

Chapter 3

Human Ecology and Ethnology

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HISTORIC PERIODS

Spanish Colonial	A.D. 1540-1821
Mexican	A.D. 1821-1846
Territorial	A.D. 1846-1912
Statehood	A.D. 1912-present

INTRODUCTION

The relationship of humans with Middle Rio Grande Basin ecosystems is complex. In historic times, humans had a critical role in the evolution of environmental landscapes and ecosystems throughout the Middle Rio Grande Basin. The relationship of humans with the land is based on and regulated by resource availability, environmental conditions, levels of technological knowledge, political and socioeconomic structures, and cultural values regarding the use of land and water. The general and specific impacts of historic human activities on Middle Rio Grande Basin ecosystems have only recently become a focus of researchers.

Three groups utilized the natural resources of the Middle Rio Grande Basin during historic times: American Indian, Hispanic, and Anglo-American. Each group had its own cultural values regarding the land and water, which influenced and regulated exploitation of the Middle Rio Grande Basin. Most studies of cultural values regarding the land and water tend to be simplistic. Studies of cultural values that do not romanticize certain groups and demonize others are a fundamental foundation for any systematic and integrated understanding of the relationship between humans and Middle Rio Grande Basin ecosystems.

Though the general outline of the political, socioeconomic, and technological history of the Middle Rio Grande Basin is available, exploration of the specific historical relationships between human impacts and the Basin's ecosystems has barely begun. Stud-

ies similar to that of de Buys (1985) on the Sangre de Cristos would contribute significantly to our understanding of the human role, human impacts, and human relationships with the land, water, and other resources of the Middle Rio Grande Basin during historic times. Farming, ranching, hunting, mining, logging, and other human activities have significantly affected Basin ecosystems in the last 450 years.

Most of the research on resource availability and its role in regulating human impacts on the Basin has focused on the 20th century. Some work has been done on the second half of the 19th century but very little on the 300 years of the historic era preceding the Treaty of Guadalupe Hidalgo in 1848. This chapter summarizes the available historic information.

OVERVIEW OF HUMAN IMPACTS

The principal factor influencing the human relationship with Basin ecosystems is the location and availability of water. Because the Basin is located in a semi-arid environment, the quality, quantity, and accessibility of water have always profoundly and decisively influenced human settlement in and exploitation of the Middle Rio Grande Basin.

Fluctuations and broad scale changes of the Basin's climate have influenced human activities such as hunting, gathering, farming, livestock raising, travel, and warfare. Drought and erratic precipitation patterns have been important limiting factors in the extent and intensity of human exploitations of Middle Rio Grande Basin ecosystems. The majority of the historic period in the Basin fell within the "Little Ice Age," which affected New Mexico from the mid-15th to the mid-19th century.

Though the broad outlines of the climatic history of the Middle Rio Grande Basin are available, several factors constrict our present understanding. While tree-ring data provide some information on climatic fluctuations and long-term climatic patterns, the amount of climatic data for the period before 1850

is very limited. For the second half of the 19th century and the early 20th century, substantial amounts of scientifically recorded climatic data exist but have not been systematically studied. Climatic records and studies for the 20th century are in general voluminous and well known.

The role of European introduced diseases such as smallpox and their impact on local populations have been relatively well documented in New Mexico as a whole. The interrelationship of disease and politico-ideological motivated concentrations of early historic Puebloan populations by Spanish colonial authorities are well known if not systematically studied. However, the devastating epidemics of the 1780s profoundly altered the population dynamics and relationships in all of settled New Mexico. The beginnings of the intermixing of Hispanic and Puebloan populations on the rich agricultural lands of the Pueblo land grants are to be found in the aftermath of the 1780s epidemics. The historic epidemics of the 17th century and the late 18th century coincided with periods of severe, extended drought and catastrophic periods of warfare that interrupted and fragmented Puebloan religious life and socioeconomic systems.

LAND UTILIZATION IN THE SPANISH COLONIAL AND MEXICAN PERIODS

When the Spanish settled in New Mexico at the end of the 16th century, they brought new technologies and new domesticated plants and animals. These introduced species along with the new political, socioeconomic, and ideological structures imposed by the Spanish significantly altered not only Puebloan but also Navajo and Apache diets, economic structures, and land use patterns. Puebloan and nomadic Indian land-use patterns prior to Spanish settlement can be reconstructed through archeological research and from the records of Spanish *entradas* (Hammond and Rey 1928, 1940, 1966; Hackett 1937).

Given the vital relationship between water and settlement in all semi-arid environments of the North American West, including New Mexico, it is not surprising that the Spanish of the 17th century, but particularly those of the 18th and 19th centuries, gravitated into the Rio Grande Valley and its tributaries. Spanish settlement depended upon irrigation agriculture for its economic base and, therefore, for its survival. Extensive development and expansion of irrigation systems accompanied the introduction of community land grants in the Rio Grande Valley af-

ter the Reconquest of 1693–1697. What is surprising about irrigation agriculture is its relative rarity among the Pueblo Indians before Spanish settlement in the late 16th century. Spanish missionaries and *encomenderos* imposed an irreversible reliance on irrigation agriculture upon the Pueblo Indians during the 17th century. This combined socioeconomic and technological change irretrievably undermined and altered traditional Puebloan subsistence systems, land use patterns, and ways of life. In addition to a plethora of domestic livestock (sheep, goats, cattle, horses, mules, hogs, chickens, etc.) and new cultigens (wheat, barley, oats, onions, lettuce, watermelon, fruit trees, etc.) the Spanish also introduced native Mexican Indian crops such as tomatoes, chiles, cultivated tobacco, and new varieties of corn and beans. These introduced species along with the introduction of metal tools such as axes, metal tipped plows, and weapons had a significant and sometimes adverse impact on native flora, fauna, and soils. The role of metal tools and their impact on ecosystems before the 19th century should not be exaggerated since metal tools were generally in short, even critically short, supply throughout the 17th and 18th centuries in New Mexico.

