Grande water above Fort Quitman, Texas, and incorporated delivery schedules at the Colorado line and below Elephant Butte Reservoir.

Two years before, a new irrigation dam was completed at San Luis, Sandoval County. Also in 1936, the district completed work on the Cochiti, Angostura, Isleta, and San Acacia diversion dams. Also finished were 180 miles of new canals, 294 miles of new laterals, and 200 miles of riverside levees. During this construction in the Albuquerque area, some 300 farmers erected a barricade in the North Valley to halt work (Orona 1994). Some 8,000 individuals, almost all Hispanic, “lost their land titles because they were unable to pay taxes and assessments on the Middle Rio Grande Conservancy District Project...” (Gonzalez 1969: 52). The shallow water table in the valley subsequently went down, and 59,159 acres of reclaimed land were put under irrigation. The district was also allowed to develop its plan for 123,000 acres of land and water under this agreement (Clark 1987: 219–221; Harper et al. 1943: 94–95).

On August 26, 1937, the Small Reservoirs Act, which provided funding for construction of small storage structures for isolated communities and groups of ranchers, was passed by Congress (Clark 1987: 212, 263–264; Widdison 1959: 277). By 1939 the Division of Grazing had constructed 585 check dams to control erosion and 31 reservoirs with an aggregate capacity of 17,500 acre-feet of water benefitting 75,000 acres of land (Clark 1987: 256).

The federal and state governments also focused on ecocultural and recreational resources during this period. Congress passed the Historic Sites Act in 1935, requiring archeological investigations prior to the construction of a federal reservoir or a federally permitted reservoir. This act also declared a national preservation policy on public use of historic sites, structures, and objects of national significance. Furthermore, it established an "Advisory Board on National Parks, Historic Sites, Buildings, and Monuments (McGimsey n.d.: 16; Udall 1962: 19)."

At the state level, the legislature created, in 1935, the office of Superintendent of Parks and a Park Commission. The commission was authorized to acquire park lands and was directed to draft rules and regulations for public use of parks. Coronado, near Bernalillo, was the first state monument, and Bluewater Lake was the first park (Clark

1987: 271–272; Young 1984: 1, 5). In 1938 the Pueblo and Spanish ruins of Abo and Quarai were declared state monuments (Toulouse 1949: 1). Under the supervision of the National Park Service in 1938–39, the CCC developed the 350-acre Hyde State Park (Baker et al. 1988: 137; Fig. 79; Table 63).

Two major, private environmental groups were formed, the Wilderness Society in 1934 and the National Wildlife Federation in 1936 (Borland 1975: 148; Brown and Carmony 1995: 163). The Albuquerque Ski Club was organized a year later; this group operated a rope tow and restaurant in the Sandia Mountains under permit from the Cibola National Forest (Baker et al. 1988: 138).

Federal and state agencies continued to implement programs for the conservation and management of wildlife resources. The New Mexico Game and Fish Department established a game refuge on the east side of the Sandia Mountains, one of 201 statewide game refuges, totalling almost 3 million acres, in existence by 1939 (McDonald 1985: 12; Workers of the Writers' Program 1940: 33). In late 1939 the department released the first of a reintroduced herd of Rocky Mountain bighorn sheep from British Columbia into the Sandia Mountains (Pickens 1980: 83). The department also continued efforts to control predators. To supplement other predator control programs, the department tested a limited bounty plan in Socorro, Catron, and Sierra Counties. Based on this test, it estimated that 16,000 coyotes could be killed annually in the state by paid hunters (Mortensen 1983: 74).

Congress passed the Pittman-Robertson Act, also known as the Wildlife Restoration Act of 1937, which provided funds for state game and fish departments to conduct wildlife surveys on a systematic basis and to institute professional research. These funds came from a federal tax on firearms and ammunition. The bill also fostered closer cooperation between federal and state wildlife agencies (Brown and Carmony 1995: 123; Clark 1987: 267–268; Udall 1963: 145). The Federal Aid to Wildlife Act of 1939 provided funds for purchase of habitat; some 30,000 acres were purchased subsequently by the state (Barker 1976: 100–101).

In 1939 the 57,200-acre Bosque del Apache National Wildlife Refuge was established in Socorro County, primarily as winter habitat for sand hill cranes and various species of waterfowl (Laycock 1965: 269). In the following year, the La Joya State Waterfowl Refuge was established, and elk from Wyoming, the Wichita Mountains National Wildlife Refuge in Oklahoma, and the Philmont Boy Scout Ranch were transplanted on Mount Taylor, in the Jemez Mountains, and in the Hopewell and Tres Piedras areas of the Carson National Forest (Barker 1976: 104, 109–110; Fig. 79; Table 63).

In the late part of the decade El Vado dam was completed on the Chama River; its primary function was flood control. During this same period, the district completed a levee system in the Middle Valley. Also, the WPA constructed small retention and diversion dams in rural New Mexico communities to prevent flooding (Bullard and Wells 1992: 47; Welsh 1987: 110, 140).

In January 1940, the Upper Rio Grande Drainage Basin Committee held its first meeting. Made up of personnel from state and federal agencies, this group heard various parties discuss and protest against certain irrigation projects and possible loss of water rights to new development along the river (Vlasich 1980: 33).

In the spring of the following year, severe flooding struck the region. This event spurred Senator Clinton P. Anderson to introduce the Flood Control Act, which was passed by Congress. This legislation directed the Chief of the Corps of Engineers to conduct a preliminary study of dam sites in the Rio Grande Basin above El Paso. The Corps, along with the Bureau of Reclamation, was also directed to develop a joint-use plan for the Rio Grande in the Albuquerque area. To facilitate this, the corps created the Albuquerque District and established an office in the city (Welsh 1987: 78–79, 111).

Two years later the All-Pueblo Council met and generally declared opposition to the Flood Control Act of 1941. The council specifically opposed construction of the proposed flood control dams at Otowi and San Felipe but supported flood control measures in general. The Council also spoke out against any plans made for Pueblo lands without its input. Later, the Pueblos complained to Congress that the district had not provided adequate water or maintenance of ditches as promised. Many claimed they had lost crops as a result (Bayer et al. 1994: 242–243).

Overgrazing and severe erosion continued to be serious problems for federal agencies administering public rangelands. The Forest Service and the Grazing Service began to fence federal land in the Rio Puerco-of-the-East valley and traditional grazing lands on Mesa Prieta and in the San Mateo Mountains, including Mount Taylor in 1940 (Garcia 1992: 23). Each family on the Rio Puerco was permitted by the Soil Conservation Service to graze 15 head of sheep in their grazing precinct. This number of livestock was considered below the minimum needed for subsistence (Forrest 1989: 159).

Most wild horses had been removed from public grazing lands except on Indian reservations and "waste lands outside of the grazing districts and fenced areas" (Wyman 1945: 173). In 1940–41, the Soil Conservation Service sponsored projects to control erosion on Santa Ana Pueblo land by erecting fences and windbreaks (Bayer et al. 1994: 228). The Forest Service closed grazing on Manzano Forest lands next to the Carnue land grant (Quintana and Kayser 1980: 50).

In 1941 there were seven livestock grazing districts, totalling almost 16 million acres, under the administration of the Division of Grazing. State and national advisory boards, made up of ranchers, were established to assist in the management of grazing on these lands. Twenty years later, these boards were expanded to represent wildlife, forestry, mineral development, soil conservation, and other resource interests (Clawson 1971: 151).

In August 1946 Congress passed the Indian Claims Act, setting up a Claims Commission to resolve long-time land disputes between Native Americans and non-Indians. As a result of extensive research and testimony over many years, the Pueblos received payments for various tracts of land and water lost to Hispanos and Anglos in the region (Minge 1976: 114–117; Simmons 1979b: 216).

On July 16, 1946, the U.S. General Land Office and the Grazing Service were merged to form the Bureau of Land Management. This new agency was responsible not only for grazing but also for the management of other natural and cultural resources on public domain lands. A regional office was established in Albuquerque, and the agency implemented a grazing fee of 8 cents per animal unit month (Clawson 1971: 38–39, 174; Utely and Mackintosh 1989: 29).

During this decade the Forest Service limited the number of livestock that one owner could graze on the national forests because of heavy, local demand. A June 1948 inspection of the grazing allotments on the Santa Fe National Forest revealed that their condition was unsatisfactory. For this forest, 50 to 100 head of cattle per owner were permitted. Also, attempts were made to reduce common use of forest ranges by constructing fences, developing more surface water, and reassigning individual allotments. On April 24, 1950, Congress passed a law authorizing advisory boards on grazing on national forests. Members were to be primarily livestock raisers holding permits on a particular forest. Previously, advisory boards had no standing under the law (Baker et al. 1988: 102; Eastman and Gray 1987: 37; Mortensen 1983: 80–81).

In the early- and mid-1940s, the New Mexico Cattle Growers' Association continued to lobby for transferring federal ownership of the public domain to the state. This organization's policy was supported by New Mexico's two U.S. senators and one of its representatives. In 1946 the state's Commissioner on Public Lands, John E. Miles, suggested that land commissioners, educators, and livestock raisers meet to develop strategy for acquiring the public domain. An Association of Western State Land Commissioners was established to procure legislative enactment for granting the states the public domain for support of schools and other public institutions. Their efforts were unsuccessful (Mortensen 1983: 85–86).

During the late 1940s and 1950s, grass reseeding and reforestation on national forest lands was common. Part of this program also involved removing Juniper from various areas and then reseeding with grasses. In an attempt to improve grazing conditions on the Carson National Forest, an area of the Tres Piedras District was reseeded with crested wheatgrass. On 7,000 acres of overgrazed lands of the Mesa Viejas, Canjilon Ranger District, of this national forest, sagebrush was cleared; the tract was also reseeded with crested wheatgrass in 1951. This species had been introduced in New Mexico earlier in the 1930s by USFS Forest and Range Experiment stations (Baker et al. 1988: 59; Rowley 1985: preceeding p. 92). In May, 1952, U.S. Senator Dennis Chavez of New Mexico convened hearings on grazing on the national forests in three locations of the state. A number of livestock raisers complained about the reduction of the number of head that they could graze under a permit and the closing of some areas to grazing (Mortensen 1983: 79). Range conditions had been deteriorating due to the ongoing drought, as well as the intensive grazing.

Congress had passed the Forest Pest Control Act in 1947; this legislation placed a new emphasis on the control and management of forest insects and diseases (Baker et al. 1988: 59). Spraying of insecticides, pesticides, and fungicides, as well as clearing of affected trees, was employed to combat insects and diseases in the forests from this year into the 1960s (Frome 1962: 239–243). DDT was one of the compounds commonly used, not only on the national forests but also on other public lands, as well as in cities and on private lands.

A 1947 study of some 87,000 acres of land and water wildlife habitat in the Middle Rio Grande Basin was conducted by the Fish and Wildlife Service (Pillow and DeVaney 1947: 16). This work examined the potential economic impact of proposed development of dams and channel improvements on the region through assigning dollar values to game mammals, birds, amphibians, and fishes harvested there. The estimate was $71,900 annually. Potential losses due to impacts were estimated at $79,500 (Ligon 1961: 19–25).

In an ongoing effort to control rodents and predation on livestock grazing public lands, the federal Predatory Animal Control Division made available a new, highly lethal rodenticide called Compound 1080 in 1949. It was especially effective against wild canids, but many domestic pets and other animals were killed as well. Highly controversial as a result, the Environmental Protection Agency banned the compound in 1972. Also, the U.S. Government outlawed the indiscriminate use of poison to kill livestock predators in 1954. Sheep ranchers turned to use of the "coyote getta," a "cyanide gun" stuck in the ground (Fig. 82). Some ranchers also controlled predators by shooting them from airplanes (Brown 1983: 103; Moyer 1979: 71).

Early in the 1950s, the BLM raised the grazing fee to 12 cents per animal-unit-month. This fee was based on current livestock market prices. The agency was later criticized for focusing primarily on leasing public lands to livestock raisers and overlooking other public values and uses for these lands. A special concern for some groups was the protection of watersheds and "marginal lands" from overgrazing (Clark 1987: 590).

The U.S. Army Corps of Engineers proposed reservoirs on the Jemez River in Jemez Canyon and at Chamita on

Figure 82—Dead coyote hung on U.S. Forest Service sign. Courtesy Museum of New Mexico Photo Archives, Santa Fe (negative no. 101965).

the Chama River early in 1948. Later that same year, Congress passed another Flood Control Act, which authorized these two flood and sediment control dams. Also in 1948, Congress passed the Federal Water Pollution Control Act, the first comprehensive legislation of its kind in the United States. The act was directed at "controlling the discharge of effluents into interstate streams". The formation of the Water Pollution Control Advisory Board was also authorized, and this board was directed to assist and cooperate with the states, whose responsibilities and rights to control water pollution were recognized (Clark 1987: 444, 532).

In 1952, Congress adopted House Resolution 9216 to expedite construction of the Rio Grande Floodway, part of the Middle Rio Grande Project. As part of this program, private and state levees and dams were targeted for reconstruction from Velarde to Elephant Butte (Welsh 1987: 166). This same year the Corps completed the Jemez Canyon dam and reservoir. In 1951 the Corps and the Bureau of Reclamation began to install the first of 100,000 jetties along the Middle Rio Grande. The Bureau began channel modification in this reach to maintain channel capacity "for safely passing high flows, reducing water losses while conveying water to downstream users, and moving sediments through the valley" (Bullard and Wells 1992: 50; Crawford et al. 1993: 43–44; Fergusson 1951: 360; Welsh 1987: 117–118). From 1947 to 1958 an intensive study of sediments in the Rio Grande Basin was conducted by the U.S. Geological Survey (Hale et al. 1965: 6).

The severe drought of 1951–56 led to the passage of two water-related acts. In 1953 the State Legislature declared "that all underground waters of the State of New Mexico are public waters subject to appropriation for beneficial use within the State" (Erickson 1954: 81). That same year Senator Clinton P. Anderson of New Mexico co-sponsored legislation to encourage experimentation in "rainmaking" and created the Advisory Committee on Weather Control (Clark 1987: 413-414).

Cognizant of the fact that flooding usually followed droughts, Congress passed the Flood Control Act of 1954, which included authorization of two diversion canals that would carry summer rain runoff from the west slopes of the Sandia Mountains. The Corps of Engineers completed the renovation of flood levees along the Rio Grande in the Albuquerque area the following year. In March 1956 the Sandia Conservancy District was created at the petition of a group of landowners to control flash-flood waters originating along the west face of the Sandia Mountains (Clark 1987: 355; Welsh 1987: 167–168).

Flood control work on the Middle Rio Grande continued from the late 1950s to the early 1980s. The Corps of Engineers reconstructed the levee-riverside drains in the Albuquerque area in 1958. Operation and maintenance of the system were subsequently transferred to the Middle Rio Grande Conservancy District (Bullard and Wells 1992: 47). In the 1960s the riverside diversions at Corrales and Atrisco were replaced by inverted siphons that ran under the river from riverside drains, converting them into seasonal water conveyance channels. In 1959 the San Marcial Channelization Project was completed (Jenkins and Schroeder 1974: 77). From 1959 to 1963 the Corp constructed Heron Dam and the Abiquiu Dam on the Rio Chama. In 1960 Congressional legislation, the agency was also directed to construct the Galisteo Dam, 12 miles upstream from the confluence of Galisteo Creek and the Rio Grande. The project was completed 10 years later (Welsh 1987: 133–134, 149, 152, 155–156).

Adequate and clean water supplies for the Basin were also a major concern in this decade. In 1960, per capita water consumption in New Mexico was about 160 gallons per day (Hale et al 1965: 51). The Bureau of Reclamation was authorized to construct the San Juan-Chama Transmountain Diversion Project in 1962. Water control facilities subsequently diverted "about 110,000 acre-feet of water from the upper tributaries of the San Juan River, through the Continental Divide, and into the Rio Grande drainage" (Bullard and Wells 1992: 20). The All-Pueblo Indian Council and Native American supporters strongly endorsed the project (Clark 1987: 653).

Struggle for traditional land and water remained important in the 1950s–60s as well. As mentioned previously, settlements were made under the Indian Land Claims Act. Acoma Pueblos received more than $6 million for loss of aboriginal lands in their area in 1970 (Minge 1976: 116–

117). Santa Ana, Zia, and Jemez Pueblos eventually received compensation for Espiritu Santo lands wrongfully taken (Bayer et al. 1994: 234). In 1959, Cochiti Pueblos lost their claim to the La Bajada land grant. Their efforts to convince the Corps of Engineers to move the location of the Cochiti Dam failed.

Also at the national level, Congress passed the Water Resources Planning Act in 1965, which created a National Water Commission to work with the National Resources Council and public and private agencies in identifying problems related to an ample supply of clean water for the future. This group produced a final report, *Water Policies for the Future*, emphasizing the economics of water (Clark 1987: 379–380).

In New Mexico, the Water Resources Research Institute was established, partially with funds from the Federal Water Resources Research Act of 1964. Since then, the emphasis of the institute has been on supplementing rather than duplicating ongoing water research, especially research related to water consumption and requirements for local entities, more efficient irrigation practices, problems of major stream basins, availability of undeveloped sources, water recycling, wastewater management, and groundwater quality (Clark 1987: 381).

In 1965 the State Legislature declared that "the State of New Mexico claims the right to all moisture in the atmosphere which would fall so as to become a part of the natural streams or percolated water of New Mexico, for use in accordance with its laws." The Weather Control and Cloud Modification Commission was also created in this year "to oversee attempts to alter natural weather conditions" (Clark 1987: 373). At the same time, the State Planning Office and the State Engineer Office carried out an in-depth inventory and report of water resources in New Mexico (Clark 1987: 374, 381).

President John F. Kennedy led the way for environmental legislation in the 1960s and, along with Rachel Carson's 1962 book *Silent Spring*, provided a foundation for the environmental movement of the mid 1960s-early 1970s. In February 1961 Kennedy delivered a natural resources message "advising" Congress that he had directed the secretary of the interior [sic] to launch a three-pronged offensive against public land abuse. This included making "an inventory and evaluation of unreserved public lands," developing a "balanced use program," and developing "an accelerated soil and water conservation program including rehabilitation of depleted rangelands" (Clark 1987: 590–591).

In his conservation message to Congress in 1962, President Kennedy said "Conservation . . . can be defined as the wise use of our natural environment: it is, in the final analysis, the highest form of national thrift—the prevention of waste and despoilment while preserving, improving and renewing the quality and usefulness of all of our resources" (Udall 1963: 173).

In 1963 an appointee of JFK, Secretary of Interior Stewart Udall, convened a panel of experts, headed by A. Starker Leopold of the University of California, to examine the Federal Government's animal damage control program. This group, in their "Leopold Report," asserted that the government should be responsible for the husbandry of every animal species and that current control was too excessive (Mortensen 1983: 75). Eight years later, another panel of wildlife experts, headed by former Assistant Secretary of the Interior Stanley A. Cain "recommended that all existing toxic chemicals be removed from registration and use for Federal predator control operations" (Mortensen 1983: 75). In response, President Richard Nixon issued an executive order on February 8, 1972, banning "the field use of any chemical toxicant for the purpose of killing a predatory mammal or bird" or that "which causes any secondary poisoning on all Federal lands and in any Federal program" (Mortensen 1983: 75).

Tourism to national parks and monuments had begun to increase significantly by 1960. Four years earlier in 1956, the National Park Service had submitted its "Mission 66" program to Congress, requesting a substantial increase in funds to renovate existing facilities and to construct and maintain new ones to meet the projected visitation for the 1960s–70s. Recreational visitation to the national forests had also risen sharply; major activities included hunting, fishing, skiing, and hiking (Baker et al. 1988: 60; Udall 1962: 32–33). These new pressures led to congressional enactment of the Multiple Use-Sustained Yield Act in 1960, which authorized and directed the Secretary of Agriculture "to develop and administer the renewable resources of the national forests, including outdoor recreation, watershed, range, timber, and wildlife and fish resources, in such a way that they would be available in perpetuity. It meant that no one demand should take precedence over another" (Baker et al. 1988: 60, 65).

This demand for public recreation also led to the formation of the Bureau of Outdoor Recreation within the Interior Department on May 28, 1963. This agency was responsible for coordination of related federal programs, assistance in state recreational planning, administration of a grants-in-aid program, sponsorship of research, and formulation of a nationwide recreation plan based on state, regional, and federal plans (Udall 1962).

In 1964 there were 1,562,600 recreational visits to the Cibola National Forest. In this same year Congress passed the Wilderness Act, led by Senator Anderson of New Mexico. The Forest Service and National Park Service initiated studies of the lands under their administration to determine suitability for classification as wilderness. Before the end of the year, the Pecos and San Pedro Parks wildernesses were created (Table 63). At the same time, the Pecos area was restocked with Rocky Mountain bighorn sheep. In contrast, the Forest Service proposed a highway from Las Vegas to Pecos Canyon in the Santa Fe National Forest. In the first major confrontation between the Forest Service and environmental groups in the region, the New Mexico Coordinating Council and the Upper Pecos Association opposed the road. The latter group filed suit against the Forest Service who subsequently abandoned the project. The Forest Service also proposed to construct a scenic roadway from Placitas to Sandia Crest, which drew sharp criticism from several environmental organizations and local residents. The proposal was dropped in 1971 (Baker et al. 1988: 70–71, 134; deBuys 1985: 289; McDonald 1985: 12–13; Rothman 1992: 271).

Congress passed the Land Classification and Multiple Use Act in 1964, directing the Secretary of the Interior "to develop criteria for determining which BLM lands should be classified for disposal and which should remain in federal ownership." These lands would also be "managed for the protection of public values" (Clark 1987: 591).

Congress also created the Public Land Law Review Commission in 1964 to examine existing public land statutes and regulations and the policies and practices of the administering agencies. Under the guidance of Representative Wayne Aspinall, chairman of the commission, the body made 137 recommendations for modification in public land management and disposition. Among these were a proposal to study public lands to determine if they would better serve the public good under state, local, or private ownership. Still another recommendation was that local advisory boards should have more input into federal planning. This and a number of other recommendations were included in the Federal Land Policy and Management Act of 1976 (Clark 1987: 575–576). This legislation also included a section mandating a 15-year review of potential wilderness areas on lands administered by the Bureau of Land Management (Kutz 1989: 9; McDonald 1985: 8).

Under the Wilderness Act the Wheeler Peak area was created as wilderness in the Carson National Forest in the mid- 1960s. A wilderness area was also established at the Bosque del Apache National Wildlife Refuge in the 1970s. Also during this period, the Sevilleta National Wildlife Refuge was established in northern Socorro County. Subsequently, the latter was designated a Long Term Study Ecological Area, a global classification (Grover and Musick 1989: 1–3; McDonald 1985: 6; Table 63).

By the mid-1960s the government was basing grazing fees on public lands on a year-by-year assessment of the economic value of the land in question (Mortensen 1983: 78). In 1972, the state advisory boards for grazing districts and the national advisory board to the Department of the Interior were abolished by federal act; they were reinstated under the Federal Land Policy and Management Act of 1976 (Mortensen 1983: 83).

One of the most important legislative bills dealing with the environment since World War II, the National Environmental Policy Act, was passed by Congress in 1969. Its basic mandate was to provide more protection for the environment where federal agencies or funds were involved in projects. The Council on Environmental Quality was established as an advisory group to the President and as a watch-dog group (Clark 1987: 450–451; Welsh 1987: 201–202).

