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From the Foothills to the Crest: Landscape History

of the Southern Manzano Mountains, Central New Mexico, USA

Since 1800

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From the Foothills to the Crest: Landscape History of the Southern Manzano Mountains, Central New Mexico, USA Since 1800

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Dissertation

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Trying to acknowledge the contribution of others to this project is a difficult proposition. So many folks contributed their time and expertise to my many questions and notions. The diverse faculty of the Geography Department provided me with ideas, questioned many of my assumptions, and taught me skills that helped with much of the research. Teaching assistantships and instructor positions from the department helped both economically and furthered my knowledge in the field of geography.

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From the Foothills to the Crest: Landscape History of the Southern Manzano Mountains, Central New Mexico, USA Since 1800

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In ~1800, after abandoning the area for about 120 years, Hispanic settlers reoccupied the eastern Manzano Mountain region. Livestock, particularly sheep introduced by these early residents, and later cattle brought in by Anglo-American settlers in the late 19th century, modified forest structure and composition. By the early 1900s, extensive commercial logging exacerbated the effects of overgrazing. Coupled with fire suppression, a much different landscape exists today than 200 years ago.

First account records such as travel diaries, and more importantly, the field notes of the US Public Land Survey System document the

increasing effect of human agency on this locale. Analysis of US Forest Service grazing allotment files revealed much of the area suffered from overgrazing early in the 20th century.

By 1880, dense underbrush had replaced the forest understory of grasses and forbs in much of the area. Logging, spurred by railroad construction's need for lumber and crossties, removed much of the open stand ponderosa pine timber, especially from the eastern side of the range. Because of fire suppression since ~1900, forest density has increased considerably. Fuel loads are high and the danger of catastrophic fire is now a real danger in many areas. Furthermore, fire suppression resulted in the decline of mountain meadows that periodic but low intensity fire helped maintain. Dense stands of coniferous forest now intercept substantial amounts of precipitation resulting in less groundwater recharge and a decline in stream flow.

Livestock overgrazing removed surface vegetation such as grass and forbs fostering arroyo cutting and surface erosion. Livestock damage riparian habitat and areas around springs and *cienegas* by trampling, selective grazing, and fecal contamination. Moreover, facilities associated with livestock production such as corrals and water points cause serious local disturbance and landscape degradation. Animal trails to and from these areas intensify soil erosion and vegetation damage.

Recreation activities and facilities, and subdividing surrounding private lands into “ranchettes” for suburban residents are creating additional pressure on the Manzano Mountain region. Unchecked or uncontrolled these newer factors may exceed the landscape degradation effects of earlier more traditional uses.

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Chapter 1

Introduction and Overview

The southern Manzano Mountains are within an hour's drive of Albuquerque and clearly visible on the city's southeastern horizon but they remain relatively remote and understudied regarding landscape change. Consequently, little specific information exists regarding the role of human disturbance on this "mountain island" (Gehlbach 1981). Most of this range is in Torrance County (Figure 1) and within the jurisdiction of the Mountainair Ranger District of the Cibola National Forest, and the Manzano Mountain Wilderness Area. I define the southern Manzanos as that portion of the range south of the Isleta Indian Reservation.

The Manzano Mountains share a number of landscape characteristics with other mountainous areas in New Mexico but are also different when studied at a finer scale. George Perkins Marsh discussed several of the topics contained in this work over one hundred years ago (Marsh 1864). Early in the 20th century, Will Barnes (1913, 1926) commented on many of the problems associated with overgrazing in the West. Several of the problems discussed in this work are common to other areas of the American Southwest and the Manzano Mountains share a number of widespread environmental and human agency processes with other southwestern forests. Livestock grazing, logging,