With the colonization of New Mexico by the Spaniards, irrigation entered into a new era in the Rio Grande Valley. The introduction of new crops such as wheat, which required irrigation to produce harvests in semiarid New Mexico, encouraged the development and/or expansion of Pueblo Indian irrigation. The Spaniards insisted that the Indians grow these crops, particularly wheat, so that the Spaniards could obtain their customary food stuffs even in New Mexico. At least part of the tribute that the Spanish regime required from the Puebloans was exacted in the form of wheat, so the Indians had to irrigate to meet these demands. Other tribute demands for food stuffs would also push the Puebloans toward intensive (i.e., irrigation) agriculture during the 17th century, with considerable disruptive consequences for both Puebloan and Spanish society in New Mexico. The Spanish reliance on Puebloan agricultural labor was due not only to politics, economics, and demographics, but also to cultural factors. In the 17th century, Spanish colonists tended to reject agriculture as a fitting occupation. Even herding was seen as being fit for native Puebloan but not Spanish labor.

During the 17th century, the Spanish settlers in New Mexico survived on tribute in food and labor collected from the Puebloans under the *encomienda*

and *repartimiento* systems (Scholes 1937, 1942). (*Encomienda* is a grant of Indians who are entrusted to the care of a Spaniard, in return for which the Spaniard provides military services to the government. *Repartimiento* is a grant to a Spaniard of the right to exact certain labor services from an Indian village or villages.) The Spanish missions or *reducciones* concentrated Puebloan populations into a much smaller number of pueblos than had been occupied before the arrival of the Spaniards. The *reducciones* were established for religious, political, economic, and military reasons and served to enhance Spanish control and supervision over the native Indian populations (John 1975: 65–67; Scholes 1937, 1940). Concentration of the heretofore scattered Puebloan settlements also enabled both ecclesiastical and secular authorities to exploit the Indian labor force more effectively and to levy tribute. Tribute demands and the *reducciones* themselves often drove the Puebloans to escape Spanish control by withdrawing into the mountains or joining the nomadic Indian tribes (Hammond and Rey 1953: 659–692).

Throughout the 17th century the Spaniards steadily increased their demands for native labor and goods while the labor force was being progressively reduced by disease and warfare. Missionization appears to have produced the first of the major population declines that then continued as a result of epidemics and drought. Demands for native labor by both the encomenderos and the friars along with the increasing European population placed strong pressures on the Puebloans to improve their productivity to supply food for both groups. These pressures led to an increased and in some cases a virtually exclusive reliance on irrigation agriculture. The Spaniards encouraged the development of Puebloan irrigation farming not only to ensure the increased productivity that would supply them with food and to obtain introduced European crops, but also because irrigation agriculture made possible the concentration of Puebloan populations in the *reducciones*. The friars thus intended both to increase Puebloan productivity and to maintain a newly imposed sedentism among the New Mexico pueblos. Dry farming was replaced by more intensive agricultural strategies involving fields irrigated by artificial diversions of water through ditches. At the same time hunting virtually disappeared, to be replaced by livestock herding. The gathering of wild plants and plant products declined as the Puebloans were tied to their irrigated fields in their efforts to meet the demands of the colonists and missionaries.

Agricultural intensification through irrigation demanded much labor, and the requirements of the system were difficult to meet owing to the decline in Indian populations. Such intensification was necessary, however, if the alimentary demands of the friars and encomenderos and the simultaneous demands for other goods and services were to be met. Contrary to Ellis's (1970) contention that the Spaniards found irrigation widespread and flourishing in the Rio Grande Valley, it was the institution of the *reducciones* that produced a rapid change in the Puebloan subsistence system from expansive to intensive agriculture. This increased and heretofore unnecessary dependence on agriculture led to a decrease in hunting, gathering, and trade in subsistence goods with the nomadic tribes. Mineral deposits, although present in several areas of New Mexico, were insignificant and unexploited in the 17th century. Apart from an erratic pinyon crop, and the relatively unimportant collection of wild animal skins and cotton textiles, there were virtually no exploitable natural resources that were not already available in quantity in the mining districts of Chihuahua, New Mexico's only potential market.

Conditions began to deteriorate seriously in New Mexico in the third quarter of the 17th century. In 1659, the first major region-wide famine occurred (Hackett 1937: 272); between 1666 and 1668, and in 1670 and 1671, famine once again struck the New Mexican pueblos (Hackett 1937: 302). In the early 1670s the suffering of the Puebloans was exacerbated by disease and the onset of devastating Apache raids (John 1975: 92–95).

Economic exploitation, religious persecution, and the failure of the Spaniards to protect the Puebloans from nomadic raiders culminated in the Pueblo Revolt of 1680 (Hackett 1942: 1: 1–82; John 1975: 96–97). After decimating the Spanish settlements and driving the remaining settlers from the northern Rio Grande Valley, the Puebloans shed Spanish religion and culture but retained Spanish crops and technology, both civilian and military (Hackett 1942: 1: 12–18, 1942: 2: 235). The continuing legacy of Spanish colonization could be seen in the residual importance of irrigation agriculture. Once the Spaniards were gone, the Pueblos quickly broke up into warring factions.

Puebloan factionalism and calculated economic warfare ultimately enabled Diego de Vargas to reduce the Pueblos once again to Spanish rule between 1692 and 1694 (Espinosa 1942: 85–208). Only Vargas himself was authorized to have an *encomienda* after

the Reconquest; all other Spanish settlers were to support themselves by their own labors. Economic conditions, however, forced the newly returned Spaniards to rely upon a system of tribute in food and labor from the exhausted pueblos that, in its operations and efforts, resembled the discredited *encomienda* and *repartimiento* system. These exactions drove most of the Puebloans into a second revolt in 1696 (Espinosa 1942: 228–246). The Spaniards crushed the new revolt with the assistance of those pueblos that did not join the rebellion (Espinosa 1942: 296–303). After 1697, a new economic regime was established in New Mexico, one that centered on community land grants rather than *encomiendas*. Internecine warfare among the Puebloans during the Revolt and Reconquest led to the abandonment of many 17th century pueblos, particularly in the Middle Rio Grande Basin. These abandonments had a profound effect on 18th century resettlement and land-use patterns.