Related to this bill was the Environmental Quality Improvement Act of 1970, which provided for an upgrading of environmental quality through mandating federal departments and agencies, conducting or supporting public work projects, to implement environmental protection policies. This act also provided aid and support for the Council on Environmental Quality through establishment of the Office of Environmental Quality in the Executive Branch (Clark 1987: 450). In the summer of that year, President Nixon established the Environmental Protection Agency to gather and organize scattered research, enforce pollution control standards, and monitor enforcement agencies relative to air, water, and land pollution abatement. The focus was to be on specific problems such as pesticides, solid waste, water quality, radiation, and pollution (Clark 1987: 452).

The Forest Service, which continued to use DDT and initiated the use of malathion in 1966 to control outbreaks of insects in the national forests, became embroiled with various environmental groups over use of the channels in the Taos area of the Carson National Forest. DDT was eventually banned by the EPA in 1973 (Baker et al. 1988: 62).

In regional national forests several important events involving management occurred at the end of the decade and in the early years of the 1970s. Members of the *Alianza Federal de los Pireblos Libres* , organized and led by Reies Tijerina, attempted to reclaim the San Joaquin del Rio de Chama land grant, which had become part of the national forest near Tierra Amarilla. Violence broke out in 1967–68, with some Forest Service facilities destroyed and personnel detained by the protesters. Members of the *Alianza* also raided the Tierra Amarilla courthouse, hoping to recover land grant papers proving their position, but this was not the case. Tijerina and some of his followers were subsequently convicted and served jail sentences for their actions against the federal and local governments (Baker et al. 1988: 72–73).

Another battle over traditional lands incorporated into the Carson National Forest was that of the Taos Pueblo's long-time struggle to have their sacred Blue Lake returned. Finally, on December 15, 1970, President Nixon signed a congressional bill placing 48,000 acres of forest land, including the lake, in trust for the sole use of the Pueblo (Keegan 1991: 50).

Joined by another federal agency, the Bureau of Land Management, the Forest Service raised grazing fees to levels more in line with fees paid for grazing private lands in 1966. Forest Service fees ranged from 21 cents to $1.81, while the BLM fee was set at 33 cents. In 1969 the BLM had raised the fee to 44 cents per animal unit month (Clawson 1971: 175). Management of grazing was complicated by the passage of the Wild Horse and Burro Act in 1971. Populations of both species, protected by the act, had been increasing dramatically on some areas on the public lands and were causing severe overgrazing. Burros were not protected on National Park lands, such as Bandelier National Monument, where they had been an ongoing problem. Park personnel had been shooting them since the mid 1940s, but public protests in the 1970s hampered eradication. Live capture was implemented, complemented by limiting shooting, and this resulted in removal of almost all of these animals by the end of 1983 (Rothman 1992: 280–283).

In 1966 and 1969 Congress passed Endangered Species Acts, which authorized the U.S. Fish and Wildlife Service to initiate studies identifying endangered wildlife species. In 1973 a new Endangered Species Act was passed, providing unprecedented protection for listing species on public and private lands through consultation, prohibition of "takings," and recovery plans (Beatley 1994: 13–22; Borland 1975: 152). The state enacted a similar law authorizing the Game and Fish Department to identify and list endangered species in the state (Hubbard et al. 1988: 1).

In 1966 Congress also enacted the National Historic Preservation Act, establishing the program for National Register surveying and selecting buildings, sites, districts, and objects significant in American history, archeology, architecture, and eco-culture. Furthermore, the Act provided matching funds to help acquire and preserve them and to aid in statewide surveys for properties to be placed on the National Register. Section 106 of the Act currently requires the State Historic Preservation Officer to comment on any undertaking that might affect property listed in or eligible for the National Register of Historic Places (McGimsey n.d.: 16–17).

In 1968 the National Wild and Scenic River Act was passed, which provided for the environmental protection of rivers in "a free-flowing, natural state." One section of a regional river, the Upper Rio Grande from the Colorado state line to below Taos, was subsequently designated a wild and scenic river (Baker et al. 1988: 72; Table 63).

The rising public awareness of, and concern for, the environment had increased sharply in the late 1960s. Membership in various long-time, as well as new, environmental groups mushroomed. Environmental organizations brought unprecedented public pressure on local, state, and federal governments to meet their environmental concerns. As a result, a number of significant environmental laws were passed at the federal and state levels. Supported by Senator William Proxmire of Wisconsin, environmentalists from these groups organized the first Earth Day on April 22, 1970. Twenty million Americans participated in rallies, marches, workshops, and environmental clean-ups (Borland 1975: 174; Pirages and Ehrlich 1974: 37–38).

One of the pieces of legislation passed was the Clean Air Act of 1970, the first serious attempt by the Federal Government to improve air quality. Sources of emissions could be held accountable for their contribution to the degradation of air quality. Stringent emission standards were subsequently adopted and were enforced by the EPA office, Region 6, Dallas, Texas, and the New Mexico Department of Health. Major sources of air pollution in the study region included the Four Corners power plants fueled by coal (Harrington and Abbey 1981: 1, 4, 22).

In March 1972 the Corps of Engineers completed construction of the north and south flood diversion channels in the Albuquerque District. The Corps received new regulatory responsibility with passage of the Water Pollution Control Act amendment, which upheld the 1899 Refuse Act. Any company intending to discharge fluid waste into navigable waters was required to obtain a permit from the corps or face a fine. Discharge of pollutants in toxic amounts into waters was made illegal, and agricultural and rural sewage treatment became a new priority (Clark 1987: 453–454; Welsh 1987: 172, 202).

During the 1970s the Bureau of Reclamation conducted a rectification project along the Rio Grande to clear and maintain a relatively linear floodway that would efficiently convey water to Elephant Butte Reservoir and to pass floodwater rapidly through the system with minimal water loss and damage to the river channel and floodplain (Bullard and Wells 1992: 47). A significant part of the federal flood control program on the Rio Grande was completed when the Cochiti Dam was closed and the reservoir began to fill in November 1973. Subsequently, downstream farmers at Cochiti Pueblo and Pena Blanca complained that rises in the groundwater table of up to 8 feet were resulting in deposition of harmful salt and "waterlogging" of 320 acres of traditional agricultural land. In 1980 the Pueblo's council filed suit against the Corps of Engineers, Albuquerque District, claiming the agency was responsible for these environmental problems (Welsh 1987: 158, 162).

In its 1972 report *The Nation's Range Resources*, the Forest Service reported that much of southwestern rangelands, public and private, were in a deteriorating condition. Also, the volume of timber cut for commercial sales in the state's national forests peaked at over 141 million board-feet (Baker et al. 1988: 84). Since 1972, tighter grazing regulations and reduced timber harvest have been implemented, partly as a result of protest and litigation by national and local environmental organizations.

During the mid and late 1970s the Forest Service worked to improve, restore, or preserve watersheds through extensive management programs. As part of these projects, the service determined grazing quotas, timber harvests, and the extent of other uses that could potentially impact these ecosystems adversely. An example of such a watershed program was (and is) the Bernalillo Watershed Project in the Cibola National Forest, which has included construction of check-dams and restoration of vegetative cover. This effort has controlled the periodic, serious flooding of the Bernalillo community by intensive runoff from the northwest slopes of the Sandia Mountains (Clark 1987: 577).

The Forest and Rangeland Renewable Resources Planning Act of 1974, and an amendment known as the National Forest Management Act of 1976, directed the Forest Service, in cooperation with state, local, and other federal agencies, to inventory and analyze the renewable resources on national forest lands relative to anticipated uses, demands, and relevant agency policies and programs. A plan, based on these studies, was to be prepared and updated every 5 years (Clark 1987: 579).

Congress also passed the Federal Land Policy and Management Act of 1976, which included a number of recommendations made by the Public Land Law Review Commission 12 years earlier. The primary purpose of this legislation "was to update and bring together in a single statute the laws governing management of" BLM lands, and to a more limited extent Forest Service lands. Moreover, the Secretary of the Interior was directed "to develop a comprehensive land-use plan incorporating multiple-purpose and sustained-yield principles based on a continuing inventory of lands and their resources" (Clark 1987: 575).

Finally, the 22,000-acre Bandelier Wilderness area was created in 1976, and on February 24, 1978, Congress passed the Endangered American Wilderness Act, which included establishment of the North Sandia Peak and South Sandia Peak wilderness areas, the Manzano Mountain Wilderness, and the Chama River Basin Wilderness (McDonald 1985: 15; Table 63).

SUMMARY

Although Native and Hispano Americans collectively held an extensive knowledge of the occurrence, range, and use of various natural resources, scientific studies of the study region did not begin until the arrival of Anglo Americans in 1846. Early map makers, photographers, and naturalists assigned to army contingents began to document and collect environmental data on the Middle and Upper Rio Grande basins. Subsequent government scientists continued the collecting of biological and geological specimens and gathered the first climatic, archeological, and ethnological information.

Following passage of various laws that greatly facilitated and aided residents in acquiring land and exploiting resources from the 1850s to 1870s, a conservation movement emerged in the midwestern and eastern United States, as well as in territorial New Mexico. Legislation was passed to regulate use of surface and ground waters, logging on public lands, and the taking of game animals and fish. Government agencies targeted predators, such as wolves and grizzly bears, for reduction in populations, and ultimately for extirpation.

Additional resource management agencies were created, and the first national forest preserves and national monuments were created in the study region in the late 19th and early 20th centuries. Water control works, such as dams, drainage canals, and levees, were constructed in the Middle Valley at the end of this period. The Middle Rio Grande Conservancy District, the Bureau of Reclamation, and the Corps of Engineers were responsible for the construction of these works and their maintenance.

During the 1930s–40s water management and use, wildlife management, and grazing regulation on public lands and Indian reservations were major issues. Legislation affecting archeological sites, wildlife refuges, and parks at the federal and state levels was passed. Conservation programs such as the CCC were created, providing employment for hundreds of citizens. Also, several new national environmental groups, along with previously established ones, began to voice their concerns for better management of eco-cultural resources.

The Historic Sites Act, passed by Congress in 1935, afforded investigations of archeological resources and preservation of significant historical sites and structures. In the same year, the State Legislature created a Park Commission. Subsequently several state parks and monuments were established in the Middle Rio Grande Basin.

The 1950s drought spurred more funding and construction of public water control facilities in the Middle Basin. Water quality and predator control became an issue on national and state levels. The Pueblos and other Native Americans continued their struggle to acquire land, which they claimed traditional rights to.

President Kennedy, Secretary of the Interior Stewart Udall, and biologist Rachel Carson sparked the environmental movement of the 1960s. Awareness of the environment and the "need" for recreating on public lands led to the passage of new laws and establishment of new parks, monuments, and recreation areas. Concern for archeological sites and historical structures resulted in passage of the National Historic Preservation Act in 1966. This legislation provided policy and funding to help survey, select, and designate sites or structures for National Register listing. Wildernesses were created in national parks, monuments, and forests under the new Wilderness Act.

Significant legislation, such as the Clean Air Act of 1963, the Endangered Species Acts of 1966, 1969, and 1973 and the Wild and Scenic Rivers Act of 1968, was passed by Congress. The Rio Grande Wild and Scenic River in northern New Mexico, west of Taos, was so designated in 1970. In the following year the Secretary of the Interior recommended that no toxic chemicals be used in federal predator control operations. In February 1972 President Nixon issued an Executive Order banning use of such chemicals in federal programs and on all federal lands. Four years later Congress enacted the Federal Land Policy and Management Act of 1976. This law stipulated that the laws governing management of BLM lands, and to a limited extent national forest lands, be updated and consolidated (Clark 1987: 371, 401–402, 575, 586–588; McIntyre 1995: 187).

In the 1970s conflicting views of public land use and management became common and have continued until the present. Grazing and water rights and opposition to major dams and other water control facilities increased, especially among environmentalists and the Pueblos. Wilderness, automobile emissions, water quality, and management of endangered species were other issues in the 1980s.

CHRONOLOGY

1812 The General Land Office was established in the Treasury Department. This federal agency managed public lands and associated resources such as minerals and timber (Udall 1962: 1).

1832 The New Mexico Territorial Assembly considered imposing a limitation on the use of water and wood by foreigners in the mountains above Santa Fe (Weber 1982: 152).

1830s–41 Josiah Gregg (1966) made relatively detailed descriptions of New Mexico's weather, streams, fauna, flora, and residents.

1841 (August-September) Naturalist William Gambel, a botanist and protegee of Thomas Nuttall, collected botanical and zoological specimens in the Sangre de Cristo Range and nearby Rio Grande Valley (Dickerman 1985: 159, 163–164).

1846 (late June-late August) Medical doctor and naturalist Frederick A. Wislizenus (1969) collected plant, rock, and mineral specimens in the study region. He also recorded weather data (Dickerman 1985: 164–165).

1846 (August-October) Lt. William H. Emory (Calvin 1951) of the U.S. Topographical Engineers surveyed, mapped, and collected plant, rock, and mineral specimens in the study region.

1846 (late September-December) Lt. James W. Abert (1962) of the U.S. Topographic Engineers surveyed, mapped, and collected fossil and rock specimens in the study region.

1846 (fall) (to summer 1847) Augustus Fendler, a Prussian botanist, collected 1,026 plant specimens along the Santa Fe River and the Rio Grande Valley to the west. Two genera in the saxifrage family were named for him, *Fendlera* and *Fendlerella* (Dickerman 1985: 167, 168–169).

1849 (March 3) The U.S. Department of Interior was created to manage natural and cultural resources, including the affairs of Native Americans (Smith and Zurcher 1968: 112; Utely and Mackintosh 1989: 2).

1849 The General Land Office was transferred to the Interior Department (Udall 1962: 2).

1849 The Bureau of Indian Affairs was transferred to the Interior Department (Dale 1949: 6).

1850–51 The U.S. Assistant Surgeon accompanied Lt. Lorenzo Sitgreaves on his expedition from El Paso to Santa Fe, then west to El Morro and the Zuni area. He was the first scientist to collect birds and mammals in the region. He collected and described, for the first time, grey-headed junco (now lumped with two former species into one), black-capped vireo, Cassin's sparrow, Abert's squirrel, Ord's Kangaroo rat, and the southern coyote (Hume 1942: 497–503).

1851 (summer) The Territorial Legislature passed legislation empowering owners of tillable lands to take water from the most convenient source and move it across the properties of others, assessing owners of trespass livestock onto another's fields damages, making the creation of a footpath across a field punishable by reprimand or fine, forbidding the building of any structures (such as mills) that would interfere with irrigating crops, and providing that "the course of ditches or acequias already established shall not be disturbed" (Clark 1987: 25).

1851 The Territorial Assembly petitioned the U.S. Congress to reserve all salt lakes, salt mines, and springs to prevent them from passing into private ownership. Also, all fuelwood and timber in the mountain should be reserved for the "common use of the people" (Clark 1987: 32).

1851–52 The Territorial Assembly declared that the acequia alignments in use at the time should not be disturbed and should remain public, and their use for irrigation should take precedence over all other uses, such as grist mills (Wozniak 1987).

1852 (January 7) The Territorial Assembly enacted legislation that detailed the administration of community acequias (Clark 1987: 25).

1852 Naturalist S.W. Woodhouse reported that wolves were common across New Mexico (Bailey 1971: 310).

1853–54 Lt. Col. Henry (1856) recorded species of birds while stationed at forts Thorn, Fillmore, and Webster (Ligon 1961: 7–8).

1854 (July 22) Congress passed an act providing for the appointment of a State Surveyor-General. William Pelham was appointed the first Surveyor-General. This act also provided that every white male citizen over the age of

21 and a U.S. citizen was granted 160 acres of land. These donations were made to promote the military strength of settlements exposed to attacks by Indians (Westphall 1965: 1, 37).

1854 (December) The first Surveyor General arrived in the territory to begin the public land surveys. The policy of the Surveyor General's Office was to only survey arable, or agricultural land (Westphall 1965: 1, 17).

1860 (March 12) The U.S. Congress passed the Preemption Act, giving free land to New Mexico and adjoining territories (Brown 1970: 13).

1862 The U.S. Department of Agriculture was created (Swift 1958: 45). Subsequently, the Forestry Division was established within this agency (Bergoffen 1976: 11).

1862 The Homestead Act was passed by Congress, allowing a settler to take out a homestead on public lands of 160 acres. A patent to the land could then be obtained either by living on it for 5 years or by commuting it through payment of cash in 6 months (Westphall 1965: 42–43).

1863 Ordinances related to animal and traffic control, sanitation, public works, and zoning were passed by Albuquerque's board of aldermen (Simmons 1992: 24).

1864 Congress passed legislation preserving Yosemite Valley, the first "scenic reserve created by federal action...". (Udall 1963: 112).

1865 (January 18) The Territorial Mining Act was passed; it provided a legal basis for mining development and supported local "Rules of Miners" (Christiansen 1974: 87).

1866 (January 18) A territorial statute providing for the right to move an irrigation ditch destroyed by rain or runoff water was passed. Construction of a new ditch was allowed if the damaged one was impossible to rebuild and if the majority of those who would furnish the labor so consented. The mayordomo was authorized to relocate the acequia and given the authority to cross any land by securing the consent of the owner (Clark 1987: 26).

1866 (July 26) The first federal legislation affecting mineral lands, the Mining Act, was passed by Congress. This act declared that surveyed and unsurveyed public lands were to be open for exploration and the establishment of lode mines by all U.S. citizens or those intending to become citizens (Westphall 1965: 96). This law stated "The mineral lands of the public domain, both surveyed and unsurveyed, are hereby declared to be free and open to exploration and occupation by all citizens of the United States" and "subject also to the local customs or rules of miners in the several mining districts..." (Limerick 1987: 65).

1872 (March 1) Yellowstone National Park, the first of its kind in the world, was created (Brown 1970: 191).

1872 A revision to the Mining Act of 1866 was passed by Congress, enabling miners to mark and register the boundaries of their claims. This legislation allowed an individual to enter unreserved public domain and the national forests in search of mineral deposits. An individual could stake out an unlimited number of claims as long as he or she diligently looked for minerals on the land. If certain conditions were met, a claimant could obtain a patent to his claim. Subsequently, the tract of land could be purchased for $2.50 or $5.00 an acre (Clawson 1971: 123–124; Utely and Mackintosh 1989: 27). The placer or lode claim remained valid as long as the miner recovered a minimum of $100 income from working the claim annually.

1873 The Timber Culture Act, which allowed an individual to acquire a quarter-section of land through planting, protecting, and maintaining 40 acres of timber, was passed. Five years later the act was amended to reduce the required area to 10 acres (Baydo 1970: 156). This act was a failure in New Mexico because the planting and cultivating of trees was not feasible without irrigation, and irrigated land was more valuable if farmed for crops and not trees (Westphall 1965: 72).

1873–85 Some cattle corporations had persons who were not corporate members file on land under the Timber Culture Act of 1873. Their intent was to secure valuable grassland and water for livestock without complying with any part of the law; that is, no timber was planted or maintained. By this strategy, "entire" townships were dominated by cattle interests (Westphall 1965: 73–74).

1874 A shovelnose sturgeon (*Scaphirhynchus platorynchus*) was taken from the Rio Grande near Albuquerque. No other specimens have been reported since (Koster 1957: 23).

1875 (September 10) The American Forestry Association was organized to publicly promote forestry and "timber culture" (Roberts 1963: 2).

1876 (January 13) A territorial act was passed, establishing a five-member board of commissioners who were responsible for taxing residents who lived within 5 miles of the Rio Grande to raise money for flood prevention (Clark 1987: 31).

1876 (August 30) The Commissioner of Agriculture appointed Dr. Franklin B. Hough as forest agent. His responsibilities were gathering data on the forests and forest products, European forestry practices, and means to preserve and renew the forests (Bergoffen 1976: 11).

1877 (March 3) Congress passed the Desert Land Act, which "extended the doctrine of prior appropriation to water used in the reclamation of arid public lands by irrigation" (Clark 1987: 38). A settler could buy up to a section of land for $1.25 an acre if the claimant reclaimed the acreage within 3 years (Buchanan 1988: 29; Westphall 1965: 76).

1878 The Timber and Stone Act was passed by Congress. Under this act, settlers and miners could buy up to 160 acres of land with potential timber or mineral resources for $2.50 an acre (Oakes 1983: 27).

1878 Under the territorial Organic Act, any timber cut on public lands and exported from New Mexico was liable to seizure by the U.S. Government (Ritch 1968).

1879 John Wesley Powell published *A Report on the Lands of the Arid Region of the U.S.*, in which he proposed a systematic classification of lands based on their potential "best use,"that is, irrigation, timber, pasture, mineral, etc. He also proposed grazing districts with boundaries drawn along contour lines (Barnes 1926: 35; Udall 1963: 88). Powell also recommended ending the homestead and preemption legislation and replacing them with small, irrigated farms no larger than 80 acres, all to be part of the irrigation districts, and livestock ranches no larger than 2,560 acres, to be part of grazing districts (Worster 1994: 13).

1879 The U.S. Geological Survey was created by an act of Congress (Swift 1958: 45).

1879 The Public Lands Commission was created by Congress to codify public land laws, set up a system of public land classification, and make "recommendations for the wise disposal and management of the remaining public lands" (Udall 1962: 5).

1879 John W. Powell was appointed to the Public Lands Commission, which undertook a general review of settlement of the West (Worster 1994: 9).

1880 All of the western surveys—such as those of Powell, Hayden, and Wheeler—were consolidated into the U.S. Geological Survey, Department of the Interior (Utely and Mackintosh 1989: 9–10).

1880 (February 12) A general act provided that "every person who shall foul the water of any stream in the Territory of New Mexico, or throw into any ditch, river or spring of flowing water any dead or pestiferous animal or other filth, dirty vessels or other impurities that might injure the general health of the inhabitants of any town or settlement of this Territory," "on conviction thereof, would be fined not less than one nor more than ten dollars" (Clark 1987: 31).

1880 The New Mexico Territorial Assembly passed an act to protect the buffalo, but this species was virtually exterminated by this date, and enforcement of the statute was impossible (Gard 1960: 216).

1880 A fish and game law was passed by the Territorial Assembly. This act made it a misdemeanor to take fish by use of "drugs, explosives, or by artificial obstructions." Trout could be taken only by hook-and-line. Operators of mills or factories could not discharge any waste harmful to trout. Commercial sale of fish was also limited (Clark 1987: 322).

1881 John W. Powell was appointed director of the U.S. Geological Survey (Worster 1994: 9).

1883 The parent organization of the National Audubon Society was formed in New York City (Matthiessen 1987: 167).

1884 (April) The Central New Mexico Cattle Growers' Association was organized in Albuquerque (Hagy 1951: 11).

1884 The Bureau of Animal Industry was established in the Department of Agriculture. Among its responsibilities were research and related activities such as disease prevention among farm animals and meat inspection. In 1953 this unit was transferred to the Agricultural Research Service, which also researches plant diseases and human nutritional problems and enforces quarantines (Smith and Zurcher 1968: 9, 47).

1885 (July 1) The Bureau of Biological Survey was created in the Department of Agriculture (Udall 1962: 6).

1885 Congress passed a law forbidding ranchers to control public domain by fencing and posting, but the practice continued until the Taylor Grazing Act passed 49 years later (Hagy 1951: 75–76). This opened the public domain to all comers, which, in some instances, resulted in overgrazing (Clark 1987: 54).

1885 Federal involvement in predator control began when the Department of Agriculture began to study ways of poisoning rodents, pest birds, and predators (Dunlap 1988: 143).

1887 (February 24) An act was passed by the Territorial Assembly authorizing the incorporation of companies to supply water for mining and milling as well as irrigation (Clark 1987: 132).

1887 The U.S. Congress passed the Hatch Act, which created agricultural experiment stations to conduct scientific research in problems relevant to their regions and to "disseminate the information resulting from these investigations." This work was to be done through land grant colleges (Clark 1987: 131).