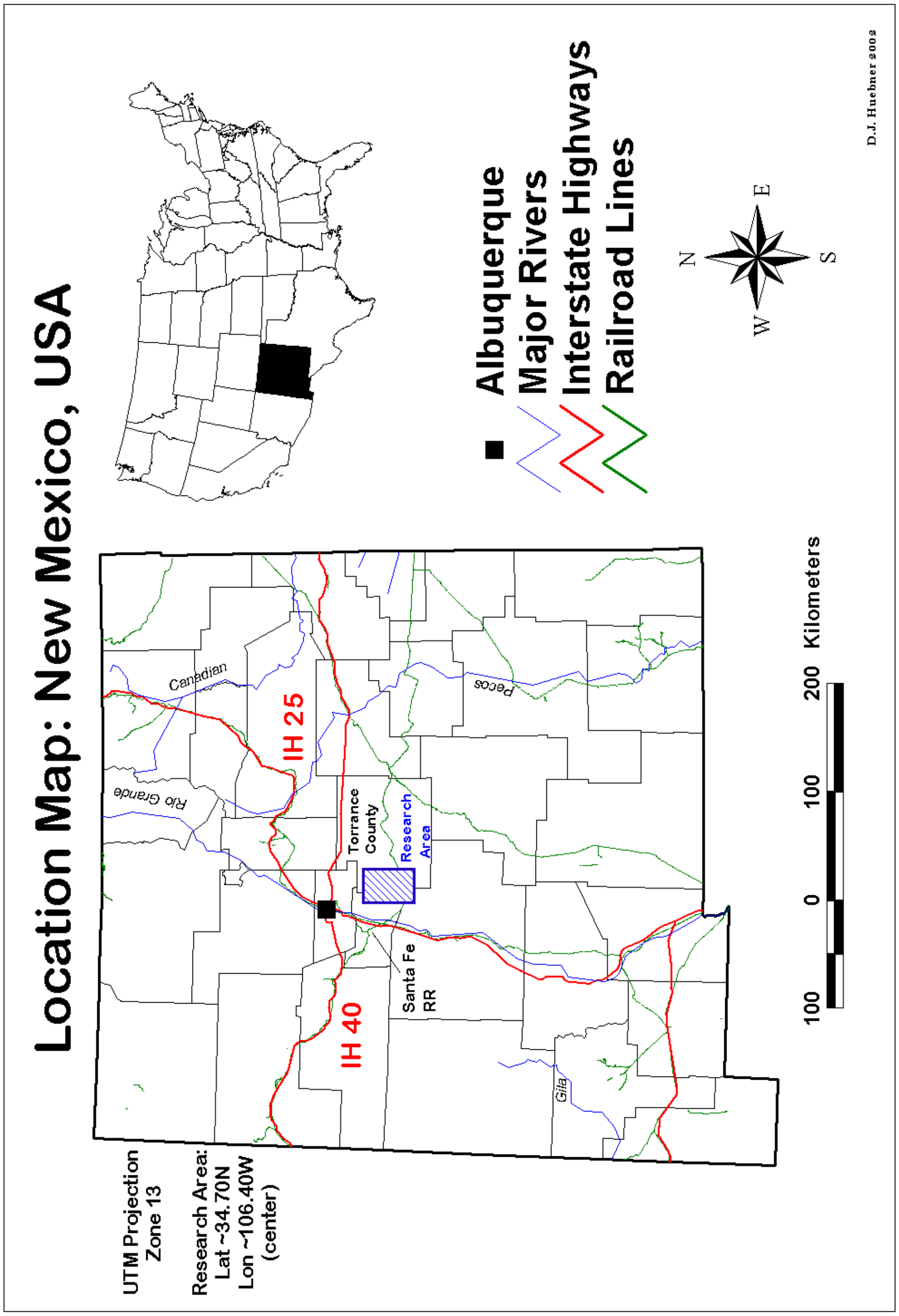


Figure 1. General location map of research area and Manzano Mountains. Albuquerque, New Mexico is located at the intersection of Interstate 25 and Interstate 40.

mining, rail and road construction, and recreation have affected various landscapes. Nonetheless, although the processes and effects may have similarities, there are differences in scale and timing. What is broadly applicable to a region may vary when we look at a specific place in detail. Landscapes have a "range of variability" that may differ spatially and temporally (Fletcher 1998). A "landscape" is the product of natural and human processes (Ruzicka and Miklos 1990). They are inseparable for one affects the other. This project identifies and documents these processes and effects to provide a baseline for the future.

Notions and assumptions regarding forest composition and structure, geomorphic change, and land use are readily available for many areas of the American Southwest. Nevertheless, one must exercise care before generalizing these conditions to other locations. For example, Charles Cooper's (1960) findings in his seminal work on southwestern pine forests and the role of fire are often applied commonly in Arizona and New Mexico but without field study and observation we cannot presume that his or others' conclusions are necessarily applicable to other sites. "Take into the field, for instance, an account of an area written long ago and compare the places and their activities with the present…" (Sauer 1941). I took Sauer's suggestion.

In contrast to Cooper's area of study in Arizona, Hispanic Europeans settled in the Manzano region much earlier (~1600s) than many other areas dominated by Anglo settlement. Further, livestock introduction, particularly sheep, occurred before the late 1800s. The Manzano's proximity to the long-settled Rio Grande Valley is different from Cooper's area of study. The pattern and timing of Hispanic and Anglo-American occupation is dissimilar. Moreover, land grants and town grant villages surround much of the southern Manzanos. Their presence creates different land use conditions than the tribal lands that Cooper worked on in Arizona. In no way does this lessen Cooper's or other worker's findings. To the contrary, there are number of similarities but the timing and pattern is different.

Conflicting Spanish and Mexican land grant claims precluded much of the southern Manzanos from homesteading until ~1900. Six years later, the Manzano Forest Reserve was created. Consequently, there is relatively little private land within the mountainous area. Private holdings, for the most part, are in the foothills creating an island of public land surrounded by private, tribal, and land grant holdings. Thus, for the past 100 years, management of forestlands has been with one agency, the US Forest Service. Their policies have affected the Manzano landscape and will continue to do so in the future.

Anthropogenic influence on this region has a long history yet the Manzanos remain different from many other mountainous areas in New Mexico. There are no paved roads through or across the range, resort facilities are for the most part absent, railroads never penetrated the mountains, and no lakes or rivers attract visitors. Furthermore, the Manzanos are adjacent to Albuquerque, the largest city in New Mexico. As it was ~200 years ago, livestock grazing remains as the principal commercial activity. Nevertheless, economics may bring about the demise of this predominant use of forestlands. What then becomes of this place and what are the management implications? Because these mountains are close to Albuquerque and its growing population, environmental pressure is escalating because of the continual demands of recreational use, land development for housing, and ground water extraction.

My study examines the historical ecology and environmental history of this region. Specifically, my focus is landscape change caused or exacerbated by human activity since ~1800. Although climate most likely had a role in environmental change, I will concentrate on several human activities that significantly altered this environment.

From 1675-80 until the early 1800s this region, particularly the east side of the range remained essentially unsettled by European settlers.

One hundred and twenty years allowed this landscape to recover to some extent from previous human disturbance by Native Americans and 17^{th} century Spanish missions.

Anthropogenic changes to environmental processes and ecosystems are not new to this area. Paleo-Indians hunted and roamed this area at least 10,000 years ago. Spanish missionaries of the 17th century located their mission churches adjacent to the Salinas Pueblos that were already 300-500 years old (Wilson 1973; Noble 1993). Prehistoric peoples affected landscape through agriculture, wood use, fire, and other disturbance processes (Denevan 1992; Kohler 1992). Furthermore, mission settlements modified the landscape by the same activities, and by the introduction of livestock, primarily sheep and goats. Nevertheless, the most damaging human disturbances to local landscapes have occurred since ~1800 when Hispanic settlers reoccupied the eastern foothills.

Livestock grazing and timber cutting are the primary causes of change to this landscape. Related to these factors are the effects of fire suppression. Recreational use and subdivision development of this area is a more recent agent but has had significant impact on the Manzano Mountains. All of these activities have current and future implications for land managers and stakeholders in this region.

Addressing change in this area at the landscape scale is appropriate because the agents of change are essentially the same throughout the study area. Moreover, climate, geology, geomorphology, vegetation, and natural processes, although differing at the micro-scale, are relatively the same at the macro level (Forman and Godron 1986).