The century following the reconquest is crucial to an understanding of the cultural diversity of the Middle Rio Grande Basin. Throughout most of the 18th century, New Mexico was not an active participant in the developing colonial world system, of which it was an almost forgotten part. More significant were raids by and warfare with New Mexico's nomadic neighbors: the Navajos, the Apaches, the Utes, and the Comanches. The alternating periods of war and peace had a major impact on settlement patterns and resulted in periods of expansion followed by periods of settlement contractions and abandonments. Warfare among the nomadic Indians, the Spanish, and the Puebloans affected land uses in the Middle Rio Grande Basin until after the American Civil War.

The 18th century also witnessed the gradual compartmentalization of Puebloan culture and society. On the one hand, Puebloan communities needed to co-exist with the dominant Hispanic culture. On the other hand, there was the equally obvious desire to maintain individual Puebloan traditions and identity. Out of the 18th century, there developed the Puebloan and Spanish Colonial cultural traditions which are still evident on the landscapes of the Middle Rio Grande Basin. Both traditions had to cooperate and interact to survive in the semi-arid environment of New Mexico, and to defend themselves against attacks by the semi-nomadic Indian tribes that surrounded New Mexico.

With the reconquest of New Mexico, the Spaniards instituted a new settlement system that transformed

the way they utilized the resources of New Mexico. Before the Pueblo Revolt the Spaniards had occupied New Mexico with a small number of settlers who held large tracts of land. These 17th century settlers grazed livestock and depended upon the Puebloans to produce surpluses of food as well as products such as woven goods, salt, and pinyon nuts. After the Reconquest, because a secure hold on New Mexico had a higher value than extraction of economic wealth, the Spanish government made grants of land (*mercedes*) to ensure the effective occupation of New Mexico by means of self-sufficient farming and herding communities.

In place of a small number of exploitive *encomiendas*, which had proved to be a political, military, and economic disaster, the Spanish authorities established an ever-expanding number of land grants on which the Hispanic settlers supported themselves through agriculture and stock-raising. In the early days after the Spanish reconquered New Mexico, a number of individual land grants were given to people who had been prominent in the Reconquest. Though given to individuals, these were not *encomiendas*; the recipients were expected to support themselves by their own endeavors and those of their extended families and servants. Indian labor was virtually unavailable owing to the catastrophic population decline of the late 17th century. This decline continued at a reduced level in the 18th century, while the non-Indian population steadily expanded. At the same time, the Spaniards were prohibited from exploiting what little Indian labor might have been available (Simmons 1969: 10–12). The Indian pueblos settled into a system of local self-sufficiency under the religious (but not economic) supervision of the mission friars (Adams and Chavez 1956). Most land grants in the 18th century were given to groups rather than individuals, to settle as many people as possible on the land and provide for defensible settlements (Simmons 1969; Westphal 1983: 3–23). New Mexico became a region of small, self-sufficient Puebloan and Hispanic communities, held together by fear of nomadic raids and by the necessities of mutual defense.

For a settlement to succeed, irrigable land was necessary (Ressler 1968: 10). The accessibility of water to cultivate bottomlands was a primary consideration in the grants of land by the Spanish government. Subsistence agriculture employing irrigation and livestock herding was the economic basis for these settlements. Consequently, land grants were made

primarily along the Rio Grande and the Rio Chama and their perennial tributaries. The irrigable lands on each grant were divided among the settlers, while the rest of the land was held in common for pasture and woodland (Westphal 1983: 3–23). While Spanish colonial ordinances required that settlements be compactly organized for defense, most New Mexico land grant settlements were straggly communities of dispersed ranchos (Simmons 1969: 12–20). Formal plazas were rare, despite the threat of Indian raids. Even the villas of Santa Fe, Santa Cruz, and Albuquerque were scattered over large areas so farmers could live near their irrigable fields (Simmons 1969: 10–12; Snow 1976: 47–48).

The development of irrigation systems for agriculture was a primary consideration in the foundation or resettlement of villas after the Reconquest. Two *acequias madres* (main ditches) that had existed at Santa Fe since approximately 1610 were rehabilitated after the resettlement in 1693 (Simmons 1972: 139). When the Spaniards resettled Santa Cruz de la Cañada in 1695, they dispossessed the Tanoan residents and took over their irrigation system (CPLC, Cases #110 and 194; SANM I: #882). At Albuquerque in 1706, one of the first tasks of the new settlers was the construction of *acequias* (Hackett 1937: 379; SANM II: #124).

It is true that an atmosphere of expediency surrounds the development of land grants and land grant settlements in 18th century New Mexico. On the other hand, the prohibition of *encomiendas*, combined with the government's expressed desire to have the province securely occupied by Hispanic settlers who could defend it, means that some thought had been given to the requirements for settlement.

The long-lot system that prevailed on most land grants was developed to accommodate community land grants and as a response to local conditions in the Rio Grande Valley of northern New Mexico. However, this system of property division did not resemble the Puebloan field systems of the 17th or 18th centuries. Long-lot farms developed as a means of growing introduced crops that required irrigation in a semiarid environment where both land and water resources were limited. The system assured settlers of maximum access to limited water resources and proved to be a practical and equitable method of partitioning irrigable lands among the large numbers of settlers required by military necessities. The resulting small subsistence farms never produced significant agricultural surpluses nor were they in-

tended to do so. Colonial policy was not directed toward economic prosperity but toward the successful occupation of New Mexico, which the defense of New Spain was deemed to require (John 1975).

In the Rio Abajo, where Puebloan populations south of the confluence of the Rio Grande and Rio Jemez had virtually disappeared, arable land was more plentiful, particularly along the Rio Grande; extensive grazing lands were also available in the Middle Rio Grande Basin. Water, also, was more securely available and more manageable for irrigation purposes in the Rio Abajo than in the Rio Arriba, especially south of San Felipe Pueblo. The continual threat and often devastating impact of raids by nomadic Indians limited expansion, however, except in the Bernalillo and Albuquerque areas.