1888 Congress passed legislation that provided for the withdrawal of irrigable land from entry. Under this act, some 39 reservoir sites amounting to 40,170 acres were selected in New Mexico (Westphall 1965: 84).

1888 Groundwater supply studies in New Mexico were begun (Hale et al. 1965: 7).

1888 Recent droughts and blizzards caused the U.S. Congress to authorize surveys for irrigable lands and reservoir sites in the West by the U.S. Geological Survey (Wozniak 1987).

1888 Congress enacted legislation forbidding trespass on Indian reservations, including timber cutting (Udall 1962: 6).

1888–91 John W. Powell, head of the U.S. Geological Survey, initiated irrigation surveys in river basins of the West. The Rio Grande was studied in 1889–1900, which also included surveys for reservoir sites (Wozniak 1987).

1889 (January 31) The Territorial Assembly passed a law providing for the election of three commissioners to protect springs and to build appropriate dams (Westphall 1965: 25).

1889 The New Mexico Legislative Assembly protested delay of immediate exploitation of the territory's water resources caused by Congress the previous year (1888, Oct. 2) (Clark 1987: 65).

1889 The USGS placed the first U.S. stream flow gauge at the Rio Grande Embudo (Bullard and Wells 1992: 12).

1889 The Territorial Assembly passed a statute "limiting stock on public ranges to the number for which the user could furnish sufficient permanent water" (Clark 1987: 149).

1889 The New Mexico Territorial Assembly supplemented the federal Fencing Act. They also passed a measure to control overgrazing; this act declared that an individual or corporation could only graze the number of livestock that could be maintained by waters for which he or they had title or legal possession. The Act stipulated that others entering that range must have sufficient "living," unfenced water to maintain their herds (Clark 1987: 54).

1889 The Territorial Assembly established a Cattle Sanitary Board to work to prevent disease and to inspect animals (Hagy 1951: 95).

1889 Legislation was passed to create unpaid fish wardens in every county to assist county sheriffs and commissioners in enforcing the fish laws, including a closed season of fishing, except for members of needy families. The law also directed that a sluice for passage of fish had to be maintained at all dams or other obstructive facilities constructed for purposes other than irrigation. Also, operators of mills or factories could not discharge waste of any kind injurious to trout into any stream (Clark 1987: 32).

1891 (July 1) The U.S. Weather Bureau was established in the Department of Agriculture (Bradley 1976: 12).

1891 The Territorial Assembly passed a stricter fencing law, making it a felony to cut fences on private land. Further, it was a felony for individuals or corporations to fence, to the detriment of others, lands they did not own or have legal use of (Clark 1987: 54).

1891 The Territorial Assembly passed a statute requiring "all persons, associations, or corporations who . . . constructed or enlarged any ditch, canal, or reservoir taking waters from a natural stream to make a sworn written statement of such diversion, to be filed with the county probate court within ninety days after commencement of the work." Construction had to be completed within 5 years of commencement (Clark 1987: 117).

1891 Congress passed the General Land Law Revision Act, commonly known as the Creative Act of 1891, a provision of which promoted establishment of national forest reserves through authorizing the president to set aside forest lands on the public domain (Baker et al. 1988: 25; Utely and Mackintosh 1989: 19).

1891 The Timber Culture Act was repealed because of abuses and difficulty in successfully growing trees in the West (Clark 1987: 62).

1891 The cutting of timber, up to $100 value per year, on the national forests was permitted (Baker et al. 1988: 79).

1892 (January) The Pecos River Forest Reserve was established by Presidential Proclamation (Tucker and Fitzpatrick 1972: 1).

1892 The Sierra Club was founded by John Muir (Udall 1963: 116).

1892–1906 Establishment of U.S. Forest Reserves (later designated National Forests) in northern New Mexico "had a tremendous effect upon the

[Spanish] villages, some of which found themselves eventually completely surrounded by federalized lands...." Large numbers of Hispanos "had to reorganize many aspects of their former economy and the way of life dependent upon that economy" (Gonzalez 1969: 122).

1893 The USDA Division of Forestry reported "without forest management no national water management is possible" (Clark 1987: 71).

1893 The Territorial Assembly passed the Territorial Bounty Act, authorizing counties to pay bounties on "predatory wolves, big bears [grizzlies], mountain lions, bobcats and coyotes" (Brown 1983: 43).

1893 The New Mexico Territorial Legislature passed a law allowing counties to raise money for paying "wolfers" for their services (Burbank 1990: 98).

1893–1915 The killing of most wolves during this period was due to the widespread use of bounties (Brown 1983: 43).

1895 (January) The Territorial Assembly passed legislation enabling the publication of a *Monthly Weather Review* (Tuan et al. 1973: 12).

1895 (February 28) The Territorial Assembly passed one of its most significant pieces of irrigation legislation. This measure defined the meaning of acequia, or community ditch, and detailed its legal status. The multiple owners of the ditches were to be considered to be "corporations or bodies corporate, with power to sue and be sued as such" (Clark 1987: 30).

1897 (February 22) President Grover Cleveland set aside more than 21 million acres of land in the northwestern states as part of national forest preserves (Rothman 1992: 61).

1897 (June 4) The Organic Act was passed by Congress, establishing standards for the use and protection of national forest reserves. This act embodied the concept of multiple–use of resources in conformity with state laws and federal rules and regulations. The act also authorized the Forest Service to manage grazing on public reserve lands. This soon resulted in the loss of grazing for livestock owned by nearby land grant occupants in northern New Mexico. Grazing fees for livestock were implemented, including permits for horses to graze on federal forest reserves. Authorized sales of timber on national forests was begun (Baker et al. 1988: 39, 79; Brown 1978: 254; Clark 1987: 140; Eastman and Gray 1987: 36).

1897 The first game laws to regulate hunting of meat animals such as mule deer were passed by the Territorial Assembly. Nevertheless, populations continued to decrease to less than 20,000 animals statewide by 1924. Two years later a bag limit of one buck deer was set (Findley et al. 1975: 329; Huey et al. 1967: 42).

1898 (June 21) The Fergusson Act authorized the transfer of federal public lands to the territory for schools and certain other public institutions. Five hundred thousand acres were designated for "establishing permanent reservoirs for irrigation purposes and 100,000 acres for improving the Rio Grande and increasing its surface flow in New Mexico" (Clark 1987: 84).

1898 Gifford Pinchot was appointed as Chief Forester in the Department of Agriculture (Udall 1963: 102).

1898–1909 Issues related to grazing regulation, grazing fees, and vegetation management for watersheds by the U.S. Forest Service were debated by Gifford Pinchot and the Secretary of Interior, U.S. Army Corps of Engineers, western stock growers, and various congressmen (Clark 1987: 141).

1899 (March 16) The Territorial Assembly responded to the Fergusson Act by creating the office of Commissioner of Public Lands and a Board of Public Lands. They were responsible for leasing, selling, and managing these lands (Clark 1983: 84).

1899 Legislation was passed that authorized towns of the "first class" to issue bonds for construction embankments, drainage ditches, and other facilities to prevent flood damage or destruction of municipal property (Clark 1987: 31–32).

1899 The Rivers and Harbors Act, also known as the Refuse Act, was passed by Congress. It instructed the Corps of Engineers to regulate all sources of effluents in the navigable streams of the United States. The Corps was authorized to prosecute polluters and could reward anyone reporting violators by paying them a percentage of the fines collected (Welsh 1987: 202). The U.S. Congress "declared it a misdemeanor to discharge refuse into any navigable streams or their tributaries," although the law did not apply to waste from properly supervised public works or waste in liquid state from streets or sewers (Clark 1987: 268).

1800s (late) (to early 1900s) Brook trout were introduced into the Rio San Jose near Laguna, then into the Rio Grande and drainages in the territory (Sublette et al. 1990: 72).

1900 (May) Congress passed the Lacey Act, ending market hunting for pelts, plumage, eggs, meat, etc. and outlawing illegal importation of foreign wildlife. A section of the Lacey Act prohibited the importation of the English sparrow, the starling, and other birds and animals. Also, the act empowered the Secretary of Agriculture to declare that those species having adverse impacts on agriculture could be destroyed or returned to their country of origin (Borland 1975: 122; Roth 1973: 94).

1900 The General Land Office ruled that forest reserves would be opened to limited, fee grazing. Preference would be given to livestock raisers with land within or adjacent to the reserves (Clark 1987: 72).

1900–25 Forty-two bills dealing with grazing regulation on the public domain were introduced in the Congress (Mortensen 1983: 82).

1900 (post) Pinyon-juniper woodlands had been spreading into the lower grassland zone during this century, as a result of suppression of fires, livestock grazing, and other factors (Dick-Peddie 1993: 91–92).

1900 (ca.) Fire suppression, which began about this time, resulted in an increased proportion of engelmann spruce and corkbark fir in the subalpine coniferous forest zone, 9,500 to 12,000 feet elevation (Dick-Peddie 1993: 51, 56).

1901 (December 3) President Theodore Roosevelt delivered a message on the need for conservation of natural resources, the first such speech by a leader of the Nation. His emphasis was on reclamation and forest reserves (Clark 1987: 134).

1901 A Forestry Division was created in the General Land Office, Department of the Interior (Udall 1962: 10).

1902 (June) The U.S. Reclamation Service was established. This agency's major responsibility was to construct irrigation works for the reclamation of arid lands (New Mexico State Engineer 1967: 81).

1902 The Reclamation Service, established by congressional act, was organized within the USGS and 5 years later became a separate bureau in the Interior Department (Utely and Mackintosh 1989: 19). This act "federalized western water development by placing the income from the sale of lands into a reclamation fund and using it to build dams and canals in the region" (Worster 1994). The act also authorized the Secretary of the Interior to construct irrigation projects in New Mexico and 15 other territories or states. Users of irrigation waters would repay the costs of construction over a 10-year period, and small farmers could irrigate 160 acres or less with water from federal irrigation projects (Clark 1987: 79–82; Wozniak 1987).

1902 Grazing permits for sheep on federal forest reserves were first issued (Eastman and Gray 1987: 36).

1903 President Theodore Roosevelt created a commission to study the laws regulating settlement and grazing of public domain lands, with the view of their long-time conservation. The commission concluded that most of the public domain was unsuitable for farming, and lack of government regulation and poor private stewardship had resulted in widespread degradation of rangelands due to overgrazing (Barnes 1926: 37–38).

1903 (and 1905, 1909) The Territorial Assembly passed acts authorizing counties to levy taxes to be used for paying bounty claims on predatory animals (Hagy 1951: 91).

1904 The New Mexico Department of Game and Fish was created by the Territorial Assembly (Barker 1970: 185).

1905 (February 1) Administration of national forest reserves was transferred from Interior to the Department of Agriculture (Udall 1962: 11). Congress passed an act transferring U.S. forest lands from the General Land Office to the Department of Agriculture. These 63 million acres formed the foundation for the new U.S. Forest Service, headed by Gifford Pinchot (Utely and Mackintosh 1989: 19).

1905 (October 12) The Jemez Forest Reserve was created, precluding continuance of traditional grazing and other activities on this former ejido land. The period of suppression of fire was also begun (Rothman 1989: 208–209).

1905 The Territorial Assembly passed an act creating the River Commission, which had responsibility for flood control on the Rio Grande. Burros, or dikes, were built at Valencia and Tome during a major flood (Ellis and Baca 1957: 17).

1905 The Territorial Assembly enacted a code that declared natural waters as belonging to the public, and all citizens had the right to appropriate them for beneficial use (Clark 1987: 117).

1905 The Forest Service began to hire trappers to kill wolves on national forest grazing land (Dunlap 1988: 143).

1905-06 The number of grazing permits for national forests in New Mexico was 878 for 53,454 cattle and horses and 234 for 312,035 sheep and goats (Rowley 1985: 78).

1905-09 Heavy stocking of the national forest reserves was thought to be desirable because of the decimation of vegetation that might fuel a fire (Brown 1985: 124).

1905–11 Inaccurate counts of livestock numbers and miscalculations of carrying capacity led to overgrazing on the national forests (Baker et al. 1988: 95–96).

1905–11 The U.S. Forest Service worked to organize a grazing program that would improve the value and use of the range (Roberts 1963: 115).

1906 (June 8) The Antiquities Act was passed by Congress and authorized by the President to create historic and prehistoric monuments. This act also included a provision for punishment of "any person who shall appropriate, excavate, injure, or destroy any historic or prehistoric ruin or monument, or any object of antiquity situated on lands owned or controlled by the Government of the United States" without permission of appropriate government officials (Udall 1962: 11–12).

1906 (June 11) The Forest Homestead Act, which allowed individuals to file on any forest reserve land considered unfit for timber, was passed by Congress. This act opened national forest lands for agricultural settlement; after a residency period, settlers could receive free title to 160 acres (Rowley 1985: 55, 63, 81–82).

1906 (June 25) Congress amended the Fergusson Act permitting the Secretary of the Interior to approve grazing leases in excess of the 640-acre limit. Following this enactment, "grazing leases became the primary source of revenue from territorial lands" (Clark 1987: 85).

1906 (October 5) The Mt. Taylor Forest Reserve was created. It was later incorporated into the Cibola National Forest (Baker et al. 1988: 42).

1906 (November 5) The San Mateo and Magdalena Forest Reserves were created. Both were later (1931) consolidated into the Cibola National Forest (Baker et al. 1988: 42).

1906 (November 6) The Manzano Forest Reserve was created (Tucker 1992: 107). The designation Forest Reserve was changed to National Forest in 1908. Manzano became Cibola National Forest on December 3, 1931 (Tucker 1992: 107, 109, 112).

1906 (November 7) The 330,000-acre Taos Forest Reserve, including Blue Lake, was created by President Theodore Roosevelt after a hunting trip in the Sangre de Cristo Mountains. Less than 2 years later this reserve was redesignated as the Carson National Forest (Baker et al. 1988: 25; Sando 1989: 83; Wood 1989: 74).

1906 The U.S. Forest Service imposed fees for grazing livestock on national forests. The fee averaged 4.7 cents per animal unit month. Some ranchers challenged the Forest Service's legal authority to charge grazing fees and regulate grazing. After lengthy litigation, the Supreme Court upheld the agency's right to do so (Clawson 1971: 170–172).

1906 Congress passed the Antiquities Act, giving Presidents the power to create "National Monuments for the preservation of historic landmarks . . . and other objects of 'historic or scientific interest'" (Udall 1963: 132).

1907 (January 16) An agreement between the United States and Mexico was ratified; it gave Mexico the right to divert up to 60,000 acre-feet of water from the Rio Grande for agricultural use (Hay 1972: 299).

1907 (June 11) Western grazing interests succeeded in having the Forest Reserve Act of 1891 repealed (Bowman 1995: 130).

1907 Gifford Pinchot and forester Overton Price coined the term "conservation" for the ongoing movement advocating appropriate, nonwasteful use of natural resources (Udall 1963: 105–106).

1907 A territorial law was passed providing for a territorial engineer, a water code, and a reconstituted board of water commissioners. Hydrographic surveys of the state were soon begun by the engineer (Clark 1987: 118–123).

1907 Some 591,000 board-feet of timber were cut in New Mexico's national forests (Baker et al. 1988: 84).

1907 The Bureau of Mines, created by Congress, promoted minerals technology and mine safety (Utely and Mackintosh 1989: 27).

1908 (April 16) The Manzano National Forest was created from the forest reserve of the same name and the entire Mt. Taylor Forest Reserve (Tucker 1992: 112).

1908 (June 26) The Carson National Forest was created by combining the Taos National Forest Reserve with part of the Jemez National Forest Reserve (Tucker 1992: 109, 114).

1908 (June 26) The Jemez National Forest Reserve became a national forest. Some of the land was combined with Taos National Forest Reserve to become a national forest (Tucker 1992: 112).

1908 (July 2) The Pecos River National Forest Reserve was designated a national forest (Tucker 1992: 113).

1908 President Theodore Roosevelt created 16 million acres of national forest in the Nation (Utely and Mackintosh 1989: 20).

1908 Trained foresters assumed administration of the national forests, which, in general, were overgrazed (Brown and Carmony 1995: 75).

1908 President Roosevelt convened the Governors' Conference on Conservation and told the members "Facts which I cannot gainsay force me to believe that the conservation of our natural resources is the most weighty question now before the people of the United States" (Swift 1958: v).

1908 A $20 bounty was paid for dead bears, and up to $50 was paid for grizzly bear hides. Some 271 bobcats were killed in the national forests, and many more were harvested by trappers or killed by ranchers statewide (Bailey 1971: 293; Barker 1953: 153).

1908 W.H. Bartlett, owner of the Vermejo Park, reintroduced elk there (Barker 1953: 93).

1909 (January 11) The first inventory of the Nation's natural resources was submitted to President Roosevelt by Gifford Pinchot, chairman of the National Conservation Commission (Bowman 1995: 130).

1909 (February 19) The Enlarged Homestead Act was passed by Congress; it basically authorized the classification and entry of semiarid lands. Qualified entrymen could occupy 320 acres of nonmineral, untimbered, nonirrigable, unreserved, and surveyed but unappropriated public land in the territory. One-eighth of the land had to be continuously cultivated for crops other than native grasses by the end of the second year, and one-quarter within the third year (Clark 1987: 136–137).

1909 The Territorial Assembly authorized two types of voluntary organizations: water users' associations and irrigation districts. In the latter, irrigation systems could be constructed for members (Clark 1987: 110).

1909 The Territorial Assembly passed a "provision for the drainage of seepage and other waters in unincorporated towns and villages by action of the county commissioners on petition of a majority of the residents and after investigation by the county surveyor" (Clark 1987: 112).

1909 President Roosevelt assembled a National Conservation Commission in Washington and he charged them "to make the nation's future as great as its present. That is what the conservation of our resources means." The commission issued a report that same year embracing his philosophy (Worster 1994: 7, 18, 20–21, 123).

1909 There were 131,621 cattle and horses permitted to graze on national forests in New Mexico (Baker et al. 1988: 98).

1909 The Forest Service allowed reservation Native Americans to graze their livestock for free where animal numbers were low and meat and hides were consumed entirely by the Indians (Rowley 1985: 86).

1909 The U.S. Bureau of Soils announced "The soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that cannot be exhausted; that cannot be used up" (Worster 1993a: 73).

1909 William Howard Taft issued a presidential proclamation establishing Gran Quivira National Monument (Carroll et al. 1991: 1).

1909 The New Mexico Territorial Assembly enacted a $15 bounty for wolves (Burbank 1990: 98).

1909 Pronghorns were removed form the list of legally hunted game animals to afford them protection (Matthiessen 1959: 283).

1910 (February) An "Indian Forest Service" was formed in the Department of the Interior. It became known as the "Branch of Forestry" (Udall 1962: 13).

1910 Many stockmen believed that grazing permits were a property right, subject to sale or transfer. The Forest Service held the position that they were "a personal privilege obtained from the secretary of agriculture [sic], and only the secretary retained the right to grant, withhold, or revoke the permit at his discretion" (Rowley 1983: 89–90).

1910–11 The Office of Grazing Studies was established by the U.S. Forest Service in 1910. In 1911 regional offices of the OGS were organized at Denver and Albuquerque (Price 1976: 7).

1910–11 More than 900 permits to take beaver were issued to individuals who claimed damages to their property. At the same time, the Santa Fe Water Company was offering $50 for each pair of live beaver to transplant in upper Santa Fe canyon, where they would help conserve water for the city (Bailey 1971: 219).

1910–12 Under legislative acts to prevent individuals or private companies from gaining exclusive use of extensive public lands or waters, the General Land Office withdrew such tracts and sources (Clark 1987: 145).

1910–18 Fifty-five new irrigation ditches went into operation in the Middle Rio Grande Valley (Hedke 1925: 22).

1911 Congress passed the Weeks Law, which authorized the purchase of forest lands on headwaters for the "regulation of the flow of navigable streams" (Buchanan 1988: 30). The law also called for a cooperative fire protection plan between the Forest Service and participating states. The legislation also authorized funds for acquisition of forest lands to protect stream watersheds (Otis et al. 1986: 5).

1911 The American Game Protective Association was formed (Brown and Carmony 1995: 9).

1912 Upon admission to the Union, Congress gave all sections 2, 16, 32, and 36 of the public domain to New Mexico for the aid and support of public schools. Other public lands were received by the state as well (Barnes 1926: 46).

1912 The Jornada Range Reserve, administered by the USDA Bureau of Plant Industry, was created by Executive Order. The primary function of the reserve was to study improving and maintaining desert grassland for sustained use and for the production of livestock. It is located just south of the study region (Price 1976: 17).

1912 The State Legislature passed a mining law governing operators, supervisors, and miners. The basic ventilation standard was set at 100 cubic feet of air per man per minute and 300 cf for each animal. "Gassy" mines had to be inspected daily (Whiteside 1989: 174).

1912 The last indigenous sage grouse in New Mexico was killed southwest of Chama. The New Mexico Game and Fish Department later reintroduced the species to northern New Mexico with birds captured in Wyoming (Ligon 1961: 93).

1912 The State Legislature, in its first session, passed the State Game and Fish Act, establishing a Game Protective Fund, codifying territorial wildlife laws, and making it a misdemeanor to pollute waters with sawdust or other materials that would kill or drive fish away (Clark 1987: 272).

1912–17 The Forest Service began to manage grazing to protect rangelands, watersheds, and wildlife by reducing livestock numbers on the forests (Roberts 1963: 115–116).

1912 Aldo Leopold found the Jicarilla unit of the Carson National Forest to be overgrazed, due primarily to Hispanic livestock owners in the area (Brown and Carmony 1995: 7).

1913 A USGS report pointed out the need to consider water in the disposal of the remaining public lands and emphasized that it must be appropriately managed (Clark 1987: 144).

1913 Congress passed the Federal Tariff Act, which prohibited "the importation of plumes and other bird parts except for scientific purposes" (Reed and Drabelle 1984:8).

1914 (June 30) Congress made the U.S. Biological Survey responsible for experiments and demonstrations in destroying wolves, prairie dogs, and other predators of livestock (Brown 1983: 52). To carry out this program, the Predatory Animal and Rodent Control (PARC), a branch of the Biological Survey, was formed in the U.S. Department of Agriculture. Three hunters were employed in 1914–15 (Brown 1983: 52; 1985: 126–127).

1914 (late and April 1915) The New Mexico Cattlemen's Association voted to pay bounties of $25 for each hide of adult wolves or mountain lions taken on the ranges of its members. The organization also passed a resolution requesting Congress to provide funds to exterminate predators on public lands (Hagy 1951: 91).

1915 The Agriculture Appropriations Act, passed by Congress, provided for the establishment of summer homes, recreation sites, and campgrounds in the national forests (Brown 1985: 130).

1915 Congress appropriated $125,000 for the Bureau of the Biological Survey to begin a program of predator control. This effort was primarily based on the rationale that "many predators emanate from federal lands, and thus much of the loss suffered by farmers and ranchers has a federal origin" (Reed and Drabelle 1984: 75).

1915 The Forest Service released 37 elk from Yellowstone into the Pecos District of the Santa Fe National Forest. In less than 20 years this small herd had increased to 300 animals, and hunting of this species was permitted within a short time (Barker 1953: 94–95, 163).

1915 The pronghorn antelope population was reduced to 1,200 animals statewide. State protection from hunting increased this number to 2,957 by 1926 (Findley et al. 1975: 334).

1915–17 J. Stokely Ligon headed up predator control in the New Mexico-Arizona district. He hired 32 hunters and trappers, including renowned bear hunter Ben Lilly. Nineteen grizzly bears and at least six mountain lions were killed. His staff of wolf hunters also killed 69 wolves in their first year in New Mexico and Arizona. An estimated 300 wolves remained in New Mexico at the end of the year (Brown 1985: 127; Burbank 1990: 102–103).