The Manzano Mountains are isolated by surrounding lowlands. A tenuous connection to the Sandia Mountains farther north exists. Extensive plains beginning in Estancia Basin isolate the range on the eastern flank and a lower piedmont *llano* isolates the range from the Rio Grande Valley on the west side. To the south, Abo Cañon separates the Manzano Mountains from the Los Pinos Mountains.

The specific objectives of this research are:

- To describe current conditions in the Manzano Mountain area.
- To investigate processes and conditions that altered the landscape since ~1800.
- To document grazing history and landscape disturbance by livestock on vegetation and geomorphology.
- To describe the relationship between logging, grazing, and fire suppression.
- To address future management issues, establish a baseline for further study, and propose solutions to existing environmental problems.

I argue that significant landscape alteration and degradation began before widespread settlement by Anglo-Americans in the late 1800s. Early introductions by the Spanish of sheep and cattle had detrimental effects on the Manzano Mountain region, and Anglo settlers exacerbated these deteriorated conditions. Logging for lumber and railroad ties had extensive effects, particularly at lower elevations and eastern side valleys. Notwithstanding the above, recreation and population pressure from nearby Albuquerque may in the future have even greater long-term effects on this landscape.

Previous studies

Very little literature specific to the physical environment of the Manzano Mountains exists. There are a few surficial geology works cited in this research and one botanical analysis by Bedkar (1966). Wesley R. Hurt's study of the community of Manzano completed as a thesis in 1941 provides some clues regarding environmental conditions and processes that cause landscape change (Hurt 1989). Nevertheless, his investigation, although fascinating and useful, focuses on sociological issues. Fletcher's (1998) work, *Cibola National Forest: range of natural variability*, though not specific to the Manzanos, is a valuable study of similar areas in New Mexico, although specific references to the Manzanos are fewer than to other districts of the Cibola National Forest. Moreover, his landscape approach to ecosystem management is refreshing and pertinent. A number of other works cited in this project lend support to contentions and notions that I have regarding landscape change in the Manzano Mountains.

The Historical Ecology Handbook explains many of the techniques and procedures I used in this study (Egan and Howell 2001). I recommend this work as a guide for anyone contemplating landscape reconstruction from archival sources.

Field Work

Field work conducted between 1997 and 2001 supports many ideas raised by me and others and opened new avenues for further investigation. During field seasons, I noted vegetation, geomorphology, disturbance, livestock grazing, and cultural features. Most of this work required lengthy hikes and, sometimes, slow travel by four wheel drive vehicle over rough terrain. Roads do not connect the eastern and western sides of the range. Transit time from one side to the other can require up to three hours by vehicle, more on foot. Because most of the settlements now and in the past were on the eastern foothills, I concentrated more of my fieldwork there. Furthermore, “gang” members seriously vandalized the one public camping and parking area on the west side destroying or damaging toilet facilities, tables, and signs. On several occasions, their presence at this location limited the time I spent working there.

Conversations with long time residents of the area often revealed valuable information regarding location of features, weather and climate, and local history. Mr. Marvin McKinley, now deceased, was kind to answer my questions and give me permission to work on his property. So were Manuel Chavez of Torreon and Mike Padilla of Mountainair.

Visits to the area by Drs. Stephen Hall and William Doolittle helped focus and refine research questions and problems. Further, my familiarity with this areas dates to 1968 when I first visited the Manzanos. I have, with few exceptions, visited the area yearly for the past 32 years. During that time, I have noted changes both detrimental and non-detrimental to the environment.

Recreating the past: records, sources, and methodology

To recreate historic landscape conditions, several sources of archival information provided an abundance of information. Spanish explorers and settlers recorded very little or no information regarding vegetation and landscape conditions in this area and other parts of New Mexico (Leopold 1951). The first English language account noting vegetation and landscape conditions in the Manzano region is the diary and notes written in 1846 by Lt. James W. Abert, Topographical Engineers, US Army, while conducting a reconnaissance of the region during the Mexican War (Figure 2). Although his journey along the