Little changed in the formalities of obtaining land grants under the Mexican regime, and the vicissitudes of settlement remained much the same as well. The total area given in land grants between 1821 and 1846, however, probably exceeded that granted during the preceding 125 years (Westphal 1983: 25–65). Most of these grants were outside the Rio Grande Valley and placed large areas of grazing land under the control of individuals in what can only be termed an orgy of deliberate fraud and rapacity by prominent New Mexicans, aided and abetted by Mexican government officials in New Mexico. This raid on the public domain had precedents in the grazing grants west of the Rio Puerco in the 1760s. The Mexican Period grants set the patterns for land use that would prevail in the Middle Rio Grande Basin throughout the 19th century and into the 20th. Trade with the Anglo-Americans, the incipient development of a livestock industry, and some mining began the gradual transformation of the economy of the Middle Rio Grande Basin and changes in land use patterns. These changes included both more extensive and intensive utilization of resources outside of the main valley.

In the northern Rio Abajo only one grant in the Rio Grande Valley was made during the Mexican Period. On November 17, 1840, the constitutional *alcalde*, Antonio Montoya, gave Salvador Barreras and his associates possession of the Tejon or Arquito tract that lay in the uplands to the east of the abandoned pueblo of Tunque (CPLC, Case #145). In the Albuquerque area the only grant dating to this period was made to Antonio Sandoval for the area of Las Laquintas (U.S. Surveyor General 1855–1987, Case #154). By 1827 Sandoval occupied the area and had dug an *acequia* along the foothills south of Las Barelillas.

On the Rio San Jose, Rafael Sanchez and other vecinos petitioned for land below the Pueblo of Laguna in 1829. Before he could give possession of the land, the constitutional *alcalde* of Laguna was required to investigate whether cultivation of this area would depend upon water already being used for irrigation by the Indians of Laguna and Acoma (SANMI: #1291).

In the southern Rio Abajo, an Antonio Sandoval (probably not the same one who acquired the Arquito grant near Albuquerque in 1827) petitioned Governor Armijo for land at Bosque del Apache, which he needed for grazing sheep but which he also intended to cultivate. On March 7, 1846, Sandoval was placed in possession of the Bosque del Apache grant by the *alcalde* of Socorro, Vicente Piño (U.S. Surveyor General, Case #35).

The arrangement of field systems and the nature of land ownership were very different among the Pueblos and in the Hispanic land grant communities. The Pueblo irrigation systems, however, were similar in engineering and organization to the Spanish ditches (Simmons 1972: 144).

Throughout the 18th century and first half of the 19th century, the Indian pueblos suffered from declining populations and had to compete with Hispanic settlers for arable land, and to a lesser extent for water. Unfortunately information regarding Puebloan irrigation systems is scarce and spotty, but enough can be derived from ecclesiastical reports to provide an adequate picture of Puebloan irrigation during the Spanish and Mexican Periods. The best and most extensive report on the Pueblo Indians was that of Fray Dominguez from the latter part of the 18th century, but other, less comprehensive reports also exist (Adams 1954; Adams and Chavez 1956; Morfi 1932).

LAND UTILIZATION IN THE TERRITORIAL AND STATEHOOD PERIODS

When the Americans occupied New Mexico in 1846, they found a largely agrarian society that was concentrated in the Rio Grande Valley and depended for its survival upon irrigation agriculture and raising livestock. Both Hispanic and Puebloan communities controlled and managed the irrigation systems that covered most of the irrigable lands along the mainstream of the Rio Grande and its tributaries.

Just prior to the annexation of New Mexico by the United States, Josiah Gregg visited the territory on

several occasions during the 1830s. Gregg (1954: 104) noted the fertility of the bottomlands and the barrenness of the unirrigated uplands. New Mexican agriculture was primitive by American standards. The crude plows were used only on loose soils; most land was cultivated with the hoe alone (Gregg 1954: 107). Nearly all of the farms and settlements in New Mexico were located in valleys with perennial streams. In some valleys, crops were regularly stunted by the seasonal depletion of stream flows. One *acequia madre* was generally sufficient to convey water for the irrigation of an entire valley or the fields of one town or settlement (Gregg 1954: 107–108). Community ditches were most common; private ditches were relatively rare (Gregg 1954: 108). New Mexicans in the late Mexican Period grew mostly corn and wheat under a system of subsistence agriculture (Gregg 1954: 108). While the scope and extent of irrigation activities in the Rio Grande Valley had steadily expanded in the Spanish and Mexican Periods, the nature of irrigation agriculture had remained very much the same. Expansion of irrigation systems in the Rio Grande Valley was strictly a response to population growth. The primary focus on subsistence agriculture and livestock herding persisted in the Rio Grande Valley for some time after the American annexation of New Mexico under the Treaty of Guadalupe Hidalgo.

After the arrival of the railroads, irrigated acreage in the Middle Rio Grande Basin expanded substantially until the 1890s when drought, upstream development, salinization, defective drainage, and a development embargo by the federal government brought expansion virtually to a halt. Although irrigated acreage had expanded, the actual irrigation systems and their organizations had changed very little between 1846 and 1910. In the upper Rio Grande Valley, virtually all of the irrigable acreage was under ditch before 1846; in the middle valley (i.e., White Rock Canyon or Cochiti to San Marcial) most expansion after 1846 took place in areas where raids by nomadic Indians had caused earlier attempts at settlement to fail.

The vast majority of farmers in 1910 were still Puebloans or Hispanic New Mexicans. Increasing numbers of Anglo-Americans had begun to engage in irrigation agriculture, but most were too poor or inexperienced to introduce modern irrigation technology. The real impact of Anglo-Americans on the New Mexican economy during the Territorial Period was in the development of a livestock industry with

its accompanying infrastructure of railroads and market towns. Most of the essential developments in the livestock industry in the Territorial Period took place away from the Rio Grande on the uplands and plains that surrounded the valley. The emergence of large scale sheep and cattle herding had significant impacts on ecosystems of the Middle Rio Grande Basin, particularly on soils, native vegetation, and water resources.