1916 (February) By executive order, President Woodrow Wilson created the 22,400-acre Bandelier National Monument (Rothman 1992: 122).

1916 (August 25) Congress passed the National Park Act, leading to the creation of the National Park Service (Udall 1963: 153).

1916 The Rio Grande Commission was authorized by the State Legislature. This group was to address regional and Middle Rio Grande water problems, such as "drainage, water storage, flood control, river rectification, riverbank protection, diversion dams, and a series of main canals between San Felipe and San Marcial ..." (Clark 1987: 205–206, 217–218).

1916 Elephant Butte Dam was completed, and the reservoir began filling. This impoundment was primarily for flood control and storage of irrigation water (Clark 1987: 195, 198).

1916 The U.S. Forest Service initiated a predator control program in the Jemez Mountains. The gray wolf, mountain lion, and coyote were targeted for trapping (Barker 1970: 113; Scurlock 1981a: 144).

1916 U.S. Biological Survey personnel killed 100 wolves in New Mexico. Some 117, including those taken by the USGS, were killed in the national forests (Bailey 1971: 311).

1916 About 1,740 antelope were reported in the state (Bailey 1971: 25).

1916 The governor proclaimed arbor and bird days for the state (Robinson 1993: 34).

1916 Congress passed the Stock-Raising Homestead Act; one of its provisions allowed for the substitution of range improvements and well drilling for cultivation. Native grasses and topsoil would thus be protected, and small livestock growers would be protected from displacement. It also provided for a free section of grazing land when filed on (Clark 1987: 147; Oakes 1983: 27). This act also provided for livestock driveways of not over one-fourth mile in width across public land (Hagy 1951: 78–79).

1916 Because of protests by cattlemen, the Forest Service raised grazing fees by 25 percent rather than 100 percent, as the agency had proposed (Hagy 1951: 62).

1916–17 Ashley Pond founded a sportsmen's club, which included a game preserve, with hunting and camping areas, at the north end of the Ramon Vigil land grant. The water source for this endeavor, a spring in Pajarito Canyon, dried up, and Pond abandoned the preserve (Ebright 1994: 244–245).

1916–17 Due primarily to intensive hunting, mule deer populations in the lowlands had been virtually exterminated (Bailey 1971: 29).

1916–18 When the United States joined World War I, the Forest Service increased the number of permitted livestock on national forest lands. Conditions caused by previous overgrazing and logging worsened (deBuys 1985: 231).

1916–19 The U.S. Forest Service issued livestock grazing permits to non-Indians for the sacred Blue Lake area (Sando 1989: 83).

1917 Congress increased grazing fees on public lands, and politicians, ranchers, and others protested vigorously (Clark 1987: 146).

1917 As the United States entered World War I, demand for beef increased sharply, and Stokely Ligon and Aldo Leopold used the situation to justify an intensified predator control effort (Brown 1983: 57).

1917 The Bureau of Biological Survey received $25,000 funding to control predatory animals and rodents in New Mexico. This amount was matched by the state (Hagy 1951: 93).

1917–18 Maximum numbers of livestock were reached in New Mexico due to the increased demand for food and wool during World War I (Donart 1984).

1917–18 The demand for beef during World War I caused cattle prices to soar, and, in response, ranchers increased the grazing pressure on their rangelands. Grasses were decimated, exposing large areas to water and wind erosion (Sanchez 1992: 2).

1917–18 Trespass livestock were common on Forest Service lands, which contributed to overgrazing (Roberts 1963: 120–121).

1917–22 The New Mexico Cattle Growers' Association "diligently pursued a policy that favored giving the State the remaining public domain to be administered in the same fashion as the previously granted trust lands." The association was in the minority on this issue (Mortensen 1983: 84).

1918 Congress passed the Migratory Game Bird Treaty Act, making the U.S. Biological Survey (later the U.S. Fish and Wildlife Service) responsible for nationwide management of waterfowl and other migratory species (Huey et al. 1967: 153).

1918 Some 81 adult wolves and 30 pups were taken by the U.S. Predatory Animal and Rodent Control Division of the Biological Survey and New Mexico A&M College employees (Brown 1983: 58).

1918 Poisoning of grizzly bears was initiated by the U.S. Biological Survey (Brown 1985: 272).

1918 Aldo Leopold declared in a published paper that game management was as much a function of the Forest Service as were timber and range management (Brown and Carmony 1995: 85).

1918–19 During this fiscal year, state and Predatory Animal and Rodent Control killed 28 grizzly bears in New Mexico (Brown 1985: 137).

1920 (March) Private forester Stewart Edward White "criticized the Forest Service for allowing their forests to become overgrown with brush, and chastised it for not using light burning to prevent tree diseases and destructive conflagrations" (Brown and Carmony 1995: 143).

1920 (June 10) Congress passed the Federal Water Power Act. This legislation provided for the establishment of a Federal Power Commission that had authority to issue licenses for the construction, operation, and maintenance of power facilities on navigable waters and public lands (Clark 1987: 145–146).

1920 The Forest Service adopted a policy of no light burning in ponderosa pine forests based on the belief that fire every 2 to 3 years would prevent restocking of the tree (Pyne 1982: 522).

1920 Congress passed the Minerals Leasing Act, enabling the General Land Office to lease lands with oil, gas, coal, and other critical minerals to private producers (Utely and Mackintosh 1989: 27).

1920 The U.S. Biological Survey's predator control program in New Mexico had reduced wolves from an estimated 300 to an estimated 60 or less (Brown 1983: 64; Flader 1978: 60).

1900s (early) The Federal Government constructed reservoirs for pueblos that did not have a reliable water supply. These quickly began to silt up, resulting in a reduction of their capacities (Vlasich 1980: 28).

1921 Created by the State Legislature, the Rio Grande Survey Commission, in cooperation with the U.S. Reclamation Service, began to study environmental conditions in the Middle River Valley (Wozniak 1987).

1921 Aldo Leopold "presented a fully formed and brilliantly considered wilderness-preservation plan to the Forest Service" (Brown and Carmony 1995: 152).

1921 (post) Some ranchers supported creation of wilderness areas because their roadlessness would keep automobiles and their passengers off grazing leases (Brown and Carmony 1995: 154).

1922 (March) The General Forest Exchange Act authorized the Forest Service to consolidate forest lands and exchanges to acquire private in-holdings within national forest boundaries. An amendment 6 years later "authorized the use of land and timber to be exchanged for grant lands adjacent to the Carson, Santa Fe, and Manzano Forests" (Baker et al. 1988: 27).

1922 There were 7,559,000 acres of public land under grazing lease and 1,500,000 acres under oil lease (Barnes 1926: 47).

1922 The state reduced grazing fees on public lands from 5 cents to 3 cents an acre (Hagy 1951: 82).

1923 The State Legislature passed the Conservancy Act, creating a Middle Rio Grande District with a governing board to initiate projects to prevent flooding, regulate stream flow, reclaim waterlogged lands, develop irrigation works, develop or reclaim sources of water, and generate electrical energy (Clark 1987: 206, 207, 209–212).

1923 The Reclamation Service was converted into the Bureau of Reclamation (Clark 1987: 189).

1923 The U.S. Biological Survey and cooperating ranchers put out 103,000 strychnine baits to control coyotes, bears, and other predators (Brown 1985: 142).

1924 (pre) The channel of the Galisteo deepened as a result of overgrazing and other abuse in its drainage. Due to this incising, water could no longer be diverted for irrigation (Brown and Carmony 1995: 169).

1924 (June 7) Congress passed the Pueblo Lands Act, which provided for the appointment of a commission to investigate Pueblo land titles and to litigate the thousands of non-Indian claims against Pueblo lands. Known as the Pueblo Lands Board, this commission was empowered to compensate Indians and non-Indians alike for lands lost via court decisions (Brayer 1938: 28–29).

1924 Passage of the Pueblo Lands Act resulted in Hispanos acquiring legal title to about 18,200 acres of northern Pueblo land through adjudication. Most of this acreage was irrigable, and water rights were appropriated with land title (Forrest 1989: 58).

1924 Lack of grazing regulation on the public domain led to continuing overgrazing (Brown and Carmony 1995: 171).

1924 The Clark-McNary Act greatly expanded federal-state cooperation in reforestation and fire control on state and private forest lands (Bergoffen 1976: 61).

1924 Assistant Regional Forester Aldo Leopold's paper "Grass, Brush, Timber, and Fire in Southern Arizona" was published. This article, the first detailed discussion of historical change in a Southwest landscape, identified overgrazing and fire suppression as the causes of the invasion of grasslands by shrubs and trees and erosion on national forest lands. Erosion, he pointed out, was caused by allowing intensive grazing to reduce plant cover, which supposedly would decrease the incidences of fire (Brown and Carmony 1995: 188–192).

1924 Owing to the efforts of Leopold, the Gila Wilderness area was established, the first such unit in the United States (Baker et al. 1988: 47).

1924 New Mexico's wildlife populations reached their lowest numbers, and more species were threatened with extinction than at any other time. Several species, such as the gray wolf and grizzly bear, were extirpated within a few years. Most other species, with the aid of restocking and the establishment of refuges, have made gains since that time (Ligon 1927: 15).

1925 The condition of rangelands became acute by this year due to drought and overgrazing. Ranchers joined U.S. Forest Service rangers in the rounding up of thousands of wild horses on national forest lands. These were sold to reduction plants in El Paso and Gallup, where they were slaughtered and ground into fertilizer and pet food (Wyman 1945: 159–160).

1925 The Middle Rio Grande Conservancy District structure was formed by this year. About 277,760 acres were included in the district. To alleviate flooding and subsequent waterlogging, dams, levees, and drainage canals were constructed over the next 5 decades (Scurlock 1988b: 136).

1925 Wild horses on the Carson National Forest were contributing to the overgrazing problem. Some 1,200 horses were rounded up; some were sold to residents surrounding the forest (Tucker and Fitzpatrick 1972: 79–80).

1926 (January 22) The Department of Agriculture issued a memo entitled "New Grazing Regulations on National Forests," which made three major concessions to livestock raisers: (1) 10-year grazing permits were given full status of a contract between the USFS and the stockmen and could only be revoked because of a violation of terms, (2) further distribution of grazing privileges was generally suspended, and (3) the role of local grazing boards was reemphasized, with one member representing the USDA and the other members selected by the grazing permittees. These boards settled grazing disputes and gave advice in developing new grazing policies (Rowley 1985: 134–135).

1926 Some Hispanic farmers in the Middle Valley expressed concern for the program of the Rio Grande Conservancy District (Orona 1994).

1926 The U.S. Forest Service published *The Story of the Range* by Will C. Barnes, Assistant Forester and Chief of Grazing. This report documented grazing history and resulting impact on Great Plains and Southwest rangelands. The questioning of the wisdom of the Taylor Act and its application were included (Baker et al. 1988: 51).

1927 (March 16) The New Mexico groundwater law was passed, "the first attempt by any western state to establish by statute and in relatively permanent form the basic principle governing the appropriation of groundwater." All underground waters in the state were declared "public waters," subject to appropriation for beneficial uses under the existing laws of the state relating to appropriation and beneficial uses of waters from surface streams, and to be supervised and controlled by the State Engineer. The State groundwater act also authorized the state to determine sources and recharge of underground waters and to control their future development. The Middle and Upper Rio Grande was declared a groundwater basin (Clark 1987: 236–238).

1927 The Corps of Engineers was authorized by Congress to conduct surveys for flood protection and hydropower facilities in all U.S. waterways (Welsh 1987: 109).

1927 Black bears received legal protection in New Mexico (Findley et al. 1975: 29).

1928 (March 13) Congress authorized the Secretary of the Interior to enter into a contract with the Middle Rio Grande Conservancy District for participation in its $10 million program of drainage, flood control, rehabilitation of irrigation systems and farmland, and general conservation (Strauss 1947: 133–134).

1928 A new agreement between the Pueblos and Middle Rio Grande Conservancy District provided that the district would "provide conservation, irrigation, drainage, and flood control" (Bayer et al. 1994: 240).

1928 The McSweeney-McNary Forest Research Act, which called for the development of methods for protection of watersheds, was passed by Congress (Buchanan 1988: 32; Bergoffen 1976: 61).

1928 The McSweeney-McNary Forest Research Act, passed by congress, authorized experiments in range management as part of a comprehensive program of forest research. One of 12 regional forest experiment stations authorized by this act was the Rocky Mountain Forest and Range Experiment Station (Bergoffen 1976: 61; Price 1976: 19).

1928 Congress appropriated $150,000 for the U.S. Forest Service "to investigate the life histories and habits of forest animals, birds, and wildlife from the standpoint of injury to forest growth and as a supplemental economic resource" (Clark 1987: 266).

1929 (March 2) Congress passed an act authorizing New Mexico to negotiate specifically for the apportionment of the waters of the Rio Grande and Pecos River with Texas (Clark 1987: 230).

1929 The Flood Control Act was passed by Congress; the U.S. Army Corps of Engineers was given responsibility for locating water sources for domestic supplies, irrigation, and hydroelectric power (Welsh 1987: 22).

1929 The state attorney general ruled that "unauthorized obstruction of any natural water course did become actionable for resulting damage" (Clark 1987: 335).

1929 The Agricultural Appropriation Act was passed by Congress; $160,000 was provided for investigation of soil erosion and the means for its control (Clark 1987: 256).

1929 In this year "westerners launched a major campaign to reduce damage by predators to crops and livestock" (Reed and Drabelle 1984: 75).

1929 President Herbert Hoover, in a communique to the Western Conference of Governors, "recommended the creation of a commission to consider the advisability of turning unreserved nonmineral lands over to the states ..." (Clark 1987: 252).

1929 (late) The new Middle Rio Grande Conservancy District promised to provide irrigation, drainage, flood control, and conservation for the Santa Ana Pueblo, and the means for control (Bayer et al. 1994: 242; Clark 1987: 256).

1929–31 Conservationists urged Congress to control grazing on the public range by establishing regulations to be administered by the Department of Agriculture (Stout 1970: 322–323).

1929–34 Several federal laws resulted in the purchase of more refuge lands; more wildlife conservation authority; studies of the economics of harvesting fish and game, wilderness recreation, and control of erosion and pollution; and creation of wildlife sanctuaries on the national forests (Clark 1987: 267).

1929 (post) Following organization of the Middle Rio Grande Conservancy District, the Pueblo persuaded Congress to make a payment of $1,321,000 to the conservancy on their behalf because they could not maintain their subsistence economy if required to pay ongoing commercial charges (Harper et al. 1943: 24).

1910s–20s Local bounties were paid for bobcats, and most sheep ranchers hunted them vigorously (Bailey 1971: 293).

1920s (late) Mule deer had become abundant on most national forests (Brown and Carmony 1995: 127).

1930 (April 15 to July 1, 1931) The Forestry Division, Office of Indian Affairs, assumed responsibility for the protection and administration of grazing on more than 42 million acres of Native American rangelands in the West. A grazing policy for Indian lands was implemented (Udall 1962: 17).

1930 By this year permits for grazing on the Santa Fe National Forest had been reduced to correlate with carrying capacities (Rothman 1992: 159).

1930 President Herbert Hoover appointed a commission called the Committee on Conservation and Administration of the Public Domain; this body recommended that "congress pass a law conveying the public domain lands of the West to the States who wanted them...." The following year the committee drafted legislation embracing this recommendation, but it was rejected in house committee (Mortensen 1983: 82).

1930 A forestry research area of 10,000 acres was established on the Santa Fe National Forest for use by the University of New Mexico (Baker et al. 1988: 29).

1930–31 Congress passed legislation creating the Committee on Conservation and Administration of the Public Domain, proposing that potential public grazing lands be offered to the states in which they were located, and the states in turn would pass them to private ownership. The Forest Service and other organizations opposed this recommendation as a threat to conservation of resources on these lands and to small-scale livestock raisers. Surprisingly, western states generally did not support this potential action (Clark 1987: 252).

1930–34 Construction of the major water control facilities proposed by the Middle Rio Grande

Conservancy District, including El Vado dam and reservoir on the Chama River, were completed. This reservoir had a storage capacity of 190,000 acre-feet (Harper et al. 1943: 53).

1931 (pre) "Users of public lands never found it advantageous to protect or even conservatively graze any range they did not fully control . . . " "Homesteaders who settled as groups or colonies on the most favorable of the remaining tracts of unreserved public domain also contributed to the impairment of range lands . . . " "For a time many of them believed that whatever was responsible for the untoward state of things was abnormal and that if they could produce enough to live on for another year, conditions would be better. They therefore grazed in common the surrounding public lands to the utmost, in the attempt to eke out subsistence" (Cooperrider and Hendricks 1937: 82)

1931 (March 2) Congress appropriated $10 million to fund (one million dollars annually for the 10-year program) predatory animal control in the West (Hagy 1951: 94).

1931 (March 2) The Animal Damage Control Act authorized the Secretary of Agriculture to conduct research and experiments in determining the best methods to control or exterminate predators and "other animals injurious to agriculture, horticulture, forestry, animal husbandry, wild game animals." Because of the 1930s economy and World War II, however, the program was never funded (Hagy 1951: 94; Mortensen 1983: 73).

1931 (November) The National Conference on Land Utilization, meeting in Chicago, recommended that ". . . in order to obtain conservation and rehabilitation of the grazing ranges of the public domain these lands be organized into public ranges to be administered by a Federal agency in a manner similar to and in coordination with the national forests." The group also recommended "that lands valuable for watershed protection should be administered under the supervision of the Federal Government." Subsequently, the Secretary of the Interior approved federal regulation of grazing on the public domain to protect these lands (Clark 1987: 252–253).

1931 (December 3) The Manzano National Forest was renamed Cibola National Forest (Tucker 1992: 109).

1931 The state declared that the waters of underground streams, channels, artesian basins, reservoirs, and lakes having reasonable ascertainable boundaries are public waters "subject to appropriation for beneficial use in accordance with the statutes and with rules and regulations formulated by the State Engineer of New Mexico" (Erickson 1954: 81).

1931 The New Mexico Legislature passed a law giving the State Game Commission full regulatory powers to manage the wildlife of the state, including the setting of hunting seasons and bag limits (Barker 1970: 188; Flader 1978: 105).

1931 Due in part to a western ranchers' campaign, Congress enacted the Animal Damage Control Act. This legislation granted the Fish and Wildlife Service broad authority "to eradicate, suppress, destroy or bring under control predators," which the act defined as "mountain lions, wolves, coyotes, bobcats, prairie dogs, gophers, ground squirrels, jack rabbits, and other animals injurious to agriculture, horticulture, forestry, animal husbandry, wild game animals, furbearing animals, and birds" (Reed and Drabelle 1984: 76).

1931 Under state game management, the pronghorn antelope population had increased to 5,000 animals (Barker 1976: 136).

1932 The U.S. Forest Service suspended grazing fees because of the emergency conditions of the Depression (Rowley 1985: 246).

1930s (early) Hispanics organized a farmer's association in the Los Lunas area over concern that their ditches might be lost to the Middle Rio Grande Conservancy District (Orona 1994).

1930s (early) Western livestock raisers "believed that the passage of regulatory legislation such as the Taylor bill would restrict their use of the public domain and would lead to financial chaos . . ." (Mortensen 1983: 83).

1930s (early) More than 1,500 horses were removed from the Jemez River District of the Santa Fe National Forest (Tucker and Fitzpatrick 1972: 81).

1933 The Secretary of Agriculture established a basic fee schedule for grazing livestock on the national forests. These fees were based on an appraisal of each range area and varied from year to year in proportion to changes in livestock prices (Clawson 1971: 172–173).

1933 The Soil Erosion Service was established as a temporary agency of the Department of the Interior. Two years later it was transferred to the Department of Agriculture (Udall 1962: 17–18).

1933 Under the National Industrial Recovery Act, the Forest Service developed a code of business practices for the timber industry. This code included commitment to "conservation, selective cutting, sustained yield, reforestation, and a program to prevent forest fires" (Baker et al. 1988: 53).

1933 President Franklin Roosevelt created the Civilian Conservation Corps. About 3 million persons, mostly young men, worked primarily on soil and water conservation projects until 1942 (Buchanan 1988: 32–33).

1933 Four CCC camps were established on the Santa Fe National Forest at Glorieta Mesa, Senorita Canyon, and Canada. On the Cibola National Forest were the West Boundary and Monica ranger station camps. Projects included boundary fencing, trail maintenance, road repair, erosion control, timber stand improvement, and rodent control (Otis et al. 1986: 29–31).

1933 An Indian branch of the Civilian Conservation Corps was organized, and several irrigation projects were begun (Hughes 1983: 126).

1933 The U.S. Forest Service declared the Pecos high country a "Primitive Area" (deBuys 1985: 285).

1933 Unionization of coal miners and a tougher, comprehensive mining law reduced deaths due to mining accidents (Whiteside 1989: 183).

1933 Bighorn sheep from Banff National Park were released in the Sangre de Cristo Mountains (Barker 1953: 90).

1933 (late) A CCC camp was established at Bandelier National Monument. Workers built roads, trails, and fire breaks and constructed residences and Park Service administrative buildings (Rothman 1992: 183–184, 193).

1933 Some 17 CCC camps were established on national forests in New Mexico. Workers performed a variety of tasks in completing some projects, including construction of roads and trails, revegetation of depleted areas, construction of erosion control facilities, and thinning of timber stands. Native American participants replanted vegetation and built water control structures on eroded lands (Baker et al. 1988: 53–54).

1933–35 Under the leadership of John Collier, a New Deal land reform program for Native Americans and Hispanics was implemented. Part of this program was aimed at restoring the fertility of severely eroded land (Forrest 1989: 129).

1933–40 New Deal agencies, and the Bureau of Indian Affairs, conducted a number of in-depth surveys of natural and human resources in the Middle and Upper Rio Grande valleys. Hispano, Native, and to a lesser extent, Anglo Americans interrelationships with each other and their shared environment were first addressed by these studies (McWilliams 1961: 287).

1933–40 The Grazing Service organized four districts embracing almost 1.5 million acres of grazing lands in the Middle Rio Grande Basin (Harper et al. 1943: 88–90).

1933–40 A range conservation program was conducted on Indian lands in the Middle Valley by the Soil Conservation Service (Harper et al. 1943: 89).

1934 (June 18) The Indian Reorganization Act, giving Native Americans the right to govern themselves, was passed. Under this act, the U.S. Government determined the organizational structure of tribal governments. It also defined the Secretary of the Interior's responsibility for conservation and economic development of resources on Indian lands. This act in part, prohibited alienation of Pueblo lands (Simmons 1979b: 217; Utely and Mackintosh 1989: 32).

1934 (June 28) The Taylor Grazing Act authorized the Secretary of the Interior to rehabilitate overgrazed and eroded areas and to construct improvements on federal lands through the new Grazing Service (Hagy 1951: 75). A major purpose was to control and manage grazing on the public lands. In 1946 this agency was combined with the General Land Office to form the Bureau of Land Management (Clawson 1971: 34–38). The bulk of unappropriated grassland (80 million acres) was closed to further settlement by the act. These lands were to be kept as a grazing resource and managed by local livestock growers organized in districts and supervised by the Department of the Interior (Worster 1979: 190). This act had been strongly opposed by the National Wool Growers' Association and the New Mexico Stock Growers' Association (Stout 1970: 314, 318).

1934 (June 30) The National Resources Board, which sponsored ground and surface water studies, was created by executive order (Clark 1987: 250, 256).