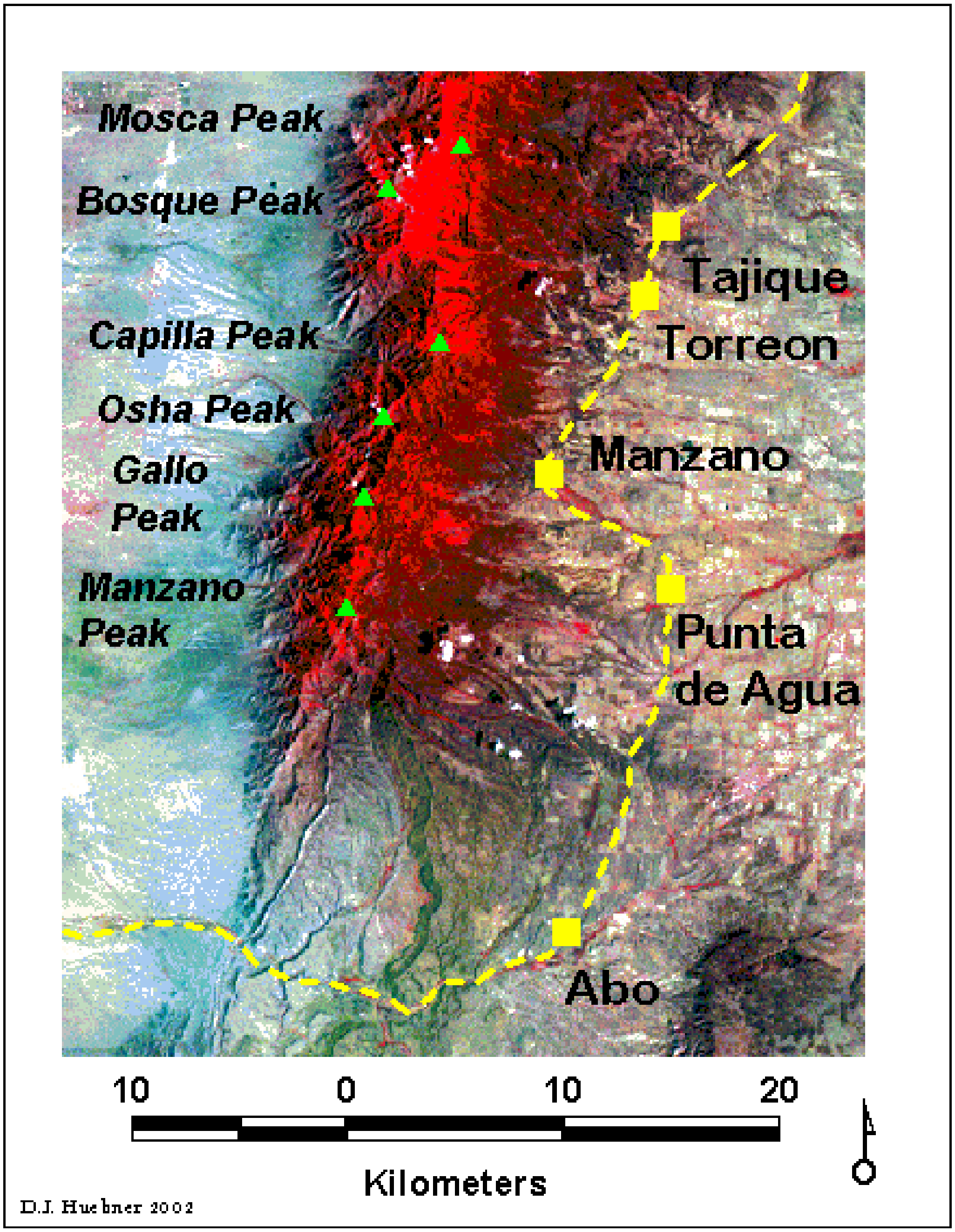


Figure 2. Lt. James W. Abert's 1846 route through the Manzano area. Imagery from North American Landscape Characterization project. Original imagery resolution is about 80 meters.

eastern front of the Manzano Mountains only lasted several days, his detailed notes, sketches, and water color paintings help establish a baseline of conditions then present. Abert, a West Point trained officer, was an astute observer, had botanical knowledge, and was an accomplished “field artist” (Figure 3). Particularly appropriate are the remarks made about Abert by John Galvin in his introduction to an edited version of Abert’s report (Galvin 1966):

> His diary of 1846-47 has little value as contributing to a record of conquest. It has value as a direct recital, from long ago, of experience and observation in a land then strange to the world at large since only the native Indians, the Mexican settlers, and a scattering of prospectors and traders from elsewhere knew the territory at all familiarly.

After the US defeated Mexico and acquired the New Mexico territory, other expeditions and explorations would follow. In December 1853, Major James H. Carleton, US Army, traveled the same route through the region that Abert had seven years prior (Bender 1934). Carleton’s report (Carleton 1965) did not include sketches and lacked some of the detail that Abert included but it is a first hand account of terrain and conditions encountered in the area. His commentary and observations regarding the Salinas Pueblos, however, were valuable to future archaeological work on the Spanish missions. Additionally, Carleton noted that Abó Pass would make a suitable route for future

Figure 3. Lt. Abert's drawing of Quarai Mission in 1846. This drawing would assist archaeological restoration in the future. The Manzano Mountains are in the background.

railroad lines. He was correct in this assessment, although it would be another ~50 years before the Santa Fe Railroad would use this corridor.

Essential to my study are the field notes of US Deputy Surveyors who began subdividing this region in the late 1850s into townships according to the US Public Land Survey System (White 1983). A more detailed analysis of these notes and records will follow in Chapter 4. I obtained the field notes on microfiche from the Bureau of Land Management in Santa Fe, New Mexico for the townships in and adjacent to the southern Manzano Mountains. In the study area, the earliest notes begin in 1856-57 and continue to the 1990s for some townships.

These notes are a voluminous record consisting of hundreds of mostly handwritten pages, sometimes difficult to decipher. As one would expect some surveyors were better than others about recording data and in a few cases the notes appear to conflict with topography. Overall, they are a tremendous first hand record of the landscape.

Survey instructions required that surveyors note timber, topography, vegetation, undergrowth, streams, character of soil, cultural features, and the presence of minerals. The instructions also required a “General Description” regarding the tract surveyed (GLO 1894; White 1983). The description summarized landscape characteristics and provided an excellent starting point for analyzing change.

Analyzing grazing conditions and patterns was a more difficult problem. There are no specific records before the 20th century. One must infer grazing conditions and numbers of livestock from other sources. Agricultural census data earlier than 1910 has limited value because Torrance County was not organized until 1903 from portions of Bernalillo, Valencia, Socorro, and Lincoln counties.

The US Forest Service has grazing allotment records dating back to the 1930s. The records are on file in the Supervisor's Office, Cibola National Forest, Albuquerque, New Mexico. Periodically, district rangers and more recently range management specialists would inspect the various grazing allotments in the national forest. Their reports normally provide information about conditions present in each area. Inspection reports also recommended procedures and stocking rates to limit overgrazing and erosion.

Some allotments had more records than others did and some inspectors provided more information than others did. Nonetheless, these reports are about the best long-term information available regarding range conditions. Not uncommon in allotment files were letters from citizens regarding grazing, and letters and instructions to allotment holders. I had access to these records and photocopied all available files for the Mountainair Ranger District allotments.

The US Forest Service cooperated admirably and made available various maps, photographs, and other information regarding grazing. Neither negatives nor extra prints were available for the photographs but I digitally scanned all pertinent photographs at the Supervisor's office for later analysis and reference. Chapter 6 reviews and synthesizes these records. With these records I documented grazing conditions for the past ~70 years on some allotments.

The US Forest Service Southwestern Regional Office, the Museum of New Mexico, and the New Mexico State Records Center and Archives also furnished area photographs. It was difficult to tell on most of the photographs an exact location from which the photographer took the picture. Because relatively few photographers documented this information, nor could I infer the location on many, repeat photography techniques were not practical. Further, because photography was not in general use until after the America Civil War (1865), one would not expect photographs of this area until later in the 19th century.