With the American acquisition of New Mexico came the beginning of the end of the economic stability that New Mexican subsistence farmers had experienced for over a century. While the stability of this adaptation gradually disappeared, the technology of irrigation and the methods of irrigation agriculture that were used changed very little for most farmers in the Rio Grande Valley until after the turn of the century. The Anglo-Americans introduced changes in the New Mexican economy that altered settlement systems, land-use patterns, and the utilization of natural resources not only along the mainstream of the Rio Grande but also in the more marginal areas of the Middle Rio Grande Basin. Exploitation of minerals, grasslands, and forests as a part of the new, commercial economy of New Mexico opened portions of the ecosystems of the Middle Rio Grande Basin to more intensive use than the preceding subsistence economy had found possible or necessary.

However, the most immediate and profound impacts of the new economics of the Anglo-Americans came along the mainstream of the Rio Grande itself. By the early 1890s, serious problems had emerged in the irrigation agriculture of the Rio Grande Valley. Drought, which had struck sporadically in the 1880s, became acute in the early 1890s (Wortman 1971: 17); by 1889 the Rio Grande below Albuquerque literally dried up for four months of the year. Stream flow had been seriously depleted by rapid development of irrigation agriculture in the San Luis Valley of Colorado; the effects on downstream users were dramatic and ultimately led to federal intervention (Follett 1896; Harper et al. 1943; Harroun 1898; Yeo 1910, 1929).

Ironically, at the same time that the Rio Grande was being seasonally depleted, lands in the middle Rio Grande Valley from Cochiti to San Marcial, especially between Bernalillo and La Joya, were becoming waterlogged and thus not amenable to cultivation (Conkling and Debler 1919: 77; Harper et al. 1943; Harroun 1898: 2; Natural Resources Committee 1938: 70). Sedimentation in the Rio Grande resulting from

decreased flows had caused the bed of the main channel to aggrade; as a result, the water table in many parts of the valley had begun to rise. Waterlogged lands had always been a problem near the Rio Grande itself owing to poor drainage and wasteful irrigation practices. Under traditional agricultural methods, excess water in the *acequias* was simply dumped onto low-lying lands at the end of the *acequia*. Only a small percentage of ditches had facilities for returning the excess flow to the Rio Grande or delivering the water to downstream ditches. Each ditch system, of which there were dozens, was independent; no plan or organization to integrate the multitude of irrigation systems in the middle Rio Grande Valley existed or was deemed necessary.

Though more urbanized and subject to outside influences than their neighbors to the north, residents of the middle Rio Grande Valley maintained patterns of agriculture that were remarkably traditional in the period before 1910 (Harper et al. 1943). After the early 1880s and the arrival of the railroad, some commercial agriculture was introduced into the area around Albuquerque, Belen, and Socorro, but for the most part irrigation agriculture preserved its traditional orientation toward subsistence farming. At least 90 percent of the farmers were Hispanic or Puebloan, and approximately 90 percent of the irrigated acreage was farmed by them (Natural Resources Committee 1938). Nonetheless, irrigated acreage did expand in the middle Rio Grande Valley in the 1860s to early 1890s.

Beginning in the mid 1890s, droughts, sedimentation, aggradation of the main channel, salinization, seepage, and waterlogging caused an overall decline in irrigable acreage in the middle Rio Grande region. The total amount of actual irrigated acreage remained relatively stable as previously uncultivated lands were brought into production to replace adversely affected acreage.

Much of the potentially irrigable acreage in the middle Rio Grande Valley had been damaged by poor drainage and the rising water table, and had been retired from production by the early 20th century (Wortman 1971: 17-18). Thousands of acres were rendered unusable by the related problems of waterlogging and alkalinization; at the same time floods were frequent and often devastating. The flood of 1874 destroyed almost every building between Alameda and Barelás (Carter 1953). In 1884, Tome, Valencia, and Belen were under water during the spring floods. The flood of 1886 wiped out part of the pueblo of

Santo Domingo, and a new church had to be built. In 1904 most of the bridges on the Rio Grande were destroyed by a late summer flood. The spring flood of 1905 washed away the community of Tomé.

As early as the 1890s, the desirability of reorganizing the middle Rio Grande Valley irrigation systems was recognized by a few individuals. The need for a unified and rationalized system of irrigation and drainage was great, but such a development was hampered by misunderstanding and mistrust (Linford 1956: 277). Local residents who were mostly Hispanic or Puebloan were naturally reluctant to surrender or assign water rights to private irrigation companies, which were mainly Anglo-American enterprises, in return for the promise of a more secure water supply. Such a hesitancy was well founded; 90 percent of the private irrigation companies in the western United States went bankrupt—hardly a record to engender confidence in a privately sponsored reorganization of the middle Rio Grande Valley's irrigation systems.

In the second half of the 19th century, a mining industry developed in the mountains of the Middle Rio Grande Basin with the usual accompanying impacts on water and timber resources. The latter were also affected by the construction of railroads with their large demands for timber in construction and operations. Other forested areas than the mountains of the Middle Rio Grande Basin were more systematically exploited than those of the Basin; the environmental effects were nonetheless demonstrable if generally localized. Of broader impact on the extensive grasslands of the Middle Rio Grande Basin was the development of the livestock industry. The emergence of a commercial livestock industry was encouraged and made possible by the construction of transcontinental railroads through New Mexico that opened national markets for sheep and cattle that utilized the Basin's grasslands. These uses had important impacts on nature vegetation, water, and soil, and the uses produced deteriorations in grasslands throughout the Basin beginning in the late 19th century and continuing into the 20th century. Transformation in Middle Rio Grande Basin ecosystems such as arroyo cutting and desertification were due not only to human activities, but also climatic changes following the end of the "Little Ice Age" in the mid-19th century.

The late 19th and early 20th century also witnessed the breakup of community land grants and the common lands (*ejido*) as an indirect consequence of land

grant adjudications by the U.S. Surveyor General and the Court of Private Land Claims. Except for the construction of larger flour mills and the centralization of distribution networks as a result of railroad constructions, agriculture in the Middle Rio Grande Basin changed very little before the 1920s from its centuries old system of irrigation farming. Frustrated in that area by antiquated farming methods, Anglos were constantly advocating "modern" techniques of farming.