1934 Under the Drought Relief Service program, the U.S. Government began buying cattle on overgrazed, drought-stricken rangelands (Limerick 1987: 88).

1934 The U.S. Government purchased the "badly overgrazed and eroded" Ojo del Espiritu Santo land grant and began a resource management program (Varney 1987: 35).

1934 The governor of New Mexico created a planning board made up of employees from five major state resource agencies and presidents of the three major universities; they began a study of the state's natural resources, with emphasis on erosion problems and water conservation (Clark 1987: 269).

1934 El Vado dam and reservoir were built on the Rio Chama (Gatewood et al. 1954: B45).

1934–35 The New Mexico State Planning Board found that the public rangelands in the state were badly damaged due to overgrazing (Clark 1987: 255).

1934–38 The extended drought spurred the comprehensive Rio Grande Joint Investigation, which led to the Rio Grande Compact between Colorado, New Mexico, and Texas (Thomas 1963: H16).

1934–44 The continuing overuse and deterioration of Pueblo land led to an accelerated land acquisition program. About 390,727 acres were purchased or assigned to Indian use on non-Pueblo lands. Another 199,255 acres of public land were under lease or permit from the state, the Forest Service, or the Taylor Grazing Service (Aberle 1948: 15–16).

1934–40s Livestock raisers "succeeded in mitigating the law's [Taylor Grazing Act] impact by formation of district and state advisory boards. These boards were elected by permittees and became the de facto governing boards." The U.S. Grazing Service generally followed the board's recommendations. As a result, range conditions improved very slowly (Eastman and Gray 1987: 35).

1935 The Wilderness Society, under the leadership of Robert Marshall, was founded (Brown and Carmony 1995: 163; Udall 1963: 154).

1935 (March 7) Coronado State Monument, site of a large late prehistoric–early historic pueblo, was established by the State Legislature. Located just north of Bernalillo, it is one of Tiguex villages contacted by Coronado in 1540–42 (Dutton 1963: 4–5).

1935 (April 27) The Soil Conservation Act was passed by Congress, creating the Soil Conservation Service (SCS) (Udall 1963: 144).

1935 (spring) Some 420,000 rainbow trout were introduced into El Vado Reservoir (Workers of the Writers' Program 1940: 34).

1935 The SES (Soil Erosion Service) initiated an erosion control program for the 11,500,000 acre watershed of Elephant Butte Reservoir, which was filling with sediment at a rapid rate (Clark 1987: 256).

1935 The ongoing drought was a factor in the bringing of a suit against the state and the Middle Rio Grande Conservancy District by water users in southern New Mexico for impairment of water rights below Elephant Butte Reservoir (Clark 1987: 218).

1935 The director of the Grazing Division established district advisory boards. These groups were made up of ranchers, a wildlife representative from a local sportsmen's group, and an employee of the division, who served as secretary. The boards were especially helpful in the organization and administration of new grazing districts (Clawson 1971: 149).

1935 Congress appropriated funds for establishment of the Rocky Mountain Forest and Range Experiment Station (Price 1976: 19).

1935 The Historic Sites Act, requiring archeological investigation prior to the construction of a federal reservoir or a federally permitted reservoir, was passed by Congress (McGimsey n.d.: 16). This act also declared a national preservation policy on public use of historic sites, structures, and "objects of national significance". Furthermore, it established an Advisory Board on National Parks, Historic Sites, Buildings, and Monuments (Udall 1962: 19).

1935 Legislation was passed creating the office of Superintendent of State Parks and a Park Commission. This commission was authorized to acquire park lands and was directed to draft rules and regulations for public use of parks (Clark 1987: 271–272).

1935 (April) The Division of Grazing administered four grazing districts totalling almost 9 million acres (Clark 1987: 255).

1935–36 The Corps of Engineers joined other agencies in the Interior and Agriculture departments in conducting the Rio Grande Joint Investigation study (Welsh 1987: 109).

1935–39 Livestock numbers were reduced on Pueblo lands because of deterioration of rangelands due to overgrazing (Aberle 1948: 20).

1936 The Flood Control Act of 1936 declared that the Federal Government had responsibility to control floods on navigable rivers and run-off-caused erosion on smaller streams in cooperation with state and local governments. This act "established for the first time an integrated flood-control policy" and laid the groundwork for the greatest public works program ever undertaken by the U.S. Government. The Corps of Engineers was placed in charge of "investigations and improvements of waterways" (Buchanan 1988: 33; Clark 1987: 259–260).

1936 The Soil Conservation Service completed a new irrigation dam at San Luis, Sandoval County, located about one-half mile above the site of the earlier structure (Widdison 1959: 277).

1936 The MRGC completed work on the Cochiti, Angostura, Isleta, and San Acacia diversion dams, 180 miles of new canals, 294 miles of new laterals, and 200 miles of riverside levees. The valley water table was being lowered, and 59,159 acres of land were being irrigated (Clark 1987: 211–212).

1936 The Forest Service estimated that at least 75 percent of the Rio Grande watershed in southern Colorado and northern New Mexico was experiencing severe, accelerated erosion, largely as a result of the removal of the plant cover through overgrazing and logging (deBuys 1985: 232).

1936 Activities of nomadic stockmen, who had roamed the range with no base of operation, were stopped by the Division of Grazing (Clark 1987: 255).

1936 The National Wildlife Federation was formed (Borland 1975: 148).

1930s (mid to late) The Soil Conservation Service purchased the Ramon Vigil grant on the Pajarito Plateau from Frank Bond. This agency initiated soil and water protection plans for the grant, for San Ildefonso and Santa Clara lands, and for other lands on the Pajarito Plateau (Rothman 1992: 199, 231).

1937 (June 28) The Civilian Conservation Corps legislation was amended by Congress, directing personnel from this agency to provide works "for the protection, restoration, regeneration, improvement, development, utilization, maintenance, or enjoyment of the natural resources of lands and waters, and the products thereof." Water development and conservation, improved range projects, and other projects were carried out with funding allocated to the National Park Service, U.S. Forest Service, Bureau of Reclamation, Soil Conservation Service, U.S. Fish and Wildlife Service, and state parks and forests. The CCC also contributed to wildlife and recreational programs (Clark 1987: 244–245).

1937 (August 26) The Small Reservoirs Act, which provided funding for construction of small water storage structures for isolated communities and groups of ranchers, was passed by Congress (Clark 1987: 263–264).

1937 The Forest Service received authorization and funding for the reserving of certain unappropriated waters in New Mexico to carry out the protection and improvement of national forest lands through water conservation (Clark 1987: 274).

1937 Some 8,000 individuals, almost all Hispanic, "lost their land titles because they were unable to pay taxes and assessments on the Middle Rio Grande Conservancy District Project . . . " (Gonzalez 1969: 52).

1937 The Works Projects Administration, the Public Works Administration, and the National Youth Administration also provided employment for workers, who carried out conservation and reclamation projects for water and wildlife improvement (Clark 1987: 245).

1937 The Forest Service released its report, *The Western Range*, which described "the critical deterioration in the condition of lands, regardless of ownership, prevailing in the public-land states" (Clark 1987: 273–274).

1937 Congress passed the Bankhead-Jones Farm Tenant Act, which authorized the Federal Government to purchase private lands of "low production." These tracts were added to national forests, national parks, grazing districts, and other public land holdings (Levine et al. 1980: 53).

1937 A soil conservation act was passed by the State Legislature, creating soil conservation districts to be assisted by other state and appropriate federal agencies. These districts were concerned with erosion control, water development, and land classification based on "best use" (Clark 1987: 270–271).

1937 Congress passed legislation creating soil conservation districts in the states (Batie 1985: 109).

1937 Three soil conservation grants totalling 174,000 acres were allocated to the Pueblos. These lands had a carrying capacity of 1,656 cattle. Three other such grants totalling 187,000 acres, with a carrying capacity of 1,601 cattle, were made to non-Indians, but primarily for Hispanic use (Forrest 1989: 141).

1937 Passage of the Pittman-Robertson Act provided funding for state game and fish departments to conduct game surveys on a systematic basis and to institute wildlife research (Brown and Carmony 1995: 123). The act levied a tax on firearms and ammunition to provide funds for state wildlife projects (Udall 1963: 145). The act also required rivers and harbors appropriations to include funding for investigations and improvements of wildlife, and it fostered closer cooperation between federal and state governments (Clark 1987: 267–268).

1937 The first state park, Bluewater Lake, was created (Clark 1987: 271).

1937–38 The National Resources Committee and the Rio Grande Compact Commission conducted a comprehensive and detailed study of the land and water resources of the Rio Grande Basin north of Fort Quitman, Texas. The study addressed problems such as stream flow, apportionment of waters between the two states and Mexico, and flood and silt control (Clark 1987: 218–221).

1937–46 The Albuquerque Ski Club was organized, and this group obtained a special use permit from the Forest Service to operate a rope-tow and restaurant in the Sandia Mountains, Cibola National Forest. In 1946, Robert J. Nordhaus organized the La Madera Company and assumed control of operations until 1963. In this year he organized the Sandia Peak and Aerial Tramway Company, which built a ski lift and a tramway system to the ski area (Baker et al. 1988: 138).

1937–38 (March 18) Representatives of New Mexico, Colorado, and Texas signed the Upper Rio Grande Compact, which delineated the tristate division of Rio Grande water above Fort Quitman, Texas. This agreement incorporated schedules for delivery of water at the Colorado-New Mexico line and below Elephant Butte Reservoir based on flow measurements at Lobatos and San Marcial. Under this compact, the Middle Rio Grande Conservancy District could develop its plan affecting 123,000 acres of land (Clark 1987: 219–221; Harper et al. 1943: 94–95).

1938 (August 20) The Pueblo and Spanish ruins of Abo and Quarai were declared state monuments (Toulouse 1949: 1).

1938 A state game refuge was established on the east side of the Sandia Mountains (McDonald 1985: 12).

1938–39 The 350-acre Hyde State Park was developed by the CCC under the supervision of the National Park Service. It is surrounded by Santa Fe National Forest land (Baker et al. 1988: 137).

1939 (February 1) Some 25,295 acres of the Ramon Vigil grant were transferred from the SCS to the Forest Service (Rothman 1992: 204).

1939 By this year the Division of Grazing had built 585 check dams to control erosion and 31 reservoirs with an aggregate capacity of 17,500 acre-feet benefitting 75,000 acres of land (Clark 1987: 256).

1939 By this year there were 201 state game refuges totalling 2,884,654 acres (Workers of the Writers' Program 1940: 33).

1939 The Federal Aid to Wildlife Act was passed by Congress, and money became available for states to acquire habitat lands. Some 30,000 acres were purchased for this purpose in New Mexico (Barker 1976: 100–101).

1939 The Bosque del Apache National Wildlife Refuge was established in Socorro County. Embracing 57,200 acres, the refuge was purchased primarily for sandhill cranes and waterfowl (Laycock 1965: 269). In recent years an experimental flock of whooping cranes has wintered on the refuge.

1939 There were 116,600 recreational visits to the Cibola National Forest (Baker et al. 1988: 134).

1930s When the large Hispanic livestock holders in the region were forced to reduce their herds due to overgrazing and drought, many young men whom they employed lost their jobs. Most of them sought work in Colorado and Utah (Gonzalez 1969: 127).

1930s Some 300 farmers in the Albuquerque area erected a barricade in the North Valley to halt construction work by the Middle Rio Grande Conservancy District (Orona 1994).

1930s Crested wheat grass was introduced into New Mexico and adjacent mountain states by Agricultural Experiment Stations and the U.S. Forest Service (Rogler and Lorenz 1983: 91–92).

1930s (late) A levee system was constructed throughout much of the Middle Rio Grande by the Conservancy District (Bullard and Wells 1992: 47).

1939 (late) New Mexico Game and Fish personnel released the first of a reintroduced herd of Rocky Mountain bighorn sheep from British Columbia into the Sandia Mountains (Pickens 1980: 83).

1930s (late) The Game and Fish Department tested a limited bounty plan to supplement other predator control programs in Socorro, Catron, and Sierra Counties. Based on this test, the department estimated that 16,000 coyotes could be killed annually in the state by paid hunters (Mortensen 1983: 74).

1930s (late) (to 1941) The WPA constructed small retention and diversion dams in rural New Mexico communities to prevent flooding (Welsh 1987: 110).

1940	(January) The Upper Rio Grande Drainage Basin Committee held its first meeting. This group, made up of personnel from state and federal agencies, heard various parties discuss and protest against certain irrigation projects and possible loss of water rights to new development along the river (Vlasich 1980: 33).
1940	The U.S. Forest Service and the Grazing Service began to fence federal land in the Rio Puerco-of-the-East valley and traditional grazing lands on Mesa Prieta and the San Mateo Mountains, including Mount Taylor (Garcia 1992: 23).
1940	Most wild horses had been removed from rangelands except on Indian reservations and "waste lands outside of the grazing districts and fenced areas" (Wyman 1945: 173).
1940	The U.S. Bureau of Fisheries and the Biological Survey were transferred and consolidated into the Fish and Wildlife Service, Department of the Interior (Clark 1987: 268).
1940–41	The Soil Conservation Service sponsored projects to control erosion on Santa Ana Pueblo land by erecting fences and windbreaks (Bayer et al. 1994: 228).
1940	(ca.) Elk from Wyoming, Wichita Mountains National Wildlife Refuge in Oklahoma, and the Philmont Boy Scout Ranch were transplanted on Mount Taylor, in the Jemez Mountains, and in the Hopewell and Tres Piedras areas of the Carson National Forest (Barker 1976: 109–110).
1940	(ca.) The La Joya State Waterfowl Refuge was established (Barker 1976: 104).
1941	Spurred by the severe spring flood, Congress passed Senator Clinton P. Anderson's Flood Control Act. This legislation directed the Chief of Engineers to conduct a preliminary study of the Rio Grande basin above El Paso. This agency, along with the Bureau of Reclamation, was also directed to develop a joint-use plan for the Rio Grande near Albuquerque (Welsh 1987: 111).
1941	The Albuquerque District of the Corps of Engineers was established (Welsh 1987: 78–79).
1941	There were seven districts with almost 16 million acres under the administration of the Division of Grazing (Clark 1987: 255).
1941–43	Each family in the Rio Puerco-of-the-West was permitted to graze 15 head of sheep, in their grazing precinct, by the Soil Conservation Service. This number of livestock was considered below the minimum needed for subsistence (Forrest 1989: 159).
1940s	(early) State and national advisory boards, made up of ranchers, were established to assist in the management of grazing on these lands. Later, in 1961, these boards were expanded to represent wildlife, forestry, mineral development, soil conservation, and other resource interests (Clawson 1971: 150–151).
1943	(February) The Manhattan Project, Los Alamos, was established within the Jemez District, Santa Fe National Forest (Rothman 1992: 209–210).
1943	(April) The All-Pueblo Council met and generally declared opposition to the Flood Control Act of 1941, which was passed after the major flood of that year. They specifically opposed construction of proposed flood control dams at Otowi and San Felipe but supported flood control measures. They also spoke out against plans made for their lands without their input (Bayer et al. 1994: 242–243).
1944	Responding to growing criticism from western states relative to federal encroachment of their rights, Congress passed a declaration of policy recognizing "the interests and rights of the States in determining the development of the watersheds within their borders and likewise their interests and rights in water utilization and control" (Clark 1987: 260).
1945	The Smokey Bear fire prevention symbol was publicly presented by the Forest Service (Bergoffen 1976: 61).
1946	(July 16) The General Land Office merged with the U.S. Grazing Service to form the Bureau of Land Management. It was responsible for the management of various natural and cultural resources on public domain lands (Clark : 255; Utely and Mackintosh 1989: 29). The BLM established a regional office in Albuquerque, and it implemented a grazing fee of 8 cents per animal unit month (Clawson 1971: 38–39, 174).
1946	The Indian Claims Commission was created to hear and resolve Native American disputes with non-Indians over ownership of land. The Pueblos and other groups were able to recover significant amounts of land during the 32-year history of the commission (deBuys 1985: 311).
1940s	(mid) The Pueblos complained to Congress that the Middle Rio Grande Conservancy District had not provided adequate water or maintenance of ditches as promised. Many claimed they had lost crops as a result (Bayer et al. 1994: 243).

1946–53 The USFS and the BLM were "under attack" during this period by livestock growers. Although representing only a small minority of the population in New Mexico and other public-land states, livestock growers "had political influence at both national and state levels far beyond that which their numbers would indicate." "Fundamentally, they were hostile to federal ownership of any grazing lands and believed that these lands could best be developed under private ownership" (Clark 1987: 589).

1947 The Forest Pest Control Act placed a new emphasis on the control and management of forest insects and diseases (Baker et al. 1988: 59).

1947–58 An intensive program of study of sediments in the Rio Grande Basin was conducted by the U.S. Geological Survey (Hale et al. 1965: 6).

1948 (June 1–25) An inspection of the grazing allotments on the Santa Fe National Forest revealed that their condition was unsatisfactory (Baker et al. 1988: 102).

1948 Congress directed the Army Corps of Engineers and Bureau of Reclamation to prepare plans for district improvement. Subsequently, the Corps constructed river levees near Albuquerque, and the Bureau deepened river canals to drain water from agricultural lands. In the southern part of the valley, channel rectification was carried out as well (Sorensen and Linford 1967: 156–157).

1948 The Flood Control Act authorized construction of the Chamita Dam (later replaced by Abiquiu Dam) above Espanola and the Jemez Canyon Dam above Bernalillo. These dams were part of other works to control flooding and sedimentation of the Rio Grande. Pushed by the devastating May-June 1941 flood, the Corps of Engineers proposed reservoirs at Jemez Canyon and Chamita (Welsh 1987: 115, 166).

1948 Congress passed the Federal Water Pollution Control Act, the first such legislation for the United States (Clark 1987: 444).

1948–51 Research and field testing of methods to "artificially make rain" failed in northern and central New Mexico (Mortensen 1983: 40–41).

1949 State advisory boards for grazing districts and a National Advisory Board to the Interior Department on grazing were officially incorporated into the Federal Range Code for Grazing Districts (Mortensen 1983: 83).

1949 The Predatory Animal and Rodent Control issued instructions and safety precautions for use of 1080, a highly lethal rodenticide, in the control of rodents and predators. Especially effective against canids, it killed wild as well as domestic pets in large numbers. This controversial compound was banned by the Environmental Protection Agency in 1972 (Brown 1983: 103).

1949 An area of the Tres Piedras Ranger District, Carson National Forest, was reseeded with crested wheatgrass (Rowley 1985: preceeding p. 192).

1940s The number of livestock that one owner could graze on the national forests was limited. For the Santa Fe, 50 to 100 head of cattle per owner were permitted. These limitations were imposed because of heavy local demand. Also, attempts were made to reduce common use of forest ranges by constructing fences, developing more water, and reassigning individual allotments (Eastman and Gray 1987: 37).

1940s The New Mexico Cattle Growers' Association continued to lobby for transferring federal ownership of the public domain to the state. This organization's policy was supported by New Mexico's two U.S. senators and one of its representatives. In 1946 the state's Commissioner of Public Lands, John E. Miles, suggested that land commissioners, educators, and livestock raisers meet to develop strategy for acquiring the public domain. An Association of Western State Land Commissioners would procure legislative enactment for granting the states the public domain for support of schools and other public institutions. Their efforts were unsuccessful (Mortensen 1983: 85–86).

1940s–50s (late to 1950s) Grass reseeding and reforestation on national forest lands were commonly carried out by the Forest Service. As part of this program, juniper was removed from various areas and then reseeded with grasses (Baker et al. 1988: 63).

1950 (April 24) Congress passed a law authorizing advisory boards on grazing on national forests; members were to be primarily livestock raisers holding permits on a particular forest. Previously, advisory boards had no standing under the law (Mortensen 1983: 80–81).

1950 Congress enacted the Rio Grande Floodway as part of the Middle Rio Grande Project. Private and state levees and dams were targeted for reconstruction from Velarde to Elephant Butte (Welsh 1987: 166).

1950–52 The Jemez Canyon Dam was constructed above Bernalillo on the Jemez River to control flooding and sedimentation (Fergusson 1951: 360; Welsh 1987: 117–118).

1951 (March) Sagebrush was removed from 7,000 acres of overgrazed rangeland on Mesa Viejas and Canjilon Ranger District, Carson National Forest. Reseeding with crested wheatgrass followed (Rowley 1985: preceeding p. 192).

1951 The Bureau of Reclamation and Corps of Engineers began to install the first of 100,000 jetties along the Middle Rio Grande Valley (Bullard and Wells 1992: 50).

1952 (May) U.S. Senator Dennis Chavez of New Mexico convened hearings on grazing on the national forests in three locations in the state. A number of livestock raisers complained about the reduction of the number of head that they could graze under a permit and the closing of some areas to grazing (Mortensen 1983: 79). Grazing conditions had been deteriorating due to the ongoing drought and heavy stocking.

1950s (early) The BLM raised the grazing fee to 12 cents per animal-unit-month. This fee was based on current livestock market prices (Clawson 1971: 174).

1953 The Bureau of Reclamation began a channel modification of the Middle Rio Grande to maintain channel capacity for "safely passing high flows reducing water losses, while conveying water to downstream users, and moving sediments through the valley" (Crawford et al. 1993: 43–44).

1953 The New Mexico Legislature declared "that all underground waters of the State of New Mexico are public waters subject to appropriation for beneficial use within the State" (Erickson 1954: 81).

1953 Senators Clinton P. Anderson of New Mexico and Francis Case of South Dakota sponsored legislation to encourage experimentation in "rainmaking" and created the Advisory Committee on Weather Control (Clark 1987: 413–414).

1954 The Flood Control Act included authorization of two diversion canals that would carry summer rain runoff from the west slopes of the Sandia Mountains (Welsh 1987: 167).

1954 The U.S. Government outlawed the indiscriminate use of poison to kill predators of livestock. Sheep ranchers turned to use of the "coyote getta," a cyanide gun stuck in the ground. Some ranchers also controlled predators by shooting from airplanes (Moyer 1979: 71).

1955 State legislation authorized change of the title of "warden" to "conservation officer" and authorized the director of Game and Fish "to appoint properly qualified persons as nonsalaried reserve conservation officers empowered to enforce the regulation of the State Game Commission and perform such other duties with respect to wildlife management and conservation education as he might assign" (Clark 1987: 370).

1955 (late) The New Mexico Land Resources Association was formed by private citizens. It was made up of farmers, ranchers, prominent businessmen, educators, and lawyers. Their main objectives were to research and address resource use, or income from that use, and the disposition of federal and state lands. Their study, which lasted 3 years "provided an extensive look at the State's land and water resources and analyzed the ways in which they were being utilized." The members were "particularly struck ... by the rising dominance on the part of the Federal Government" (Mortensen 1983: 86).

1956 (March) The Sandia Conservancy District, petitioned for by a group of landowners, was created to control flash flood waters originated along the west face of the Sandia Mountains (Clark 1987: 355).

1956 The Soil Bank Act encouraged farmers to withdraw land from production under acreage reserve and conservation programs (Clark 1987: 302).

1956 The Bureau of Indian Affairs returned grazing control to the Navajo. Stocking steadily increased, causing severe overgrazing of rangelands by the mid 1980s (Eastman and Gray 1987: 106–107).

1956 The National Park Service submitted its "Mission 66" program to Congress, requesting a substantial increase in funds to construct and maintain new facilities, as well as old, to meet the rapidly increasing visitation to national parks and monuments (Udall 1962: 32–33).

1957 A bill to establish federal wildernesses was submitted to Congress. Over the next 7 years a powerful coalition of grazing, logging, mining, and motorized recreation interests lobbied tenaciously against the bill, causing it to be rejected some 65 times (deBuys 1985: 287).