Landsat multispectral scanning system (MSS) imagery available from the Environmental Protection Agency and the US Geological Survey, North American Landscape Characterization project portrays general vegetation and landscape patterns but its ~80 meter resolution was often too coarse for detailed study. Nevertheless, these data are useful for broad analyses, as base maps, and to illustrate general land patterns and uses (Edmonds 2001). Aerial photography available from the New Mexico Resource Geographic Information System (RGIS) provided larger scale imagery that was geo-referenced for use in geographic information systems (GIS) (RGIS 2002).

Ethnicity terminology

Choosing terms to describe ethnicity and origin is sometimes controversial. In this study, to keep descriptions relatively simple, I will use several descriptions to refer to various peoples that settled or traveled through the mountains and surrounding locales.

- Paleo-Indian: refers to Late Pleistocene and early Holocene people
- Native American: refers to aboriginal inhabitants present at the Spanish *entrada*.
- Spanish/Spaniard: refers to those occupants under the rule of Spain but not Native Americans.
- Mexican: refers to people governed by Mexico but not Native Americans.
- Hispanic: refers to persons of Spanish or Mexican ethnicity.
- Anglo: people primarily from the United States, typically of northern European origin and who arrived in this area after ~1860.

These descriptions are general in nature and there is no intent to exclude other ethnic groups that settled this area. My inclusion and use of these terms is a way to simplify description of the various phases of settlement.

Significance and value of this work

This is the first extensive work on landscape change and historical ecology of the southern Manzano Mountains. As is true with many projects there is considerably more to do. Nevertheless, this work synthesizes and analyzes a large and diverse amount of information, confirms or changes many notions through field observation, illustrates that landscape degradation began before Anglo-American settlement, and will provide a baseline for future work. Further, the forest vegetation association map (Figure 9) I created is a valuable reference for current and future study of the region. Furthermore, it raises land management issue that agencies must address.

I know of no other work in central New Mexico, and in particular, the southern Manzano Mountains that has combined first hand accounts, historical documents and photographs, US Public Land Survey Records, US Forest Service grazing allotment records, and field observation to document landscape change.

Chapter 2

Research Area

Location, ownership, and jurisdiction

The Manzano Mountains are southeast of Albuquerque, New Mexico (Figure 1 and 4). The range extends ~60 km north to south, from Tijeras Canyon (Interstate Highway 40) to Abó Pass (Santa Fe Railroad tracks). Estancia Basin, the location of Pleistocene Lake Estancia, is to the east and the Rio Grande is west of the range. The focus of this study is primarily in the area administered by the U.S. Forest Service, Cibola National Forest, Mountainair Ranger District. National Forest area is 83,764 acres (33,899 ha) and the Manzano Wilderness Area on the west side has 36,970 acres (14,962 ha). The combined area is 120,734 acres (48,861 ha). A number of private inholdings fall within the boundary of the national forest. Most private land, however, borders the national forest. To the north of the primary study area is Isleta Pueblo. The unincorporated towns of Manzano, Chilili, Tajique, and Torreon are land grant villages that bound the eastern portion of the Manzano Mountain region. With the exception of a small portion on the west side of the mountains, most of the range is in Torrance County.