In 1879, the long-awaited railroad arrived in New Mexico. The railroads immediately superseded the limited trade on the Santa Fe Trail and were able to transport larger masses of goods more quickly than the old system of wagon transportation. Connections with the eastern United States spurred the growth of new industries in New Mexico, including the Middle Rio Grande Basin. These included the livestock industry in sheep and cattle, and natural resource extraction in minerals and lumber. The railroads also directly spurred population growth through employment in construction and operations; by 1920 over half of Albuquerque's male heads-of-households worked for the Santa Fe railroad.

Physical resources deteriorated in the middle Rio Grande Valley from the 1890s to the mid 1920s (Harper et al. 1943: 28). Water shortages resulting from drought, and especially from over-exploitation of surface water for irrigation in the San Luis Valley, were frequent throughout the period after the early 1880s (Conkling and Debler 1919; Follett 1896; Gault 1923; Hodges 1938; Yeo 1910). These shortages were often tragically combined with devastating floods (Carter 1953; Yeo 1943). Water shortages particularly affected the annual flows on the middle and lower Rio Grande, producing increased sedimentation and dramatic channel aggradation in the early 20th century that choked the ditches (Harper et al. 1943: 36–40). The aggradation of the main stream channel increased the frequency and destructiveness of floods and also contributed to the waterlogging of arable lands in the middle and lower valley through lateral seepage and raised water tables (Burkholder 1928: 34; National Resources Committee 1938: 70). Waterlogging was frequently accompanied by salinization and alkali poisoning of soils (Conkling and Debler 1919: 77; Harper et al. 1943: 36–40). The changes in the hydrology of the valley were not the only causes of waterlogging and its accompanying effects on arable lands. Traditional irrigation practices in the middle valley encouraged and frequently were a pri-

mary immediate cause of arable acreage going out of production (Stewart 1936). The combined effect of all of these factors was a decline in irrigation agriculture in the middle Rio Grande Valley (Harper et al. 1943: 51). Drought in the 1920s and 1930s had similar effects on the grasslands of the Middle Rio Grande Basin. Overgrazing reduced the cover grasses and contributed to serious soil erosion.

Concern over the deterioration of conditions in the middle Rio Grande Valley gradually grew in the 1920s (Burkholder 1928; Linford 1956: 287–289). In 1921, the State Legislature created the Rio Grande Survey Commission, which was to study conditions in the middle valley in cooperation with the U.S. Reclamation Service (Hedke 1925). Finally in August 1925, the Middle Rio Grande Conservancy District was organized. When the district was organized, two-thirds of the arable bottomlands within its boundaries were subject to seepage or were waterlogged (Burkholder 1928: 45–55; Conkling and Debler 1919: 77).

Over the next three years an official plan for reclamation, flood control, and irrigation was developed; the plan was presented in its final form by the chief engineer of the district, Joseph L. Burkholder, in 1928. The plan covered flood and river control, irrigation (especially diversion dams and main canals), drainage, water supply (a reservoir at El Vado), management of Indian Lands belonging to five pueblos (Congressional legislation was needed in order to include Pueblo lands within the Middle Rio Grande Conservancy District), and sedimentation control (dealing with aggradation of the Rio Grande, channel shifts, lateral seepage, and waterlogged lands). In March 1928, Congress authorized the Secretary of the Interior to enter into an agreement with the Middle Rio Grande Conservancy District for irrigation, drainage, and flood control on the lands of the pueblos of Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta. The MRGCD and its projects would transform Middle Rio Grande Basin agriculture in the 1920s, 1930s, 1940s, and 1950s.

The arrival of modern irrigation technology not only meant a reorganization of the irrigation systems, a renovation of the facilities, and a rationalization of the structure of irrigation, but also the infusion of outside influences and a tremendous escalation in the costs of irrigation. Much of the latter impact was absorbed by the largesse of the federal government, which wrote off or massively subsidized the costs of irrigation agriculture in the Rio Grande Valley as it did in the rest of the arid American West. The changes

in the character of irrigation agriculture in the middle Rio Grande Valley of New Mexico included: (a) the appearance of modern, surveyed ditch alignments to replace the old meandering systems; (b) the construction of a few concrete diversion structures to replace the multitudes of primitive head works; (c) construction of large water storage structures to provide a virtually guaranteed source of water during the irrigation season; and (d) the institution of operation and maintenance methods using heavy machinery to replace human beings with shovels. Many of the old problems of flooding, sedimentation, waterlogging, alkali poisoning, and unreliable water supply were resolved or at least held in check, but they were replaced by new problems related particularly to finances, especially maintenance costs and reimbursement of construction costs. The new problems have proved to be much more intractable than the old ones.

The organization of the U.S. Forest Service and the U.S. Bureau of Reclamation in the 20th century introduced federal involvement in land uses and land management to the Middle Rio Grande Basin. The formation of federally mandated grazing districts on public lands in the 1930s and the related organization of the Bureau of Land Management brought similar federal involvement with the grazing resources of the Basin. The role of these and other federal agencies in resource utilization on public lands has increased throughout the 20th century in the management of grazing, mining, forestry, recreation, water, soil, and other areas of resource utilization.

LITERATURE REVIEW

The following literature review briefly summarizes previous research on the human role in the ecosystems of the Middle Rio Grande Basin during the historic period. The environmental history of the Basin is reviewed elsewhere (Scurlock this volume). In general, only limited attention has been given to the complex relationships of humans and ecosystems throughout New Mexico, including the Middle Rio Grande Basin.

Overviews of human activities in the Basin can be found in the following studies: Berman (1979); Cordell (1979); Dick-Peddie (1993); Dyerson (1971); Flores (1992); Horgan (1954); National Resources Committee (1938); Tainter and Gillio (1979); Tainter and Levine (1987); and USDA Soil Conservation Service (1936a,b). A unique body of information on eco-

systems in the historic period is contained in the records of the Wheeler surveys. The published records are contained in Wheeler (1875–1889), while the extremely important unpublished records are held at the National Archives and at Yale University.