1958 The levee-riverside drains in the Albuquerque area were reconstructed by the U.S. Army Corps of Engineers. Operation and maintenance of the system were transferred to the

Middle Rio Grande Conservancy District (Bullard and Wells 1992: 47).

1959 The channelization project on the Rio Grande at San Marcial was completed (Jenkins and Schroeder 1974: 77).

1959–60 Cochiti Pueblo lost their claim to the La Bajada land grant. The Pueblo also asked the Corps of Engineers to change the location of the proposed Cochiti dam and reservoir, but the Corps refused (Welsh 1987: 145–146).

1959 The State Legislature created the Rio Grande Gorge State Park. Eleven years later, 48 miles, including the 7-mile-long park, were designated the Rio Grande Wild and Scenic River (Young 1984: 108).

1959–63 Heron Dam was constructed by the Corps of Engineers on the Chama River near Tierra Amarilla (Welsh 1987: 133–134).

1950s To combat forest damage caused by the spruce bud worm, pine and fir engravers, and pine bark beetles, spraying with insecticides such as DDT was initiated. Selective cutting of infested trees was also employed, but on a much reduced scale compared with the 1930s, when so many unemployed men were available for low wages due to the Depression (Baker et al. 1988: 62).

1950s Recreational use of the national forests increased sharply. Among these uses were hunting, fishing, skiing, and hiking (Baker et al. 1988: 60).

1950s The Bureau of Land Management was criticized for primarily focusing on leasing public lands to livestock raisers and overlooking other public values and uses for these lands. A special concern of some groups was the protection of watersheds and "marginal lands" from overgrazing (Clark 1987: 590).

1960 The Flood Control Act directed the Corps of Engineers to construct the Galisteo Dam, 12 miles upstream from the confluence of Galisteo Creek and the Rio Grande. It was not completed until 10 years later (Welsh 1987: 149, 152, 155–156).

1960 Per capita water consumption in New Mexico was about 160 gallons per day per person (Hale et al. 1965: 51).

1960 The enactment of the Multiple Use-Sustained Yield Act authorized and "directed the Secretary of Agriculture to develop and administer the renewable resources of the national forests, including outdoor recreation, watershed, range, timber, and wildlife and fish resources, in such a way that they would be available in perpetuity. It meant that no one demand should take precedence over another" (Baker et al. 1988: 65).

1961 (February) President Kennedy delivered a "natural resources message" advising Congress "that he had directed the secretary of the interior [sic] to launch a three-pronged offensive against public land abuse." This included making an "inventory and evaluation of unreserved public lands," developing a "balanced use program," and developing an "accelerated soil and water conservation program including rehabilitation of depleted rangelands" (Clark 1987: 590–591).

1962 (April 2) The Bureau of Outdoor Recreation was established within the Interior Department. This agency was responsible for coordination of related federal programs, assistance in state recreational planning, administration of a grants-in-aid program, sponsorship of research, and formulation of a nationwide recreation plan based on state, regional, and federal plans (Udall 1962: 40).

1962 The Bureau of Reclamation was authorized by congressional act to construct the San Juan-Chama Transmountain Diversion Project. About 110,000 acre-feet of water were diverted from the upper tributaries of the San Juan River, across the continental divide, and into the Rio Grande drainage (Bullard and Wells 1992: 20). The All-Indian Pueblo Council and interested individuals strongly supported the San Juan Chama Project (Clark 1987: 653).

1962 In his conservation message to Congress, President John F. Kennedy said "Conservation . . . can be defined as the wise use of our natural environment: it is, in the final analysis, the highest form of national thrift—the prevention of waste and despoilment while preserving, improving and renewing the quality and usefulness of all our resources" (Udall 1963: 173).

1962 Rachel Carson's *Silent Spring*, documenting the adverse effects of DDT and other pesticides on wildlife, was published (Utely and Mackintosh 1989: 30).

1963 Abiquiu Dam on the Rio Chama was completed (Welsh 1987: 134).

1963 The Albuquerque Metropolitan Arroyo Flood Control Authority was created to study and alleviate "the problem of urban flooding from unregulated, ephemeral tributaries" of the Rio Grande (Bullard and Wells 1992: 22).

1963 The Clean Air Act was passed by Congress and amended in 1965 and 1966. Ambient air quality standards affecting auto, industrial, and other air-polluting sources were to be established by the EPA (Clark 1987: 451–452).

1963 Secretary of the Interior Stewart Udall convened a panel of experts, headed by A. Starker Leopold of the University of California, to examine the Federal Government's animal damage control program. This group, in their "Leopold Report," asserted that the government should be responsible for the husbandry of every animal species and that current control was too excessive (Mortensen 1983: 75).

1963 Over 6,300 coyotes were trapped or poisoned by federal and state personnel without causing a noticeable decrease in the overall population (Findley et al. 1975: 281–282).

1963–69 The first major confrontation between the Forest Service and environmental groups in the region was over a proposed highway from Las Vegas to Pecos Canyon in the Santa Fe National Forest. The Upper Pecos Association and the New Mexico Conservation Coordinating Council opposed the road, and the former brought suit in federal court. Subsequently, the Forest Service abandoned the proposed project (Baker et al. 1988: 71).

1964 The Water Resources Research Act of 1964 was directed at supplementing, rather than duplicating ongoing research, with special emphasis on state problems that had only a small chance of being funded. A Water Resources Research Institute was established in New Mexico, partially with funding authorized by this act (Clark 1987: 380–381).

1964 Under the direction of Wayne Aspinall of Colorado, Congress created the Public Land Law Review Commission to examine existing public land statutes and regulations and the policies and practices of the administering agencies. Based on its study, 137 recommendations for modification in public land management and disposition were made. Major ones included a proposed study be made as "to which public lands would serve the public good better by being transferred to state, local, or private ownership." Another significant recommendation was that local advisory boards should have more input into federal planning. This and a number of other recommendations were later part of 1976 legislation (Clark 1987: 575).

1964 Congress passed the Land Classification and Multiple Use Act, which directed the Secretary of Interior "to develop criteria for determining which BLM lands should be classified for disposal and which should remain in federal ownership." These lands would also be "managed for the protection of public values" (Clark 1987: 591).

1964 With the leadership of Senator Clinton P. Anderson, Congress passed the Wilderness Act. The Forest Service subsequently began studies of their lands to determine suitability for classification as wilderness (Baker et al. 1988: 70).

1964 The 41,132-acre San Pedro Parks Wilderness Area was designated in the Santa Fe National Forest (Rothman 1992: 271).

1964 The Pecos Wilderness, some 167,416 acres, was created in the Santa Fe and Carson National Forests (Rothman 1992: 271).

1964 There were 1,562,600 recreational visits to the Cibola National Forest (Baker et al. 1988: 134).

1964 The Pecos Wilderness Area, including Pecos Baldy and Truchas Peaks, was restocked with Rocky Mountain bighorn sheep (deBuys 1985: 288).

1964–74 The Wheeler Peak, San Pedro Parks, and Bosque del Apache national wildernesses were established (McDonald 1985: 6).

1965 The Water Resources Planning Act created a National Water Commission to work with the National Resources Council, public and private agencies "in isolating major problems and suggesting alternative solutions which would assure an ample supply of clean water for the future." A final report, *Water Policies for the Future*, was produced, with emphasis on the economics of water (Clark 1987: 378–380).

1965 The legislature declared that "the State of New Mexico claims the right to all moisture in the atmosphere which would fall so as to become a part of the natural streams or percolated water of New Mexico, for use in accordance with its laws." The Weather Control and Cloud Modification Commission was also created "to oversee attempts to alter natural weather conditions" (Clark 1987: 373).

1965–66 The State Planning Office and the State Engineer Office carried out an in-depth report and inventory of the state's water resources (Clark 1987: 374).

1960s (mid) The government based grazing fees on public lands on a year-by-year assessment of the economic value of the land in question (Mortensen 1983: 78).

1966 The Bureau of Land Management and the Forest Service raised grazing fees to levels more in line with fees paid for grazing private lands. The BLM fee was set at 33 cents per animal unit month, and the Forest Service fees ranged from 21 cents to $1.81 (Clawson 1971: 175).

1966 Congress passed the National Historic Preservation Act establishing the National Register program of sites, properties, districts, buildings, and objects significant in American history, architecture, archeology, and culture. Matching funds were to be made available to help acquire and preserve these sites and artifacts and to conduct statewide surveys for identifying sites and properties to be placed on the National Register. Furthermore, the act provided some protection for sites on the register that might be adversely affected by any federally permitted or funded project (McGimsey n.d.: 16–17).

1966–67 (late to 1968) Members of the *Alianza Federal de los Pueblos Libres*, organized and led by Reies Tijerina, attempted to reclaim the San Joaquin del Rio de Chama land grant, which had become part of the national forest near Tierra Amarilla. Violence broke out, and the now infamous raid on the courthouse at this community received national news coverage. Tijerina and some of his followers were convicted and served jail sentences for assaulting government employees and destroying government property (Baker et al. 1988: 72–73).

1966, 1969 Congress passed Endangered Species Acts, policy directives to federal agencies to protect these species largely through listing. These acts contained little regulatory power (Beatley 1994: 13; Borland 1975: 152).

1960s (mid to 1971) The Forest Service proposal to construct a scenic roadway from Placitas to Sandia Crest was dropped due to opposition from several environmental organizations and local residents (McDonald 1985: 12–13).

1968 Congress passed the National Wild and Scenic River Act, which provided for the environmental protection of rivers in a "free-flowing, natural state." One section of a regional river, the Upper Rio Grande between the Colorado state line and near Taos, was subsequently designated a wild and scenic river (Baker et al. 1988: 72).

1969 The National Environmental Policy Act, requiring the study and assessment of all activities that will impact the environment on federal lands or projects, was passed by Congress (Baker et al. 1988: 34). The act mandated that all federal agencies incorporate the ecological consequences of their projects into their development plans and, where feasible, suggest alternatives. Environmental Impact Statements were required for all federal projects (Welsh 1987: 201–202). The act also established the Council on Environmental Quality in the Executive Office of the President. This group consisted of three appointees, who were to gather, interpret, and analyze data relative to environmental quality, to evaluate federal programs and activities in relation to national policy, and to advise and recommend to the President regarding CEQ responsibilities (Clark 1987: 450–451).

1969 The fee for BLM grazing districts was raised to 44 cents per animal-unit-month (Clawson 1971: 175).

1960s The riverside diversions at Corrales and Atrisco were replaced by inverted siphons which ran under the river from riverside drains, converting them into seasonal water conveyance channels (Kernodle et al. 1995: 19).

1960s DDT continued to be used by the Forest Service to control insect infestations. This use continued into the next decade until DDT was banned, except for public health emergencies, on January 1, 1973. In 1966 malathion was introduced as a pesticide (Baker et al. 1988: 62).

1970 (April 22) The first Earth Day was held in the United States (Borland 1975: 174). Some 20 million citizens participated, organizing marches, workshops, and political speeches (Pirages and Ehrlich 1974: 37–38).

1970 (December 15) President Richard M. Nixon also signed a bill placing 48,000 acres of Carson National Forest, including their sacred Blue Lake, in trust for the sole use of Taos Pueblo (Keegan 1991: 50).

1970 The Environmental Quality Improvement Act was to provide for an upgrading of environmental quality through mandating that federal departments and agencies conducting or supporting public work projects should implement environmental protection policies. Also, to provide aid and support for the recently created Council on Environmental Quality, the Office of Environmental Quality in the Executive Office of the President was established under this act (Clark 1987: 450).

1970 Congress passed the Clean Air Act, the first serious attempt by the Federal Government to improve the quality of air, although acts were enacted in 1963, 1965, and 1966. Ambient air quality standards affecting auto, industrial, and other air-polluting sources were to be established and enforced by the EPA.

These standards were to be sufficient to protect the public health and welfare of the Nation (Harrington and Abbey 1981: 1–2).

1970 President Richard M. Nixon established the Environmental Protection Agency (Borland 1975: 174). The EPA's basic mission was to restore and maintain a healthy national environment (Clark 1987: 452).

1970 The Rio Grande Wild and Scenic River was formally dedicated (Young 1984: 108).

1971 The Wild Horse and Burro Act, which complicated the management of these two animals on BLM and U.S. Forest Service lands, was passed. Both species increased on most areas, and burros moved into Bandelier National Monument. Partly due to their intensive grazing, soil erosion on the monument increased to an estimated 36 tons per year. Despite public protests, virtually all of these animals were shot or removed by late 1983 (Rothman 1992: 280–283).

1971 Another panel of wildlife experts, headed by former Assistant Secretary of the Interior Stanley A. Cain, "recommended that all existing toxic chemicals be removed from registration and use for Federal predator control operations" (Mortensen 1983: 75).

1972 (February 8) President Nixon issued an Executive Order banning "the field use of any chemical toxicant for the purpose of killing a predatory mammal or bird" or "which causes any secondary poisoning on all Federal lands and in any Federal program" (Mortensen 1983: 75).

1972 (March) The Corps of Engineers completed construction of the north and south flood diversion channels in the Albuquerque District (Welsh 1987: 172).

1972 Congress enacted the Federal Water Pollution Control Act, which extended the regulatory responsibility of the Army Corps of Engineers. This act upheld the provision of the 1899 Refuse Act, mandating the Corps to regulate the sources of effluents going into the nation's navigable streams. Any organization or individual who planned to alter streamflow in any way had to apply to the agency for a permit (Welsh 1987: 202).

1972 The Forest Service issued *The Nation's Range Resources*, which reported that much of western rangelands, both public and private, were in a "deteriorating condition" (Rowley 1985: 238).

1972 The state advisory boards for grazing districts and the national advisory board to the Interior Department were abolished by federal act but were reinstated under the Federal Land Policy and Management Act of 1976 (Mortensen 1983: 83).

1972 The volume of timber cut for commercial sales in the national forests of New Mexico peaked at 141,141,000 board-feet (Baker et al. 1988: 84).

1972 The Sevilleta National Wildlife Refuge was established in Socorro County. Subsequently, the refuge was designated a Long Term Ecological Research Area (Grover and Musick 1989: 1–3).

1973 (November 12) With completion of Cochiti Dam by the Corps of Engineers, the reservoir began to fill. Subsequently, downstream farmers at Cochiti Pueblo and Pena Blanca complained that rises in the groundwater table of up to 8 feet were resulting in deposition of harmful salt on their agricultural lands (Welsh 1987: 158–159).

1973 Congress passed a new Endangered Species Act. This legislation "substantially expanded the powers of the federal government in this area" and placed "major and significant restrictions on government agencies and private citizens regarding listed species." Regulatory provisions included identifying and listing endangered species, consulting with the USFWS about projects that would adversely affect a species, prohibiting the "taking" of a species, and preparing recovery plans for each listed species. The law was amended in 1982 to permit the incidental taking of a listed species where an acceptable habitat conservation plan ensuring the survival and recovery of the species was prepared. The ESA has been reauthorized by Congress three times (Beatley 1994: 13–22).

1974 Congress passed the Forest and Rangeland Renewable Resources Planning Act, amended by the National Forest Management Act of 1976, which together provided that the USFS, in cooperation with state, local, and other federal agencies, inventory and analyze the renewable resources on national forest lands relative to anticipated uses, supplies, demands, and relevant agency policies and programs. A plan, based on these studies, was to be prepared and updated every 5 years (Clark 1987: 579).

1974 The State Legislature passed the Wildlife Conservation Act, giving jurisdiction to the New Mexico Department and Commission of Game and Fish over all native, nondomestic vertebrate species and crustaceans and mollusks. Animals identified as endangered were to be listed and protected by the agency (Hubbard et al. ca. 1988: 1).

1975 The Indian Self-Determination and Education Assistance Act, while reaffirming the Federal Government's trust responsibilities to Native Americans, deplored its domination of Indian programs. At the same time, Congress issued a joint resolution for the establishment of the American Indian Policy Review Commission, which would in part investigate the policies and practices of federal agencies responsible for protecting Indian resources. Their final report, sympathetic to the Indian position, was not favorably accepted because of a number of political events, which generated an anti-Native American backlash (Clark 1987: 622–623).

1976 The Federal Land Policy and Management Act, passed by Congress and including a number of recommendations made by the Public Land Law Review Commission 12 years earlier, had as a primary purpose to update and bring together in a single statute the laws governing management of BLM, and to a more limited extent, USFS lands. Moreover, the Secretary of the Interior was directed "to develop a comprehensive land-use plan incorporating multiple-purpose and sustained-yield principles based on a continuing inventory of the lands and their resources." This act also included a section mandating a 15-year review of potential wilderness areas on lands administered by the Bureau of Land Management (Clark 1987: 575; McDonald 1985: 8).

1976 The 22,000-acre Bandelier Wilderness area was created (Kutz 1989: 9).

1970s (mid to late) The Forest Service was involved in extensive watershed management programs for their improvement, restoration, or preservation. As part of these projects the agency was determining grazing quotas, timber harvests, and the extent of other uses that potentially could impact these ecosystems. An example of such a watershed is the Bernalillo Watershed Project in Cibola National Forest. This effort, including construction of check-dams and restoration of vegetative cover, has controlled the periodic flooding of the Bernalillo community by intensive runoff from the northwestern portion of the Sandia Mountains (Clark 1987: 577).

1978 (February 24) Congress passed the Endangered American Wilderness Act, which included establishment of the North Sandia Peak and South Sandia Peak wildernesses, the Manzano Mountains Wilderness, and the Chama River Basin Wilderness (McDonald 1985: 15).

1970s The Bureau of Reclamation carried out "a rectification project to clear and maintain a relatively linear floodway . . . to more efficiently convey water to Elephant Butte and to pass floodwater" rapidly through the system "with minimal water loss and damage to the river channel and floodplain" (Bullard and Wells 1992: 47).

1980 The Cochiti Pueblo Council filed suit against the Corps of Engineers, Albuquerque District, for causing the "waterlogging" of 320 acres of traditional Cochiti farmland below the Cochiti Dam, which the Corps had constructed in 1967–73 (Welsh 1987: 162).

1980–84 Three wilderness areas—Cruces Basin, Latir Park, and Wheeler Peak—were created in the Carson National Forest. Total acreage was 57,663. Four other wilderness areas, totalling 138,286 acres, were also created in the Cibola National Forest. The Chama River Canyon Wilderness, totalling 50,300 acres, was created in the Santa Fe / Carson National Forests (Baker et al. 1988: 140).

1981 The Salinas National Monument, including Gran Quivira National Monument, Abo State Park, and Quarai State Park, was established (Chilton et al. 1984: 437).

1982 (August) The Rio Bravo State Park, located in Albuquerque's south valley, was dedicated (Young 1984: 106).

CHAPTER 7

SUMMARY, CONCLUSIONS, AND CONSIDERATIONS

SUMMARY

This study of the environmental history of the Middle Rio Grande Basin, which began in June 1994, is part of a 5-year, multidisciplinary study under the auspices of the USFS Rocky Mountain Forest and Range Experiment Station, Albuquerque. The goal of the parent study is

> [t]o develop, synthesize, and apply new knowledge to aid in understanding processes, interactions, and sociocultural uses of upland and riparian ecological systems for sustaining diverse, productive, and healthy plant, animal, and human populations and associated natural resources in the Rio Grande Basin (Finch and Tainter 1995: 1).

This larger, ongoing study is based on the primary thesis that all ecosystems are anthropogenic to some extent and cannot be understood without examining the role of human groups as components of and agents of impact on the environment. Environmental history not only embraces this view but also the belief that interrelated "natural" and human-induced impacts and changes in ecosystem components can result in modified or abandoned strategies of resource exploitation and even a shift in "world view."

Within the parent study, four research areas or problems were defined, one being the need for an in-depth study of the environmental history of the Middle Rio Grande Basin, so as to better understand the interrelationships of human populations and their environment. The following spatial and temporal interrelationships were emphasized: (1) the role of various eco-cultures in adapting to and exploiting Basin ecosystems and associated resources, (2) the kind and extent of anthropogenic disturbances, (3) human responses to environmental changes, and (4) the sustainability of traditional activities of various groups in the Middle Basin.

Based on extant knowledge and preliminary research, four spatial and temporal models of environmental change in the Middle Valley ecosystems were developed for testing (Scurlock 1995a: 20). In general, these models were relatively accurate; however, a few modifications and revisions were made and are presented in the Conclusions section (pp. 389–390).

Environmental History

For more than 450 years the ecosystems of the Middle Rio Grande Basin have evolved dynamically with the interrelated vagaries of climate, land forms, soils, fauna, flora, and most importantly, human activities. Various land use practices have caused an array of environmental problems. Activities such as grazing, irrigation farming, logging, and constructing flood control features, combined with climatic fluctuations, have produced changes in stream flow-morphology, groundwater levels, topsoils, biotic communities, and individual species. Indigenous human populations have, in turn, been impacted by modifications in these resources. These processes, impacts, and changes were discussed in Chapters 3–5. A summary of this eco-cultural history is presented here.

Droughts, floods, severe cold, and deep snow influenced or directly impacted many activities, notably travel, agriculture, livestock raising, warfare, hunting, and gathering during the historic period (A.D. 1540-present). Occurring locally or regionally, droughts damaged or destroyed crops and rangeland grasses, decimated wildlife populations, contributed to soil erosion, reduced stream flows, depleted water supplies, and contributed to the occurrence of infectious diseases such as smallpox. These impacts sometimes resulted in widespread suffering, and even loss of human life and the shifting of human populations. Historical documentation from the mid 17th century to the late 19th century substantiates more recent detailed weather records, which indicate the occurrence of a moderate to major drought in the region every 20 to 22 years. These periodic droughts, increasing use of surface and ground waters, and intensive grazing have generally resulted in dramatic changes in the flora.

The various effects of extended cold winters, or shorter periods of below-normal temperatures associated with high winds and snow (blizzards) and above-normal snowfalls, were also significant. Events such as these commonly occurred during the "Little Ice Age," which gripped New Mexico from about the mid 16th to mid 19th centuries. Adverse effects of this cold period included human fatalities, crop and livestock losses, and general unrest and suffering. The warming period and relatively frequent droughts that followed, especially from the 1860s to the 1950s, adversely impacted ranching and farming economics as well, and human population shifts and trends.

Wildfires caused by lightning were a common phenomenon during the period of greatest lightning-strike frequency, July to September. The highest occurrence of these natural fires appears to be correlated with La Nina, or dry, years. Native Americans used fire as one method of clearing the bosque for cultivation. Only in this century have naturally caused woodland or range fires on the adjacent grasslands been suppressed in the Middle Rio Grande Basin. In the late prehistoric and historic periods Native Americans burned grasslands and woodlands to drive game animals to a location where they might be more easily killed, as well as to stimulate new plant growth. Hispanics used fire to create meadowlike conditions in upland forests and to generate healthy grass growth on rangeland.

Range fires usually killed small woody species, whereas grass regeneration was stimulated. Removal of dense stands of dry grasses by overgrazing also reduced available fuel for range fires and decreased competition from grasses, allowing propagation and growth of woody plants. Woody shrubs and small tree species such as fourwing saltbush, juniper, and pinyon have encroached on semi-desert grasslands adjacent to the valley as a result of fire suppression.