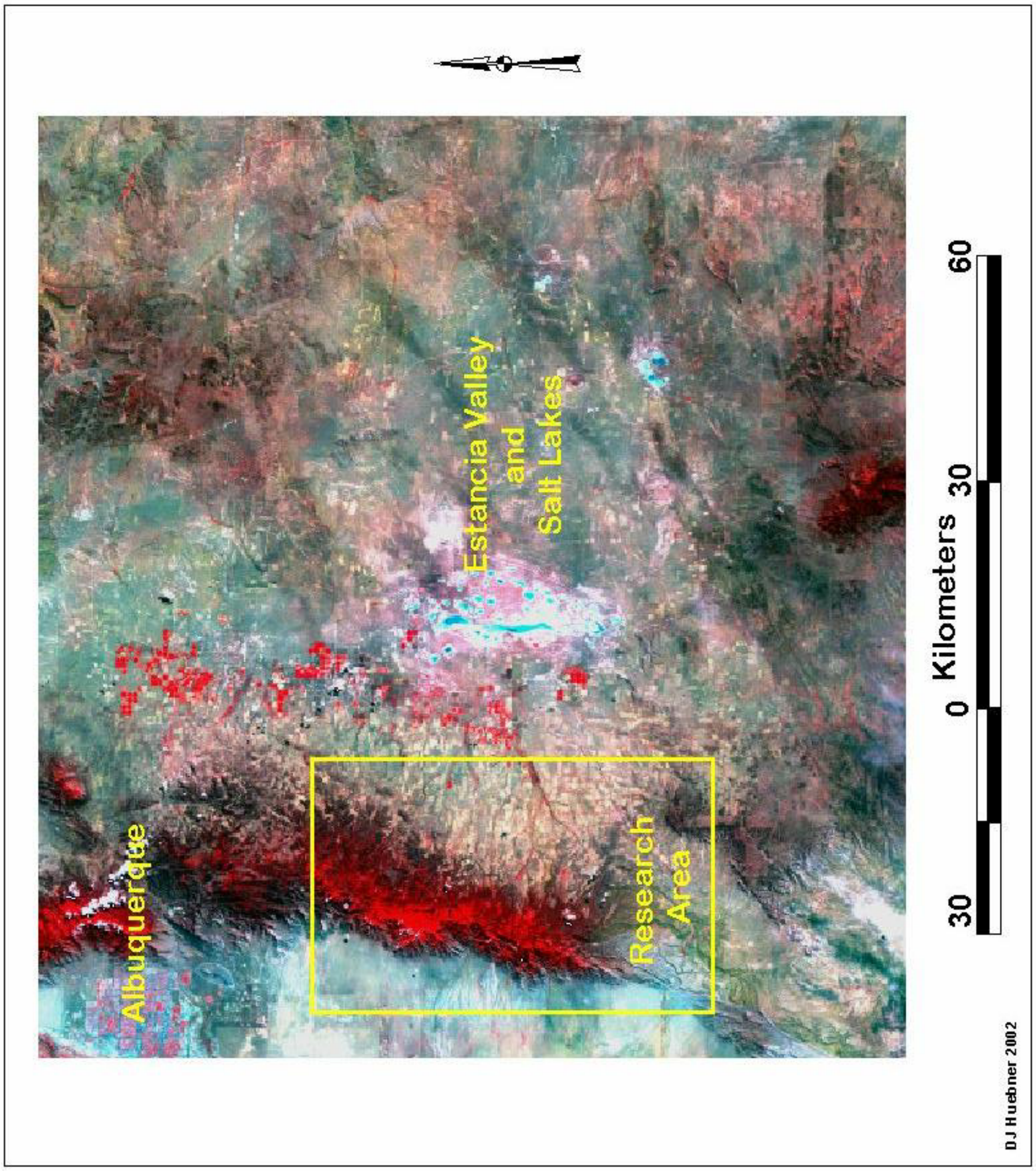


Figure 4. False color infra-red composite Landsat photograph (1990) of central New Mexico and research area in the Manzano Mountains. Red color indicates “healthy” vegetation. Irrigated fields are present on the east side of the mountains. Numerous alluvial fans drain the west side of the range. Data source: North American Landscape Characterization Project. The original image resolution was ~80 meters.

Geology and Landforms

The Manzano Mountains are a tilted fault block range located southeast of Albuquerque (Figure 5). This range consists primarily of Precambrian igneous and metamorphic rocks forming an unconformable contact with eastwardly dipping layers of Paleozoic sedimentary rock. Altitude ranges from ~1800 m (5900 feet) in the foothills to 3078 m (10,098 feet) at Manzano Peak. Slopes are generally steeper and more dissected on the west side (Figure 6 and 7).

Large alluvial fans consisting of Quaternary sands and gravels and deeply incised canyons draining into the Rio Grande Rift are typical on the western side of the range. Sedimentary deposits derived in part from the Manzano Mountains form the *Llano de Manzano*, a piedmont deposit that extends to the Rio Grande. The *Llano* contains a number of north trending scarps that are the result of faults (Stark 1956; Myers 1966; Myers 1967; Myers and McKay 1971; Myers and McKay 1972; Myers 1977; Maxwell and Wobus 1982; Connell 2001).

The eastern side of the range is less precipitous and has lower gradient slopes. Most of the eastern side drains into the enclosed Estancia Basin, a relict Pleistocene pluvial lake. Additionally, numerous north-south trending faults in the range compound the local geology. Currently, no perennial streams flow from the Manzano Mountains to

Figure 5. Digital elevation model of the southern Manzano Mountains. The view is from the southwest. Image derived from US Geological Survey 30 meter DEM data.

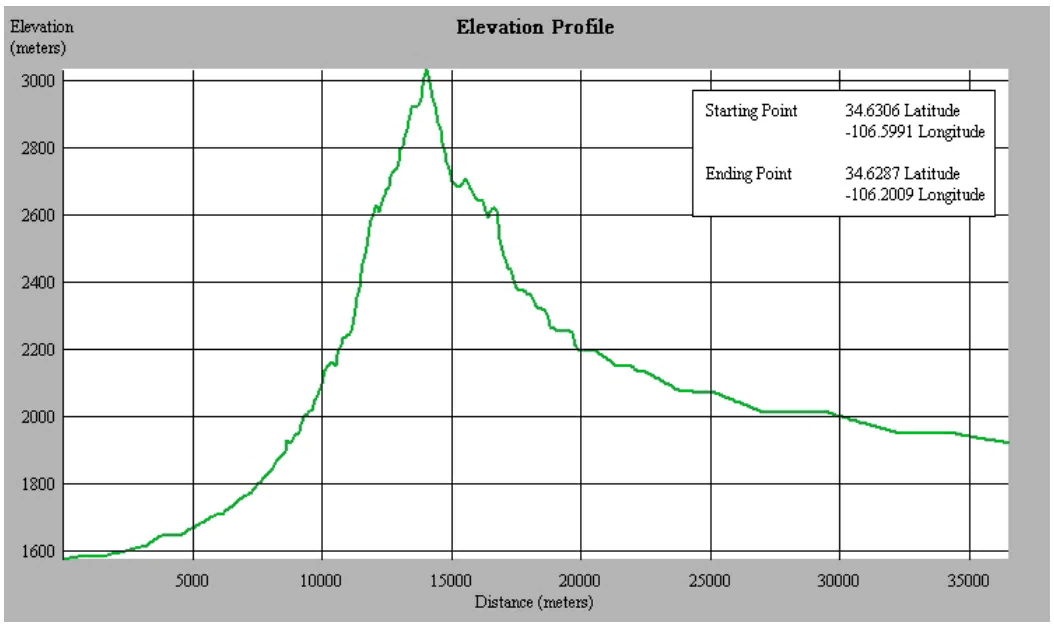


Figure 6. Topographical profile bisecting Manzano Peak, southern Manzano Mountains. Vertical exaggeration ~275%.

Figure 7. View of the west side of the Manzano Mountains. Montane vegetation rapidly changes to desert grasses and scrub. The view is northwest. The Rio Grande is in the distance. Photographed July 1999.

Estancia Basin or to the Rio Grande Valley. The range divides these two watersheds (Stark 1956; Kelley and Northrop 1975; Grambling 1982; Thompson, Grambling *and others* 1991). Scores of *arroyos,* in some cases related to historic grazing practices, logging, and changing climatic conditions (Denevan 1967), now dissect the Quaternary alluvial fans of the mountain range. On the east side, many of these *arroyos* terminate at about 1900 meters, the approximate high level stand of Pleistocene Lake Estancia.

There are no indications or records in the literature of Late Pleistocene alpine glaciers in the Manzano Mountains, although alpine glaciation was present in the higher elevation Sangre de Cristo range ~120 kilometers to the north, and ~140 kilometers south on Sierra Blanca Peak. Large talus fields and the remains of rock glaciers exist near the crest of the range in several locations (personal observation and (Maxwell and Light 1984).