Many archival guides and references exist to assist the researcher in the study of the region: Beers (1979); Burger (1990); Chavez (1957); Colley (1972); Gallacher (1986); Jackson and Teeple (1978); Jenkins (1968, 1969, 1970); Jenkins, Simmons and Martinez (1967); National Archives and Records Service (1973); O'Connor (1989); Rex (1991); and Tyler (1984). The fundamental primary records for the Spanish and Mexican Periods are contained in the Spanish Archives of New Mexico and the Mexican Archives of New Mexico, which are available on microfilm at the State Archives and Records Center (Santa Fe) and at the University of New Mexico (Albuquerque). Also of primary importance in the study of land uses in the 17th, 18th, and 19th centuries are the records of land grants in the Spanish and Mexican archives, and the American Period investigations of Spanish and Mexican land grants; these records are contained in the proceedings before the U.S. Surveyor General of New Mexico (1855–1887) and the Court of Private Land Claims (1891–1904). For the study of land use by Indians and non-Indians on Pueblo Indian Land grants, the records of the Pueblo Lands Board (1926–1932) provide considerable information on the 19th century and the first part of the 20th century.

The interrelationships of human populations and the river valley itself have been explored in Abbink and Stein (1977); Bowen and Sacca (1971); Burkholder (1928); Carter (1953); Debler (1932); Hernandez (1971); Kelley (1969); Kelley (1955); Leopold (1951); Linford (1967, 1968); Marshall and Walt (1984); Moir et al. (1971); Nickerson (1945); Sargeant (1987); Sargeant and Davis (1986); Scurlock (1988a, 1988b, 1988c, 1993b); and Wortman (1971).

Population studies and human demography for the historic period in northern and central New Mexico are provided for the Pueblos by: Creamer (1994), Dozier (1970), Earls (1992), and Thornton (1987); for the Hispanics by: Bailey and Haulman (1977), Carroll and Haggard (1942), Jones (1979), Nostrand (1992), Olmsted (1973, 1975, 1981), and Tainter and Levine (1987); and for the Anglos by: Johansen (1971, 1972).

The largest, longest, and most profound human impacts in the Middle Rio Grande Basin during the historic period have been upon the riparian ecosys-

tems as a result of irrigation agriculture. The role and impacts of irrigation in the human history have been more studied than any other human roles and impacts. This investigator (Wozniak 1987) has written an overview of the development of irrigation systems in the Rio Grande Valley of New Mexico (including the Middle Rio Grande Valley) during the historic period. A comprehensive history of irrigation and its impacts in the Middle Rio Grande Basin is still needed. The study of irrigation agriculture and of agricultural water uses has been undertaken in a series of studies: Clark (1987); Clark (1958, 1971); Conkling and Debler (1919); Downing and Gibson (1974); Ellis (1970); Follett (1896); Hodges (1938); Hutchins (1928); Meyer (1979); Meyer and Deeds (1979); Ressler (1968); Simmons (1972, 1983); Sunseri (1973); Swan (1977); Wortman (1971); and Yeo (1910a, 1910b, 1929).

Puebloan settlement patterns, land use, and irrigation agriculture for the historic period are addressed in Abbink and Stein (1977); Bandelier (1892); Cordell (1979); Dozier (1970); Du Mars et al. (1984); Earls (1985); Euler (1954); Ford (1972, 1984); Hewett and Dutton (1945); Hewett et al. (1913); Hodges (1938); Lange (1951 and 1959); Michael (1976); Nelson (1914); Ortiz (1979); Poore (1893); Ressler (1968); Riley (1951 and 1987); Sando (1982); Scurlock (1991); Snow (1981); and White (1935). Marshall and Walt (1984); Schroeder (1968, 1972, 1979); Vivian (1932); and Wozniak (1987) have addressed the question of Pueblo abandonments in the Middle Rio Grande Basin during the historic period. Zubrow (1974), in this study of the relationships of climate, populations dynamics, and Euroamerican contacts, has examined the problems for the Pueblos of Hispanic and Anglo-American settlements on Puebloan land grants and resource bases. An ecological perspective on the Eastern Pueblos has been offered by Ford (1972).

Perspectives on Hispanic settlement patterns, land use, and agriculture has been provided by Bailey and Haulman (1977); Briggs and Van Ness (1987); Campa (1979); de Buys (1985); Greenleaf (1972); Hall (1982); Hernandez (1971); Jones (1979); Kelley (1955); Kutsche (1979); Leonard (1943); Nostrand (1992); Rothman (1989); Simmons (1969, 1972 and 1983); Snow (1976, 1979); Sunseri (1973); Swan (1977); Tainter and Levine (1987); Van Ness and Van Ness (1980); Westphall (1983); Widdison (1958); and Wozniak (1987). The results of the USDA Soil Conservation Service's Human Dependency Surveys of the 1930s are contained in Calkins (1935, 1937a, b and

c); Cockerill et al. (1939); Harper et al. (1943); Leonard (1943); Maes and Fisher (1937); and Oberg (1940). These studies provide valuable perspectives on Hispanic land use patterns, human relationships with the land and its resources, the interrelationships of Anglo and Hispanic land and water uses, and human impacts on a variety of Middle Rio Grande Basin ecosystems. Widdison (1958), in his study of the Rio Puerco valley, has prepared the only historical geography within the Middle Rio Grande Basin. A review of colonial Hispanic water use has been provided by Meyer (1984) in his study of water rights, irrigation, and litigation in the Southwest. R.E. Clark (1958) has provided a study of water law and traditional Hispanic and Puebloan communities.

Anglo-American settlement of the Middle Rio Grande Basin has been addressed in Cordell (1979); Tainter and Gillio (1979); and Tainter and Levine (1987). Studies of the settlement of the public domain in New Mexico in the period after 1848 have been provided by Ganoë (1937), and particularly, Westphall (1965). Simmons (1982) has provided a study of the city of Albuquerque, which is the principal urban area in the Basin. The impacts of urban development in the Middle Rio Grande Valley are addressed by Clark (1987), Linford (1956, 1968), and Simmons (1982). The phenomenon of health seekers in New Mexico is discussed by Jones (1967); however, questions about recreational visitation and tourism, and their impacts, have been addressed only peripherally and for only the most recent years of the 20th century.