Human-generated impacts have generally and ever-increasingly altered the structure, function, and dynamics of Basin ecosystems during the historic period. Some activities, such as grazing and logging, have reduced vegetative cover, and combined with periodic droughts and fires, have resulted in high rates of surface run-off due to precipitation and associated erosion. Sediments from these events have, generally, increased through time, and the resulting impacts on riparian plant and animal communities have been, in cases such as the Middle Rio Grande Valley and major tributaries such as the Rio Puerco, severe. Other human impacts, such as the introduction of exotic species of plants and animals, use of various toxins, diversion of water for irrigation, and construction of water control dams, have also brought dramatic changes to riparian ecosystems. Additional impacts on riparian communities, as well as on upland ecosystems—grasslands, pinyon-juniper and ponderosa woodlands and montane mixed-conifer forests—are noted in the following overview.

Adverse impacts on all of the Middle Rio Grande Basin Pueblos began with arrival of the first Spanish explorers in 1540. Hostilities against the Pueblos by these Europeans included war, rape, seizure of goods, burning of villages, and sometimes involuntary use of individuals as guides or servants. Spanish colonization, which began in 1598, centered on the main pueblos along the Rio Grande from Taos to Isleta, as well as the village of Acoma. Missions were established, farmland appropriated, and many Pueblo Indians were pressed into service for Spanish government officials, encomenderos, and missionaries.

Early Spanish contact with the Navajo and Apache in the study region soon erupted into a pattern of alternating periods of peace and warfare. Their acquisition of the horse from the Spanish made these two groups, as well as the Southern Ute and the later-arriving Comanche, more mobile raiders and more successful hunters. Hides from bison, mule deer, pronghorn, and elk were obtained from these Indians by Spaniards through trade, including the trade fairs held at Taos, Picuris, Pecos, and Abiquiu during the colonial period. Captive Indians, usually boys or girls, were obtained in trade to work for governors in their workshops weaving woolen goods or tanning hides. Girls were also used for various work in Spanish homes, where they were adopted.

In the late 16th century to early 17th centuries, the Spanish brought with them new technologies and a number of new domesticated plants and animals, which had a decisive impact on Pueblo, Navajo, and Apache diets and the landscape. Introduced livestock included sheep, goats, horses, mules, burros, oxen, cattle, hogs, and chickens. Introduction of metal tools such as the axe, which made cutting green wood easier and faster, as well as iron-tipped plows and various metal weapons, had a significant adverse impact on surface water, fauna, flora, and soils. New cultigens included wheat, barley, cabbage, onion, lettuce, radish, cantaloupe, watermelon, and several species of fruit trees, as well as native Mexican Indian crops such as chile, cultivated tobacco, tomato, and new varieties of corn and beans. Some introduced non-cultigens, such as alferillo and horehound, became established in fields and other disturbed areas.

Hispano settlement patterns and land-water use, especially irrigation, generally were successful adaptations to local ecosystems. Similar to Pueblo view and usage, Spanish colonial water law evolved to protect the communal interest rather than that of the individual.

The relatively sharp increase in livestock numbers, especially sheep, during this period was due to the growth in mining markets to the south in Mexico (and later California). This intensive and widespread grazing resulted in loss of vegetative cover and subsequent erosion in various locales. Grass shortages on Spanish land grants led, in part, to encroachment of Mexican flocks and herds on Pueblo crop and range lands, additional erosion of hillsides, and the siltation of river and stream beds and irrigation facilities.

Limited mining in the colonial period by Spaniards and Pueblos impacted local ecosystems. Perhaps the best known of these locales are the turquoise and lead mines in the Cerrillos area, Tonque drainage, and the north end of the Sandia Mountains. Pinyon, juniper, and oak were cut for "smelting" fuelwood, mining timbers, and structures. Some local water pollution was generated by these mining activities as well. Around gold, silver, and copper mines in the Ortiz, Sandia, and Jemez mountains, the land was denuded of trees by wood cutters, who used them to make support timbers and charcoal for the mines.

The impact of introduced European diseases such as smallpox on Native Americans has been relatively well documented in New Mexico; more Indians died of epidemics in the colonial period than of any other single cause. These serious maladies contributed significantly to unrest in the province, some of which resulted in several 1600s Pueblo revolts and increased raiding by nomadic Indian groups. These raids were interrelated with severe, extended drought conditions in the 1640s, 1660s, and 1770s to early 1780s and produced the most catastrophic periods of conflict and war in the colonial period.

During the Mexican period (1821–46), some of the effects of settlement and land use on the natural environment were recorded by government and ecclesiastical officials. Overgrazing around old settlements and nearby valley and upland rangelands, begun in the colonial period, intensified as flocks of sheep and other livestock increased. Some of the choice grazing areas in the region were cienegas and other wetlands, which were heavily impacted by livestock during this period. Livestock trails turned into linear arroyos, and silt-laden runoff increased.

The arrival of relatively large numbers of Anglo-American military personnel, ranchers, and settlers, beginning in 1846, had the most significant impact on New Mexico's environment. Although these groups did not introduce a large number of new domesticated plants and animals, their view of resources as commodities and implementation of more intensive land use patterns, coupled with new tools and weapons, increasingly contributed to the ongoing erosion of hillsides and siltation of river beds, the extermination or reduction of several animal species, and the decimation and fragmentation of plant communities.

Intensified irrigation farming—Anglo, Hispano, and Pueblo—impacted stream hydrology and increased salinization and water-logging of soils in the Middle Rio Grande Basin in the late 19th and early 20th centuries. Increased sediment loads in the river and its tributaries caused the streambed of the Rio Grande to aggrade, enhancing the effects of overbank flooding and bringing the water table near or to the surface of the floodplain. This resulted in the loss of thousands of acres of agricultural land by the early statehood period and was a factor leading to the creation of the Middle Rio Grande Conservancy District in 1926. The drainage systems, dams and reservoirs that followed produced a new set of environmental problems, such as a rapid drop in shallow ground waters, desertification of portions of floodplains, irregular stream flows, and diminution of native bosques, all of which have only recently begun to be addressed.

The rapid growth of the range cattle industry in New Mexico after the Civil War led to increased grazing of grasslands and contributed to the flooding specified above. Overgrazing occurred along streams, at wetland sites, and at windmill tanks. Anglo ranchers, unlike Native and Hispano Americans, also suppressed range fires, which combined with overgrazing, caused native plant species such as broomweed, cholla, prickly pear cactus, sagebrush, and less desirable grasses to spread and increase on pristine grasslands. The exotic Russian thistle and several introduced grasses also proliferated. Consequently, the carrying capacity of New Mexico's rangelands was reduced significantly during this period.

Military forts, mining camps, and railroad construction crews made heavy use of natural resources such as trees for building and fuel supplies, native grasses for hay, and local game for food and sport. Major stream pollution occurred at many mining sites, killing associated fauna and flora and poisoning water supplies. Many of these mining sites were abandoned, leaving open pits and shafts and toxic spoil deposits. Air quality was also negatively impacted by the railroad and mine smelters, and these technologies were the first serious sources of noise pollution in the territorial period.

Early sawmills in or near such settlements as Santa Fe, Taos, and Albuquerque resulted in the first extensive clearcutting of forests. As a result, soil erosion was accelerated at these locales, and habitat loss contributed to the reduction of game populations. The severity of floods increased, with associated impacts on settlements, agriculture, and ranching.

Railroads were influenced by and in turn affected environmental components in several adverse ways. Topography, in particular the requirement for low grades, and the need for water for steam engines every 10 miles played a significant role in the choice of route. Rail routes generally followed stream valleys, causing damage to riparian communities and polluting streams. Train engines were often the cause of range or forest fires (ignited by ashes and sparks) and other environmental change. Railroad construction also impacted forests (mainly for ties and locomotive fuel) and streams (siltation from exposed soils).

Loss of Spanish grant land in the Upper and Middle basins in the late 19th and early 20th centuries occurred due to imposition of a legal system based on precise measurement of boundaries, and due to language differences, unscrupulous lawyers, coercion, and fraud. Some portions of grants were included in creation of the forest reserves beginning in the late 1800s. There were protests by Hispanics against "land grabs," as well as loss of water rights. The Gorras Blancas were formed in the late 19th century in San Miguel County to protest and take action against rico Hispanos and Anglos who were fencing large sections of the traditional common lands. Members of the "white caps" cut fences and telegraph wires and burned houses, barns, railroad bridges, and sawmills. These actions temporarily brought a halt to development on these contested lands.

Nonviolent and armed protests were made by Hispano farmers and ranchers against projects undertaken by the Middle Rio Grande Conservancy District in the late 1920s and 1930s. They were afraid that district programs would irreparably damage or destroy their traditional irrigation systems and associated ditch organizations. In the late 1930s some 8,000 Hispanics lost title to their farm and ranch lands because they could not pay taxes and assessments imposed by the district. In all, 2 million acres of private land and 1.7 million acres of communal land were lost.

Wage labor for Hispanics virtually disappeared during the depression years of the 1930s. Owing to degraded environmental conditions, which had declined over the previous 100 years, the land could no longer support most residents in rural areas.

Animal populations were subjected to additional pressures as commercial hunters harvested meat animals to feed railroad and road construction crews, miners, and at times, military personnel. During the late 19th and early 20th centuries, commercial hunters, along with subsistence and "sport" hunters, sharply reduced or exterminated populations of native game animals such as pronghorn, elk, bighorn sheep, and Rio Grande turkey. This overharvesting was due to the lack of regulatory game laws, more efficient firearms and ammunition, an increasing number of hunters, and a philosophy that there would always be wild animals to hunt. In response, the New Mexico Game and Fish Department was created by the Territorial Assembly in 1904; State and federal regulatory laws were passed subsequently. From this time through the 1930s this agency, the U.S. Forest Service, the U.S. Biological Survey (later the U.S. Fish and Wildlife Service), farmers, ranchers, and the general hunter population also killed large numbers of predators, notably the grizzly bear, gray wolf, Mexican wolf, coyote, and mountain lion. By the 1930s the grizzly bear and the gray wolf were eradicated in the region; a few Mexican wolves survived in extreme southwestern New Mexico until the 1960s. Mountain lion populations were decimated.

At least 50% of the fish species were exterminated in the Middle Rio Grande drainage between the 1870s and recent years. Competition with introduced exotic species, loss of habitat, and water pollution were the primary causes of this eradication.

A number of exotic plant and animal species were introduced and naturalized during the historic period, and some became ecological-economical problems by the early 1900s. These species were either inadvertently or purposely introduced. Some of the introduced animals included the Norway rat, house mouse, burros, horses, and several species of amphibians and fish. The most aggressive introduced plants that have caused severe ecological and economic impacts are tamarisk, Russian olive, Russian thistle (tumbleweed), and Siberian elm.

Responding to the virtually unregulated, widespread, and careless resource exploitation of the late 19th and early 20th centuries, private citizens and government officials began to speak out, address, and plan for conservation policy and legislation at the national and local levels. Their concern was partly based on the scientific work of soldier collectors, naturalists, geologists, paleontologists, botanists, and zoologists. These activists were also influenced by early map makers and photographers, whose work reflected the rich variety of the New Mexico landscape, associated resources, and indigenous peoples.

The earliest conservation agencies and programs were created in Washington, D.C., for example, the Department of the Interior in 1849 and the Bureau of Forestry within the Department of Agriculture in 1862. Laws to protect traditional use of water for irrigation and reserve springs and salt lakes were passed by the New Mexico Territorial Assembly in 1851. Laws to protect wildlife followed later in the century.

From 1878 through 1885 federal laws were passed creating the Public Lands Commission, U.S. Geological Survey, and Bureau of Biological Survey in the Agriculture Department. The USGS began gathering data on surface flow of springs and potential dam sites.

In 1891 Congress empowered the President to create forest reserves on public lands of the states and territories. Within a month some 15 reserves totalling 13 million acres were set aside under the administration of the Department of the Interior. The first national forest in New Mexico, the Pecos Reserve, was established the following year. Later, these forests were transferred to the administration of the Department of Agriculture.

Management of water, grazing on public lands, and logging were major conservation issues in the early 20th century. Federal legislation, policy, and programs were shaped in part by President Theodore Roosevelt. He created three national forests in the study region from 1906 to 1908. Also in 1906 the Antiquities Act was passed by Congress, which in part gave presidents the power to establish significant historic landmarks. Gran Quivira National Monument was the first such area designated in the Middle Basin.

An Office of Grazing Studies was formed within the U.S. Forest Service in 1910. Grazing fees, livestock reduction, and fire suppression, along with ongoing predatory control, were important strategies. Over the next 2 decades, programs to protect streams and wildlife were initiated by this agency. Aldo Leopold was a major contributor to these new efforts. His later writings shaped wildlife management policy and helped inspire the environmental movement of the 1960s–70s.

Construction of the first major impoundment on the Rio Grande in the study region, Elephant Butte Reservoir, was completed in 1916. Planning for new irrigation facilities, water control, and water reclamation was led by the newly formed U.S. Corps of Engineers, Bureau of Reclamation, and Middle Rio Grande Conservancy District. Subsequently, more major flood control and irrigation dams, drainage canals, flood control levees, and other structures were constructed in the Middle Valley and major tributaries.

The dry and economically depressed years of the 1930s resulted in the creation of several federal agencies to manage and conserve resources, such as the Soil Conservation Service, the Grazing Service, and the National Resources Board. Programs such as the New Deal land program and the CCC were implemented to carry out conservation work such as revegetating areas, building check-dams, and constructing outdoor recreational facilities.

Management and restoration of some game animal populations by the New Mexico Department of Game and Fish were carried out in the 1930s and 40s. Some of this work was federally funded through the U.S. Fish and Wildlife Service, which also managed several new national wildlife refuges, such as the Bosque del Apache established in 1939.

During the 1940s–50s the new Bureau of Land Management and the Forest Service focused on managing livestock grazing, fencing public lands, and removing wild horses and burros from rangelands. The Forest Service also carried out grass reseeding and reforestation on the national forests, as well as projects to control insects and fungal diseases. Spraying was widely used to accomplish this task, which led to protests by environmentalists, especially after publication of biologist Rachel Carson's book *Silent Spring* in 1962. Also controversial was the use of Compound 1080 to control rodents and predators on public and private lands. This poison, as well as DDT, was later banned.

Water management in the Middle Basin continued to be a major focus in the 1950s with construction of levees, jetties, and other water control works, including Jemez Dam. Channelization of the Rio Grande was also carried out. Ironically, the period 1951–56 was the severest drought of the century in the state. With completion of Abiquiu Dam on the Rio Chama in 1963, Galisteo Dam on Galisteo Creek, and Heron Dam on Willow Creek near the Chama River in 1971, flooding of the Middle Valley was virtually an event of the past.

The environmental movement of the 1960s, spurred by Carson's and Leopold's books, *The Quiet Crisis* by Secretary of the Interior Stuart Udall, and the leadership of President Kennedy, was a strong influence on Congress and federal and state resource management agencies. Memberships of environmental organizations such as the the Sierra Club, the National Audubon Society, the Wilderness Society, and the National Wildlife Federation increased dramatically during the 1960s and 1970s. Also, sharply increased visitation to parks, monuments, and national forests brought a higher level of awareness about environmental issues. The work of these and other organizations, as well as support from the general public, led to legislation such as the Wilderness Act (1964), the Land Classification and Multiple Use Act (1964), the National Historic Preservation Act (1966), and the Endangered Species Act (1973). Other significant laws, such as the National Environmental Policy Act and the National Wild and Scenic River Act, were passed also. In late 1970, after decades of discussions, protesting, and lobbying, Taos Pueblo finally got their sacred Blue Lake in the Taos Mountains of the Carson National Forest returned. More federal and state laws for better management of wildlife and timber and for controlling water pollution, flooding, and grazing were enacted in the 1970s.

Public concern for the Middle Rio Grande and its bosque grew from the 1970s to the present. Establishment of the Rio Grande Nature Center in Albuquerque, the Corrales Bosque Preserve, the Rio Grande Valley State Park, and the Sevilleta National Wildlife Refuge in the 1970s–80s reflected public and governmental concern for the biota of the valley. These and other public conservation areas along the valley also were instrumental in raising public awareness in support of saving portions of the bosque and associated biota and maintaining somewhat "healthy," diverse ecosystems.

CONCLUSIONS

Research Methodology

The bioregional or biotic strategy, including humans, is the best methodology for determining past landscape conditions and the events and processes that evolved to bring us to the present. Bioregionalism reduces the significance of political boundaries in studying the environmental history of a region or smaller definable unit. Establishment of state and county boundaries, and those of national and state public land units, did of course affect the eco-cultural components in the study region.

The term eco-culture has been used in this report to reflect the biological-cultural behavior and activities of all human groups. This term clearly suggests that humans, as part of the environment, play a major role in environmental change. In turn, these changes have sometimes resulted in modification of human attitudes and strategies for environmental exploitation, or even abandonment of such views and strategies. For example, the slaughter of elk, bighorn sheep, and wild turkey in the Middle Basin and of bison along the region's eastern margins adversely impacted Native Americans, as these species were major sources of food and hides. These animals also were important to these groups as deities and religious symbols, part of their world view and integral parts of some ceremonies. Pueblo, Hispano, and Anglo commercial and subsistence hunters had to hunt other species such as deer and pronghorn, decimating populations of these species as well. Many professional hunters eventually had to find another means of making a living.

In the early stages of this investigation, four temporal models reflecting impact and change for the Middle Rio Grande Valley were developed (Scurlock 1995: 20–21). These were subsequently "tested" as more data were collected and analyzed. Model 1 (16th century) presented the river as a dynamic, slightly aggrading stream with considerably greater volume of water, normally perennial, than that of the last 150 years. Various types of wetlands existed on the floodplain. Wildlife was more diverse and abundant during this time than at any other time in the historic period. This model, with some revision, follows.

Model I: Middle Rio Grande Valley in the 16th Century

Historic river hydrology-morphology:

- Perennial flows; relatively deeper, larger volume of water.
- Transport of relatively low sediment load.
- Braided, slightly sinuous, aggrading, shifting sand substrate.
- Overbank flooding with two peaks—April to early June (snowpack melt, highest water flow); August to September (intense precipitation on watershed).
- Movement across floodplain (avulsion) and shifting river channel.
- Island and sand bar formation-destruction.

River-floodplain biological and eco-cultural components:

- Grass meadows, cienegas, charcos (ponds or small lakes).
- Varied, changing age structures of cottonwood-willow stands.
- Wildlife diverse and relatively abundant.
- Some life forms present—wolf, river otter, mink, whooping crane, Rio Grande turkey, shovelnose sturgeon, and 11 other fish species (now extinct).
- Limited Pueblo diversion of river for irrigation.
- About 25,000 acres of floodplain under Pueblo cultivation.

Model II, A.D. 1700 to 1850, manifests the increased impacts on the Middle Valley from a growing population, which surpassed the highest numbers of the previous century. Acreage in cultivation increased about three times that of 1600. Aggradation, flooding, and related processes increased markedly. Riparian vegetation and associated wildlife were impacted by increased farming, grazing, and hunting. Some soils were becoming waterlogged and more alkaline, and new wetlands were created. This latter process probably caused populations of aquatic nongame species to increase. Again, research data generally supported Model II, which, with minor revisions, follows.

Model II: Middle Rio Grande Valley in the 18th to Mid 19th Century

Historic river hydrology-morphology:

- Somewhat decreased stream flows.
- Flow widening and becoming more shallow.
- Braided, sinuous, increasing aggradation.
- Overbank flooding and avulsion more frequent and severe.
- Increased frequency of channel shifting resulting from intense floods.
- River banks and islands less stable.
- Increasing sediment load due to various land-use practices.

River-floodplain biological and eco-cultural components:

- More fragmented and reduced stands of cottonwood-willow communities due to intense floods.
- Increased alkalinity and waterlogging of soils.
- Increased numbers of grass meadows, cienegas, and charcos.
- Less stable and decreasing populations of faunal communities.
- Increase to about 100,000 acres under cultivation by Pueblos and Hispanos.

With the arrival of relatively large numbers of Anglo Americans and their technology beginning in 1846, and a continued growth of the Hispanic population, new impacts-processes began in addition to those of the preceding 150 years. Rangelands long grazed by goats and sheep were subjected to intensive grazing by cattle herds, especially from Texas. Local second-growth or extensive virgin forests were intensively logged. Droughts followed by above-normal precipitation years further reduced vegetative cover and resulted in rapid runoff and erosion. The Rio Grande and tributaries received ever-increasing amounts of sediment. Stream banks eroded, and the river aggraded even more rapidly, creating more waterlogged soils and wetlands. Floods were more intense and destructive. Riparian vegetation and wildlife and fish were severely impacted by these processes, as well as unregulated hunting and fishing. Several animal species were extirpated, and some exotic plants became naturalized and spread. This latter phenomenon was not included in the proposed Model III (see below). District projects drained wetlands, built levees, and renovated irrigation systems, all resulting in changes in Rio Grande ecosystems.

Model III: Middle Rio Grande Valley in the Late 19th to Early 20th Century

Historic river hydrology-morphology:

- Continued decrease in flows, increase in sediment load, and aggradation of river.
- Flood frequency and intensity increased.
- Some scouring and incising of river channel due to floods.
- Increased soil alkalinity and waterlogging.
- Rising water table, then lowering water table.

River-floodplain biological and eco-cultural components:

- Most extensive and widespread number of wetlands

and associated plant communities, then severe reduction to lowest in historic period.
- Cultivated acreage increased to 100,000 to 125,000 acres by Euro Americans and Pueblos, then decreased to 35,000 acres due to environmental changes.
- Increased alkalinity and waterlogging of valley soils.
- Less stability and severe decrease in wildlife populations.
- Several wildlife species extirpated.

For the fourth model, about 1930 to the present, some of these adverse processes and impacts were reversed. Revegetation, reduction of numbers of livestock grazing, construction of terraces and other erosion control features, and reduced soil erosion and stream sedimentary loads at some locations took place. Almost all wetlands were drained throughout the entire valley. Some decimated or extirpated game species were reintroduced. Most game species increased, but with the possible exception of mule deer, these mammals and birds did not reach mid 19th century population levels. A few wildlife species, including fish, were extirpated locally. Construction of dams brought reduction of floods. Agricultural lands were reclaimed. Model IV, with revisions based on new research data, is presented below.

Model IV: Middle Rio Grande Valley in the Mid to Late 20th Century

Historic river hydrology-morphology:

- Decrease in sediment load and aggradation of river.
- Flood frequency and intensity decreased dramatically due to construction of major dams.
- Continuing lowering of water table in some areas.
- Channel straightened and bermed, channel shifts virtually halted, and banks stabilized.

River-floodplain biological and eco-cultural components:

- Cultivated acreage increased to 58,000 acres.
- Floodways cleared and channel modified.
- Construction of several ponds for wetland habitat.
- Some wildlife populations increased.
- A few exotic plant and fish species introduced.
- A few wildlife species, including fish, extirpated.
- Rare, endangered, threatened species determined and managed accordingly.

The Upper and Middle basins of central and northern New Mexico compose a region unique to the United States in terms of diverse ecosystems and long-time, indigenous human populations. Records of these peoples and their interactions with each other, as well as with physical and biological components of the ecosystems, are equally as diverse. Tree-ring chronologies provide data on climate, fire history, and human activity. Other archeological evidence from the late prehistoric-historic periods, archival documents, oral history, and living history (centuries-old extant traditional eco-cultures and associated views and activities) provide an eco-cultural "data base" found nowhere else in the country. Only some of these diverse and extensive bodies of information have been utilized in this limited study.

I have presented research data from these various sources on the interrelationships of various human groups with other components of the Middle Rio Grande Basin environment over the last 450 or so years. Climatic variability, diverse land forms, water availability, soil fertility, and floral and faunal diversity have been the major elements of regional ecosystems that have delineated the range of possible strategies used by various eco-cultures in adapting to, exploiting, and shaping the regional macro and micro environments.