Small deposits of gold, silver, copper, and lead are found in the southwestern portion of the range and in some Quaternary alluvium. These deposits are not significant and have little economic value because of low concentration ore (Maxwell and Light 1984). In the early 1900s a few small processing mills in the vicinity of Scholle produced copper (Lasky 1932). One may view the remains of the mills from US Highway

60 along the southern boundary of the Manzano Mountains. Scattered next to Forest Road 422 there are copper prospect diggings that are now abandoned.

Three major passes cross the Sandia/Manzano Mountain Ranges. Tijeras Canyon between the Sandias and Manzanos is now the route of US Interstate Highway 40. Southward, and beginning on the Isleta Reservation is Hell's Canyon, also known as *Cañon Infierno*. At the southern terminus of the Manzano Mountains is Abó Pass through which the Burlington Northern Santa Fe railroad tracks and US Highway 60 pass through. These three routes have served historically and pre-historically as routes over the mountains. By at least 1800, primitive wagon roads traversed these passes.

Soils

The 1970 Soil Survey for Torrance County describes most of the mountain soils as thin, stony, and generally unsuitable for crop production. For the most part, the Soil Conservation Service recommended timber production and livestock grazing on most of the soil types located within the national forest area.

Landscapes that developed on soils in deeper valley alluvium, although supporting crop production in the past, have mostly reverted to grass and range plants. The most eroded portion of the Manzanos is the southern foothills east and west of Forest Road 422. Soils in this locale formed in association with red beds (Abó Formation) that are highly susceptible to water erosion (USDA 1970). Consequently, numerous deeply incised *arroyos* are common and in some cases have incised to bedrock (Figure 8).

Weather and Climate

The Manzano Mountains are about equidistant (~1100 km) from the Gulf of Mexico and the Pacific Ocean. The climate is continental. Moisture in the winter, usually snowfall, is mostly from eastwardly moving storms originating in the Pacific. On a yearly basis, however, moisture from the Gulf of Mexico predominates. Most of this is rainfall associated with short, but intense, orographic and convective thunderstorms in the summer months. *Arroyos* that are normally dry can rapidly fill with water, reach flood stage, and quickly subside. These episodic events significantly affect local geomorphology, particularly on disturbed ground. Agriculturally, local climatic conditions favor livestock grazing rather than crop production (USDA 1970).

Weather information for the Manzano Mountains depends primarily on observations from stations in Estancia, Mountainair, and Tajique (USFS 1988). None of these stations is in the mountains. There is US Forest Service information that indicates precipitation varies from about

Figure 8. Salidito drainage in T3NR5E. This arroyo has incised to bedrock on its upward reach. US Public Land surveys did not note entrenched drainages in this township in 1882. Photographed in July 1998.

76 cm at the high elevations to about 20 cm in the lower foothills of the west side (USFS 1988). Snowfall is common from November to April (personal observation). Similar to most New Mexico mountain ranges, precipitation peaks in July and August with summer thunderstorms. Temperature varies from sustained periods below freezing during the winter months to highs of about 27° C during the summer months. Summer nights are generally 5-15° C with occasional freezing temperatures at higher elevations (Williams 1986; Huebner 1997). Temperature and precipitation vary considerably on an annual basis (USDA 1970).

From November 1997 to November 1998, I used a RL100™ temperature data logger from Ryan Instruments, Redmond, Washington to measure daily variation. During this time, temperature ranged from a low of -15.5° C on 11 December 1998 to a high of 27.5° C on 29 June 1998. Based on the last freeze date in the spring and the first freeze date in autumn, I computed the growing season length as 142 days for 1998. Table 1 details other temperature variables for January 1998 and July 1998.

Table 1. January and July 1998 temperature comparison. Temperature measured in degrees Celsius.

Month	Mean Low	Mean High	Max Daily Difference	Mean Daily Difference
January	-5.2	1.2	13	6.34
July	11.7	18.9	13	7.19

Modern Vegetation

Vegetation Associations or Zones

Landscape division by predominant or significant vegetation is an attempt to organize certain regions into manageable units for further study and analysis. The process is not perfect. One must keep in mind specification of particular associations. Nonetheless, various workers have devised different hierarchies to classify vegetation zones.

In the 1890s, C. Hart Merriam likened elevational change to latitudinal climatic change as a method to classify vegetation variance. In the Southwest, his method usually classified mountainous areas as Transitional, Canadian, or Hudsonian in character, that is, warm and dry to cool and wet (Merriam 1898; Dahms and Geils 1997). Vernon Bailey's study of life zones in New Mexico followed Merriam's classification scheme (Bailey 1913). Although often applied and still referenced in many cases, Merriam's method did not account for ecotones and local differences.

Several other classification methods attempted to correct the shortcomings of Merriam's classification with varying degrees of success (Daubenmire 1943; Marr 1967). To a large extent, the *General Ecosystem Survey*'s division of life zones in the Southwest improves earlier attempts at vegetation classification by recognizing the importance of biotic communities and ecosystems (Carleton, Robbie *and others* 1991; Dahms and Geils 1997).

The following descriptions of New Mexico vegetation associations use a combination of the *General Ecosystem Survey* and classifications used by Dick-Peddie (1993) and Brown (1994):

1. Coniferous and Mixed Woodland
2. Montane Coniferous Forest
3. Subalpine Coniferous Forest.

Table 2 summarizes the characteristic taxa and approximate altitudes for each category except Alpine Tundra which is not present in the Manzano Mountains (Dick-Peddie 1993; Brown 1994).

Notwithstanding the above, classification of vegetation zones remains complicated and subject to numerous local climatic, geological, and disturbance conditions. Furthermore, many mountainous areas of New Mexico exist as "mountain islands" (Gehlbach 1981) and they may have relict populations of certain taxa spatially isolated from previous and present distributions. Vertical compression and rapid shifts in flora are

Table 2. Vegetational associations characteristic of montane areas of New Mexico (Bailey 1913; Baker 1983; Dick-Peddie 1993; Brown 1994; Dahms and Geils 1997). Altitudes are approximate and vary considerably due to aspect, moisture, other local limits. Further, some characteristic species are not present in the Manzanos, notably Engelmann Spruce.