In the matter of the diversity of attitudes toward the land and the use of natural resources, we have only limited information in the studies by Eastman et al. (1971) and Harper et al. (1943). Frequent discussions have been carried in the popular media regarding the alleged distinctions among Puebloan, Hispanic, and Anglo-American attitudes toward the land and environment but none of these discussions have any greater time depth than the last three or four decades, and they tend to reflect present and generally non-historical perspectives.

Numerous reports and studies on water control, water supply, and water management in the Middle Rio Grande Basin during the late 19th and 20th centuries have been prepared that address the problems associated with water control and management. These include Burkholder (1928); Clan (1987); Debler (1932); Follansbee and Dean (1915); Gault (1923); Harroun (1898); Lampen (1930); Linford (1956);

Nickerson (1945); van Cleave (1935); and Wortman (1971). The conditions of water control systems for the same period have been reported in detail by Follett (1896) and Yeo (1910 and 1929). The origins and history of the Middle Rio Grande Conservancy District are provided by Clark (1987); Linford (1956); Welsh (1985a, b); and Wozniak (1987). Welsh (1985 a and b) has examined the management of water resources in the basin by the U.S. Army Corps of Engineers.

The lands of the Middle Rio Grande Basin include not only the river valley areas that have been utilized for irrigation agriculture, but also grasslands and forests that have been historically exploited by the communities from the riparian zones. The herding of cattle and sheep on grasslands and forests in the Spanish, Mexican, and American Periods have been explored by Akins (1987); Baxter (1987); Baydo (1970); Carlson (1969); Denevan (1967); Eastman and Gray (1987); Humphrey (1953 and 1987); Jordan (1993); Nickerson (1945); Rowley (1985); Smith (1953); Widdison (1958); and Wooton (1908). The utilization of forest lands in the American Period during the administration by the USDA Forest Service has been specifically addressed by Baker et al. (1988) and Rowley (1985).

Following and associated with the construction of the railroads in the latter part of the 19th century (Greever 1957; Myrick 1989), the commercial exploitation of timber, mineral, and other resources took place in the Middle Rio Grande Basin. Hispanic use of timber has been addressed by Jones (1932). The trapping of fur-bearing animals in the Mexican Period and early American Period has been presented for the whole of New Mexico by Weber (1971). Mining and mining settlement in New Mexico has been studied by Anderson (1957); Christiansen (1974); Long (1964) Northrup (1959); Shannon and Shannon (1975); and Young (1965). A study of mining in a portion of the Jemez Mountains above Cochiti Pueblo has been provided by Wozniak (1981). Utilization of timber resources and their consequences are presented in Baker et al. (1988); Cooper (1960); Cooperrider and Hendricks (1937); Scurlock (1993a) and Tucker (1992).

The results of the utilization of ecosystems throughout the Basin have been reflected in studies by Brown (1974); Bryan (1927 and 1928); Cooke and Reeves (1976); Cooperrider and Hendricks (1937); Dortignac (1963); Headley (1936); Isaacson et al. (1936); and Stewart (1936). These authors have focused on the most visible consequences in the form of arroyo development and soil erosion. The effects

of human uses of the land are also reflected in stream channelization and floods that have been studied by Bryan (1927 and 1928); Bowen and Sacca (1971); Carter (1953); Calkins (1937c); Sergeant (1987); and Scurlock (1993b).

RESEARCH NEEDS, STRATEGIES, AND GOALS

Research in the historical data from the Spanish, Mexican, and Anglo-American Periods would provide the bases for analyzing the human and ethnoecology of the Middle Rio Grande Basin. The result of this research and analysis would be an integrated understanding of the human role in, and human impacts on, the ecosystems of the Basin. Addressing the following problems would create an integrated understanding of the relationships among cultural, political, economic, and environmental factors and processes:

1. Need an improved understanding of the relationship between riparian, grasslands, and mountain ecosystems of the Middle Rio Grande Basin and human activities such as irrigation agriculture, dryland farming, herding of livestock, mining, and lumbering.
2. Need to know the relationship between exploitation of diverse ecosystems by traditional Puebloan and Hispanic communities and the consequences of the late 19th century's introduction of a commercial economy.
3. Need better understanding of the presumably different world views of the Puebloans, Hispanics, and Anglo-Americans regarding land use, land management, and nature itself, and how the differing land-use histories of these distinctive groups have affected relationships among them. This improved understanding would address the question of the cultural sustainability and alternative cultural responses to changes in climate, energy, population, land use, politics, national and global economics, and the environment.

To solve these three problems, the following research topics or goals should be addressed:

- a. History of irrigation agriculture and its impacts on riparian ecosystems.
- b. History of livestock herding on the upland and riparian grasslands.
- c. Comparison of the differing impacts of traditional agriculture practices and "modern" agri-

cultural practices on riparian and upland ecosystems.

- d. Comparison of Hispanic and Anglo-American herding practices. Comparison of herding impacts on grassland environments and the differential effects of traditional and commercial livestock raising on the land.
- e. History of the impacts of commercial mining and lumbering on upland and mountain ecosystems.
- f. Reconstruction of the cycles of arroyo formation, stream channel cutting, deposition and how utilization of the land by Puebloans, Hispanics, and Anglo-American affected soil erosion and arroyo formation regimes.
- g. Analysis of the similarities and/or differences in Puebloan agricultural systems along the mainstream of the Rio Grande and along tributary streams.
- h. Comparison of differential responses of Puebloans, Hispanics, and Anglo-Americans to changes in ecosystems.
- i. Reconstruction of the historic world views of the Puebloan, Hispanic and Anglo-American communities regarding land use, land management, and resource exploitation.
- j. Comparison of historic and contemporary Puebloan, Hispanic, and Anglo-American world views regarding land use, land management, and resource exploitation.
- k. Understand the role of urbanization in the Albuquerque area on Middle Rio Grande Basin ecosystems.

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