Climate was the one environmental element that most impacted eco-cultures, plants, and animals. Recently, or since the late 1800s, a warming trend has been occurring and appears to be continuing. The decade of the 1980s in New Mexico was the warmest decade ever scientifically recorded. Mild winters have prevailed over the past few years, with a relatively large number of record high temperatures for the maximum and minimum highs. Whether this warming is part of a "natural" cycle or is due to human activities, or perhaps to both, is not known.

Although pre-Spanish plant communities were dynamically shaped and maintained by these periodic climatic changes, as well as other environmental forces, the introduction of livestock and exotic plants added another factor that brought severe changes, not only to the vegetative composition and density but also to soils and surface water quality and quantity. In some situations the composition of vegetation in riparian zones may be irreparably changed. No one knows what the impacts of the above factors will be on vegetation and associated fauna, including humans.

Each of the three major identifiable eco-cultures in the region—Native American, Hispano, and Anglo American—has employed a basically different set of adaptations resulting from its different view of the land and water. The view of Native Americans was generally shaped by intimate relationships with the land over thousands of years and was (and is) to some extent manifested in their religion, economy, and social organization.

The later-arriving Spaniards brought a European belief that they were not only separate from the physical-biological environment but also superior to the indigenous Indians of New Mexico. Some assimilation took place, primarily as a result of intermarriage between the two groups. Hispanics did adopt some Native American techniques of resource use such as floodwater farming and fall buffalo hunting. Establishment of commons was similar to Pueblo land use. The introduction of livestock, new cultigens, metal tools, and infectious diseases initiated major changes in indigenous populations, water, soils, fauna, and flora.

Some plants important to Native Americans for food, medicinal, or religious use were decimated or eradicated locally due to various non-Indian land and water use activities. Traditional collecting areas where these species were found have at times been lost to usurpation of that land by another group or transfer of that land to the public domain.

With establishment of national forests, some traditional areas used for religious ceremonies, plant gathering, and hunting (of some species) were no longer available to practice these activities, or they were subject to visitation, and in some cases vandalism, of religious shrines and objects. Some traditional uses in these forests by Hispanos were also modified or, as with Native Americans, even precluded by Forest Service policy and regulation in the early 1900s. These same problems also appeared with establishment of national monuments and state parks in the Middle Basin.

In recent years federal and state agencies have worked with traditional groups to allow access to historic use areas, while excluding some non-native use of these locales. The American Indian Religious Freedom Act, passed in 1978, recognizes the rights of Indians to practice their religion at traditional-use sites.

Conflicts have arisen recently between environmentalists and Hispanos over wood cutting on areas of national forests that are known or potential habitat for rare or endangered animal species, such as the Mexican spotted owl.

Another example of reduction or loss of a resource, which impacted New Mexicans and their environment, is surface and ground water. Upstream diversions have resulted in inadequate or no irrigation water for downstream users, and too many or too deep wells in a locale have drawn groundwater levels below more shallow, older, traditional wells. This latter situation is a continuing process today in many areas. In some cases, the relationship between recharge and use or draw down and use of ground water is not understood. Continuing to develop new wells given these unknowns in the water-short Middle Rio Grande Basin is obviously risky.

During the dry and economically depressed years of 1930–40, many traditional and rural residents depended in part on game animals and fish for sustenance. This placed even more pressure on already low populations of deer, bighorn sheep, and native trout. Fur-bearing animals were widely trapped or shot for their skins, which could be sold or traded for needed commodities.

Throughout this century some Anglo livestock raisers, and a smaller number of Hispanos, have believed that they have traditional rights to public grazing lands, and many of these individuals lobby for transferring these public lands to the private sector. At the same time ranchers have demanded that agencies managing public lands protect their stock from predators and competing wild grass eaters. Several western states practiced extirpation of predators, which prey on game species. Ongoing federal and state animal control programs for predators and "pest" animals have, of course, been financed with public monies, which has become a public issue. Conflicts have also arisen as proposals have been made for reintroducing wolves or managing certain grazing lands to ensure survival of rare or endangered species.

The effects of dams, floodways, bridges, channelization, bank stabilization, and other management activities will continue to have adverse impacts on the Middle Rio Grande. These are not well understood, but some negative effects are known. For example, the Rio Grande has been changed through these activities from a dynamic natural-flowing river to a greatly modified water storage and conveyance system. The periodic spring and summer flooding no longer occurs because of the construction of dams and levees, adversely affecting faunal and floral communities that have evolved to depend on adequate floodplain moisture and nutrients at critical times. Dams have also altered the dynamic flow of the river and, with diversions for irrigation, have caused flow to cease in summer from Bernalillo south. Extensive areas of the floodplain outside the levees have been converted to agricultural lands or to urban development. Many of these areas have begun the process of desertification, with invasion of drought resistant plants, both native and exotic (Bullard and Wells 1992: 35–36).

Continued fragmentation of the riparian zone by the above development would produce more degradation among plant and animal communities (Crawford et al. 1993: xiii). Lack of flooding, drainage canals, and wells have lowered the ground water, impacting native tree species and contributing to desertification of the historic floodplain outside the levees. Inside and outside the floodway, aggressive, deep-rooted, and alkaline-tolerant exotic trees continue to spread, replacing native cottonwood and willow species.

Agriculture uses about 90 percent of all available river water in the Middle Rio Grande Valley (Crawford et al. 1993: ix). Per capita use by Albuquerque residents is considerably higher than that of Phoenix and Tucson residents.

Runoff from rain storms, discharges from municipal and resort waste water, mine tailings, septic tanks, leaks from fuel storage tanks, seepage from landfills, and agricultural pesticides and herbicides are obviously producing adverse impacts on surface and shallow ground water in the Basin. Fauna and flora have been, and will continue to be, impacted negatively (Crawford et al. 1993: 150).

The Biological Interagency Team described future conditions in Middle Rio Grande ecosystems if there is no change in current land-water use given ongoing continued population growth (Crawford et al. 1993: 145): (1) continued conversion of agricultural and grazing lands in valleys and adjacent uplands to residential sites, (2) continued grazing pressures except on lands converting to residential use, (3) increased recreational use of all ecosystems, (4) possible decrease in unregulated firewood cutting and collecting of green or dead wood in the bosque and on private woodlands and forests, (5) continued decline in shallow and deep groundwater quantity, (6) decrease in surface and groundwater quality, (7) increase in urban runoff adversely affecting water quality and sediment loads in streams, (8) continued degradation of the Middle Rio Grande as far south as the mouth of the Rio Puerco or even to San Marcial, (9) continued fragmentation of the Rio Grande bosque, (10) continued decrease in aquatic faunal populations due to abuse, (11) increase in non-native fish populations, and (12) continued spread of exotic plant species, some of which may perhaps attain dominance.

Human populations, the major underlying cause of these environmental problems, will continue to grow in the foreseeable future. Current adverse impacts will continue, some will increase in their effects, and new ones will undoubtedly appear. Suffice it to say, as population and associated technology grow, the expertise, resources, and time necessary to deal with environmental problems will probably diminish

CONSIDERATIONS

Much more work on the environmental history of the Middle Rio Grande Basin is needed. This report is only a general data base to aid research and investigation of a wide number of topics in this and related fields, such as climatology, landscape ecology, geomorphology, hydrology, range management, zoology, botany, archeology, and history. The four major research questions posed previously (Scurlock 1995a: 19–20) have only been partially "answered" here:

1. Need a better understanding of the long-term responses of ecosystem components—soils, nutrients, water, flora, and mycorrhizae—to past and present perturbations caused by climate change, fire, herbivore grazing, irrigation and dry farming, logging, fuelwood harvesting, and other human activities. Secondarily, these historical data will shed light on how such responses influence ecosystem dynamics, stability, and productivity of upland communities.
2. Need a better understanding of upland biotic communities, including the historic, spatial, and temporal interrelationships with fluvial ecosystems.
3. Need a better understanding of how humans adapted to changing environmental conditions, both "natural" and human induced, and used to determine when and how these perturbations occurred and what the consequences were. These data will be used to determine sustainability of traditional land-water activities today and, more importantly, in the future.
4. Need a better understanding of the evolution of Basin ecosystems in terms of human interactions related to cultural elements—world view, use of resources, and economics—and how these land-water use histories relate to conflicts between specific groups. Data collected for use in planning for sustainability of resources, as related to differing group views, will afford a more sound basis for such decision making.

Similarly, the goals or research needs (Scurlock 1995a: 20) of this investigation have only been partially resolved due to time limitations. These goals are listed below hierarchically, from the one that needs the most work to the one that needs the least work.

1. Reconstruction of historic climatic regimes for specific locales in the Middle Rio Grande Basin.
2. Reconstruction of water flow data and interrelationship with climatic fluctuations and human use.
3. Reconstruction of morphological dynamics of the Rio Grande and major tributaries related to floods and human use and management.
4. Reconstruction of historic fire occurrence, spatially and temporally.
5. Reconstruction of grazing history and impacts at specific locales.
6. Reconstruction of farming history and impacts at specific locales.
7. Reconstruction of human responses to environmental changes, especially in plant and animal communities and particular species populations important to a given group.
8. Construction of spatial-temporal models of ecosystems, including humans as a major factor in the dynamics and change of ecosystems, that is, the Rio Grande and major tributary watersheds.
9. Delineation of eco-cultural areas based on spatial-temporal distributions of specific groups related to identifiable ecosystems.
10. Reconstruction of adaptations of various groups to the same subregional or area environments.
11. Reconstruction of human-induced changes in ecosystem components, especially plants and animals.
12. Comparisons between the exploitation strategies of different eco-cultures, for example, Hispano and Anglo livestock raisers utilizing the same resource area, as well as the impacts of utilization.
13. Examination of the similarities and differences in Pueblo agricultural techniques and production along the Rio Grande compared with production on major tributaries.

Introduction

Historical use and management of land and water by regional eco-cultures has varied, and each eco-culture probably considers its way of life as "wise use" of resources. Individual leaders, residents, and governmental bodies from each group, and resource management agencies representing all citizens in New Mexico, must work together to determine what traditional land-use practices are ecologically and culturally sustainable, either intact or modified. There is commonality for some practices, such as irrigation agriculture, while differing views of the role of fire, for example, have existed until recently. Land-use practices must be factored into ecosystem plans for the Middle and Upper Rio Grande basins to determine if they are sustainable and contribute to the health and integrity of ecosystems. Covington (1994: 95) defined health as the "inherent ability for self-renewal" and integrity as "coevolved biological diversity."

As deBuys (1993) has written, federal agencies, as a result of the environmental legislation of the late 1960s and 1970s, are now required to solicit greater participation of the general public in making resource management decisions. New Mexicans now have an unprecedented opportunity to contribute to the process, which will ensure a healthier and more productive (in the broadest sense of the word) environment. As was so often said in the 1960s, it is time to be part of the solution, not just part of the problem. Defining these problems, to some degree, and providing data to help in finding solutions have been the primary focus of this report. As a result of this investigation, some personal ideas for management of Basin ecosystems, including traditional eco-cultures, have emerged.

Ecosystem Management: Restoration and Sustainability

Bonnicksen (1994: 108) explored four major questions related to environmental restoration that he believes must be considered if this management tool is to be tried and effective: (1) Should restoration of ecosystems even be attempted? (2) What do we want to restore? (3) What can we restore? and (4) Who decides finally what we do restore?

Although the first question is still being debated, some people support at least partial restoration, in contrast to none at all based on the philosophy that we should not intervene in the evolution of these separate ecosystems. Furthermore, for restoration, certain natural areas would have to be off limits to those wanting to use them for recreation or other passive activities. The second question is much more complicated and deserves more investigation and discussion, which is the goal of the ongoing 5-year study of the Middle Rio Grande.

Whether ecosystems or components thereof can be restored involves a complex set of criteria, including current ownership, use, existing restrictions, feasibility of restoring specific components, and political will. Further, restoration must be based on comprehensive, historical reconstruction of a particular ecosystem, and for some ecosystems such information is not available.

Who decides what is to be restored also deserves continued discussions among political, management, land and water user, and urban and residential entities. Traditional users of the land should be given full consideration in a decision to restore a given area, as well as what will be restored and what impacts that restoration might have on the human and non-human components of the ecosystem.

One restorative activity that began in the 1980s and continues today is pole-planting native trees and shrubs in degraded riparian areas. But this is more than just biological restoration, as Russell (1993: 29) has written; it is not a simple one-dimensional act. In her words,

> These reintroduced trees represent the particular. As they leaf and root, they are meant to shade one particular river, to withstand the force of a particular flood, to fall prey, perhaps, to a particular beaver. Pole-planting means community as the willows encourage and are enhanced by a complex of grasses, insects, birds, and small mammals. Pole-planting is a gesture of healing. It is a laying on of human hands in an effort to restore what humanity has diminished.

The present floral composition of the Middle Rio Grande Valley is different from the composition of vegetative communities and distribution of individual plant species during any period preceding 1930. This condition is the result of discontinuance of local uses of plants (fuelwood, construction, etc.) control of floods, fire suppression, protection of the cottonwoods on public lands, and the introduction of aggressive exotic plants. Restoration of the Rio Grande bosque to some historical condition is virtually impossible and highly improbable given the numerous resource agencies responsible for its management, other land owners such as the six Middle Rio Grande Pueblos, and a multitude of private owners. Also, removal of the tamarisk and Russian olive would be too expensive and perhaps unsuccessful given their widespread occurrence and regenerative powers. Controlled overbank flooding to maintain native riparian flora in most of the river's reach is also highly unlikely because of development and conflicting uses. The only probable restoration would be attainable at dispersed, smaller, and low-lying areas of the ecosystem where mechanical removal of exotics, spring flooding, and pole-planting of native species could be carried out.

Beaver populations, whose numbers have to be regulated, can be allowed to cut and girdle young, established cottonwoods and willows as part of restoration. Exotic species of fish might be removed cautiously through chemical application. Some historic species, such as shovelnose sturgeon, could not be successfully reintroduced due to changes in the volume of river flow, temperature, and clarity. Other native species can be restocked, provided that aggressive exotics can be removed effectively from particular reaches of the river where the reintroduction is planned.

Other management considerations for the biological resources of the Middle Rio Grande appear in the report of Crawford et al. (1993: 159–222), which has been widely circulated and is available in governmental resource management offices and public libraries. Included as an appendix in the Crawford report are the 1993 recommendations of the Rio Grande Bosque Conservation Committee, formed in September 1991. This committee held public hearings at key locations in the Basin, and inquiries, concerns, and other data collected and synthesized provided the basis for their recommendations, one of which was for the interagency study cited above (deBuys 1993).

The continuing crisis management of individual rare, endangered, or threatened species or fragments of ecosystems has not, according to some, brought the desired results. Clearly, the most effective approach for managing a stand of ponderosa pine or population of a single species, as Covington (1994: 95), Rinne (1994: 261), and others have pointed out, is that of viewing and investigating the interrelationships of all components in a given ecosystem. Nevertheless, conservation management of some species in critical situations must continue concurrently with studies to produce effective management plans for ecosystems in which the plants or animals occur.

Role of Traditional Eco-cultures

There is no other state or region in the United States where so many different indigenous populations (including Hispanos) have survived with traditional world views relatively intact than New Mexico. Therefore, traditional eco-cultures in the study region should be included in planning and decision making, as they have been a significant part of the Middle Rio Grande environment for many centuries. Over this time they have lived or used resources in every part of the basin. The intimate, detailed environmental knowledge that they have acquired and passed along over generations provides a perspective with insights into the sustainable maintenance of ecosystems. From this long experience of directly interrelating with the complete spectrum of environmental components and viewing themselves as part of ecosystems, Native Americans have maintained an "environmental 'memory' of times past" based on a philosophy and spirituality that reflects "the centrality of nature in its orientation" (Grinde and Johansen 1995: 263–264).

Historically, this traditional lifeway of the Pueblo has generally resulted in their conservation and maintenance of a sufficiently diverse and healthy environment in the study region, until the recent past. Although many of the specific details of Pueblo world view and related ritual activity have, for justifiable reasons, been kept from Euro Americans, some information about traditional-use areas or sites has become public. One example is the thousands of petroglyphs and associated features such as shrines, located on Albuquerque's west side, which remain important to some area Pueblos. These archeological manifestations are now included in a national monument established a few years ago to preserve and manage the eco-cultural resources for the general public, as well as for private use by Pueblos for traditional activities.

Recently, various native groups worldwide have been drawing attention to the ongoing environmental degradation of their lands caused by industrialized societies. Some natives in very remote areas, such as the Kogi of the northern Andes, have been able to detect changes in air, water, fauna, and flora. Elders from this group have warned of the consequences of continuing some old resource-using activities and initiating new ones that severely impact the environment (Ereira 1992). Thomas Banyacya, interpreter of the Hopi prophecies, expressed his concerns about the "destructive ways" of non-indigenous peoples (Wall and Arden 1990: 92–97). Dialogues from other natives from around the world have been published recently (Piacentini 1993). Most of their statements summarize their eco-culture's view as "the points of view of traditional societies are absent from the international debate on the environment" (Piacentini 1993). Some have termed this exclusion of native peoples as environmental racism. The traditional authors also described the impact of western civilization on their peoples.

As deBuys (1985: 308) pointed out, the problem of preserving traditional eco-cultures in the study region is directly linked to maintaining diverse and healthy land and water resources in their communities and associated common land. Furthermore, some authors believe that by involvement of these groups and evaluation of their traditional views and uses of ecosystems, we can perhaps find some answers to the complex question of sustainability of these resources. Native American Donald A. Grinde and Bruce E. Johansen (1995: 19–20) state this view:

> By learning from Native American societies, we are gaining a measure of perspective on how to change consumption patterns and cultural values in order to live in reciprocity and harmony on a sustaining earth. This recognition of the need for changes in our environmental perceptions must also encompass the realization that native peoples need once again to enforce their own environmental values, unfettered by regulations and environmental management practices of the industrial state. Regaining a more

harmonious environmental state means that known harmonious environmental ethics must be allowed to reemerge and become prominent as quickly as possible to facilitate the flow of ideas that will lead to a more natural relationship in all of creation.

Specific Resource Management Considerations

Environmental history not only provides data for determining sustainability of an area or region but also offers a spatial-temporal baseline for use in planning and implementing bioremediation projects. Species diversity and general population numbers in the historic period relative to recent numbers can also be determined to some degree.

The historical record shows that there is lag time in recognizing the cause, growth, or impact of a particular environmental problem. Nor do we generally understand all of the ramifications of managing certain resources in attempting to improve environmental conditions. Control of predators on deer, which led to rapid increase of populations, the introduction of exotic plant or animal species, and climatic changes caused by human activities are classic examples of these phenomena. To assert that we can quickly recognize or understand all of the interrelationships and processes in ecosystems is an erroneous belief that can result in serious environmental consequences. In the study region we need to examine closely our environmental history to better understand our attitudes, motivational values, and consequences of organizational and individual roles and related impacts on the complete environment—water, flora, fauna (including ourselves), soils, and air.

There are a number of highly visible environmental issues in the study region that environmental history data could be used in resolving. The major issues are water rights, quality, and quantity; grazing on public lands; logging, firewood cutting, and old-growth forests; and endangered species, including reintroduction of the Mexican wolf and restoration of spotted owl, willow flycatcher, and silvery minnow populations. Less significant, but nonetheless important, environmental problems need further resolution: high per capita consumption of water, fragmentation or destruction of the Rio Grande bosque, continued spread of exotic plants, urban sprawl, loss of traditional communities, repatriation of Native American items, loss of traditional Pueblo lands, and some resource management policies.

The ongoing degradation of some ecosystems, and the associated diminishment or extirpation of individual species, is a widespread concern and one shared by Basin residents. Concern for this human-generated process and its possible consequences for future generations of New Mexicans provides common ground for discussion and development of possible solutions, not just among managers but among all interested individuals. These processes can only be realized and made effective by careful review, study, and analysis of the historical data.

Some commonly used terms in current discussions and debates, besides "wise use," mean different things to different groups of people (Box 1994: 4–5). Examples are conservation of resources, stewards of the land, standard of living, quality of life, and improvement of the land. These words should be reexamined, reevaluated, and redefined in the context of land health and integrity for the immediate and distant future. The challenge to reaching a consensus of what these and other "value" words mean for sustainability of our total environment is only part of the ongoing, complex dialogue of today.

Based on historic climate records for the study region, the 1995-96 dry period was predicted. More work is needed for the historical data to determine if there is a cyclic pattern of occurrence that could be used in predicting droughts.

Ownership of land within the Basin by government resource agencies and private groups such as the Nature Conservancy or the Archaeological Conservancy provides at least relatively dense "islands" of "natural" habitat. Especially critical are riparian reaches of the Rio Grande and its tributaries. Zoning or leasing of important tracts of land could be pursued as well. Potentially, acquiring tracts will help ameliorate fragmentation of bosques, contribute to preservation of rare species, or protect archeological remains. Some of these lands are severely degraded and lend themselves to biological restoration.

William deBuys (1996) wrote that northern New Mexico fuelwood cutters and small-scale loggers could be used effectively by the U.S. Forest Service to better manage the forests and woodlands found there. By thinning dog-hair timber stands, utilizing controlled burns, and protecting old-growth trees, the loggers could return regional forests to historical conditions (i.e., open stands with scattered mountain meadows), which would foster more biodiversity and maintenance of populations of the endangered spotted owl. In the midst of a vigorous debate regarding "salvage" logging of burned stands of trees (March 1996), a recommendation for leaving this dead timber might be made to further emulate historical conditions.

There is now consensus that human-caused fire, used prehistorically and historically to modify plant communities, and lightning-caused fire are necessary in maintaining productive, healthy grasslands, woodlands, and forests. The role of wolves as predators is now considered by many to be desirable in maintaining viable ecosystems. And, like Native Americans, more and more non-Indians are viewing wolves and other large predators as evokers of spiritual feelings. Finally, there is a segment of New Mexicans and other Americans who believe that animal and plant species have a right to exist and flourish. Management of resources is in large part an educational process, a phenomenon that obviously must continue if we are to arrive at a consensus of what is indeed "wise use" from an ecological viewpoint.

Repeat photography from identified historic stations was used only minimally in this investigation. This technique of documenting environmental change over a relatively long period at a particular location generally provides more accurate data, primarily plant change and soil erosion, than anecdotal descriptions. Unfortunately, changes due to long-term human activities were already in progress in the Middle Basin when the first photographs were taken in the 1860s. Relatively good photo coverage of the study region dates from the 1880s. Nevertheless, comparing older photographs made in the Basin to contemporary images is worthwhile, and repeat photography from the same station will prove more important over time. As techniques for detecting environmental change improve, even more data will be retrieved from comparing new with old images. The earliest aerial photographic coverage was initiated in the mid 1930s. Changes in the Middle Rio Grande's hydrology, riparian vegetation, and upland land use can also be detected when comparing with more recent, same area, aerial images.

Finally, I hope that the data in this report, in addition to being used by resource management personnel and academic researchers, will be useful for agencies or groups that prepare and provide interpretive services for school teachers, students, and the public in general. Environmental history provides a different view of our past and can provide a foundation for future programs aimed at understanding eco-cultures and their environment, restoring ecosystems, setting aside critical areas, and making necessary lifestyle changes as ecosystems and associated resources become more scarce and threatened. I further hope that curriculum developers and teachers can adapt this information for use in biology, geography, science, and other courses in the classroom and on field trips in the study region. The necessity for this educational process was succinctly stated by environmental historian Donald Worster (1994: 30):

> Learn where you are. Learn about this place and its history. Learn not only the history of its people but the history of the land itself, its deep history. Learn to adapt your ideas and institutions to that land. Learn to work together if you mean to endure.

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