General Association	Significant or Characteristic Taxa	Altitude Range
1. Coniferous and Mixed Woodland	Juniper (*Juniperus* sp.) Piñon (*Pinus edulis*) Oak (*Quercus* sp.)	1500-2130 m
2. Montane Coniferous Forest	Ponderosa Pine (*Pinus ponderosa*)-lower zone Douglas Fir (*Pseudotsuga menziesii*)-upper zone White Fir (*Abies concolor*) Aspen (*Populus tremuloides*) Limber Pine (*Pinus flexilis*) New Mexico Locust (*Robinia neomexicana*)	2100-2750 m
3. Subalpine Coniferous Forest	Engelmann Spruce (*Picea engelmannii*) Corkbark Fir (*Abies lasiocarpa* var. Arizonica)-southern NM Subalpine Fir (*Abies lasiocarpa* var. Lasiocarpa)-northern NM	2700-3500 m

readily apparent in many isolated ranges such as the Manzanos of central New Mexico (Bedkar 1966). Furthermore, assemblages or associations are not static but may reflect only coexistence at a particular time and place (Forman and Godron 1986). Disturbance can rapidly affect the associations and their location.

1. Coniferous and Mixed Woodland

Also known as piñon/juniper woodland, this association is the most common forest type in New Mexico. At lower elevations, it often forms the transition to grasslands and at higher elevation grades into ponderosa pine forests. Shallow rocky soils characterize this zone. Typically this zone has cold winters with ~150 days below freezing but hot summers. Precipitation ranges from ~20 cm to ~50 cm. Furthermore, evaporation usually exceeds precipitation. Snow is an essential component of the moisture budget. Characteristic of this zone are open stands of trees with grasses, some forbs, and occasionally bare areas forming the under story. Gambel oak is often present in this zone and may dominate in certain areas. Alligator juniper (*Juniperus deppeana*) is another more dispersed species in this woodland. Junipers generally dominate the lower elevations and piñon the upper portion of this zone. Tree height is about 6 m but may increase to about 12 m at higher elevations. Humans, both pre-historically and historically, have used, and in many cases over-used, this zone for subsistence and habitation (Bailey 1913; Elmore 1976; Dick-Peddie 1993; Brown 1994; Dahms and Geils 1997).

2. Montane Coniferous Forest

Lower zone. This zone begins at the lower elevations as a transition from the piñon/juniper woodland. Ponderosa pine is the predominant tree and typifies this zone. Although cooler and moister (~55 cm to ~60 cm precipitation/year) than the lower woodlands, moisture stress is recurring in these forests. Gambel oak frequently forms extensive stands, often as an under story to pine but sometimes as the dominant species where pine has been clear-cut or destroyed by fire. New Mexico locust is also widespread in some areas. In mature stands, ponderosa pine may achieve heights of ~50 m and diameters (dbh) of ~1.2 m. The age class of larger trees is 300-500 years.

Ponderosa pine is ubiquitous in the West and furnishes much of the lumber used in the US. Human use has greatly modified this forest type by logging, grazing, and fire suppression (Cooper 1960). Once described as an open, park-like woodland with a grass under story, today's ponderosa forests form dense and sometimes relatively mono-specific stands (Cooper 1960; Bedkar 1966; Elmore 1976; deBuys 1985; Dick-Peddie 1993; Brown 1994; Dahms and Geils 1997).

Upper zone. Although ponderosa pine is often present in the lower sections of this zone, Douglas fir and white fir become the indicator species for the upper zone. Annual precipitation is higher (~70 cm/year) with more snowfall than lower zones. Udic soil regimes are typical. Snowpack melt is much slower than that of lower elevations due to lower average annual temperatures of 3°-4° C. Englemann spruce is frequently present at higher elevations (~3000 m) but may remain absent although suitable conditions are present (Bedkar 1966). Neither Bedkar nor I found Englemann spruce in the southern Manzanos.

Aspect, particularly at the lower limits of this zone, often defines forest composition. South-facing slopes will have ponderosa forests but Douglas fir is more common on north-facing slopes. In this zone aspen is a frequent indicator of recent fire disturbance, that is, within the past 150 years. An easily observed example is ~2000 ha of aspen forest (Aspen Basin) overlooking Santa Fe. (Bailey 1913; Benedict 1991; Dick-Peddie 1993; Dahms and Geils 1997).

3. Subalpine Coniferous Forest

This association constitutes the highest forests in New Mexico and continues to the treeline (~3500 m). Engelmann spruce is the predominant species but Subalpine fir (northern New Mexico) and Corkbark fir (southern New Mexico) are generally present. Cold temperature, not moisture, is the limiting factor in this zone. Low temperatures may reach ~ -30° C and highs about 25° C. About 225 days per year have temperatures below 0° C (Huebner 1997). High snow pack accumulations (1 m to >3 m) are normal with melting not occurring until May or June and in some small areas remaining throughout the summer. Forests in this zone often form closed canopies that shade the ground and further decrease moisture loss. At the transition to alpine tundra many trees exhibit *krummholz* growth as a response to increasingly harsh alpine conditions. Subalpine forests store and release moisture gradually and are critical to many watersheds in New Mexico (Benedict 1991; Dick-Peddie 1993; Dahms and Geils 1997).

In summary, vegetation in the Manzano Mountains varies with elevation, slope aspect, and moisture availability (Figure 9 and 10). These factors determine where certain species are present. Frequently species associated with higher elevations such as Douglas fir are found at lower altitudes because of moisture availability. Conversely, many lower elevation species, such as piñon and juniper are found on high altitude xeric ridges.

At lower elevations on the east side, piñon-juniper (*Pinus edulis* and *Juniperus* sp.) woodlands are predominant in the foothills that rise from Estancia Basin and the eastern plains of New Mexico.

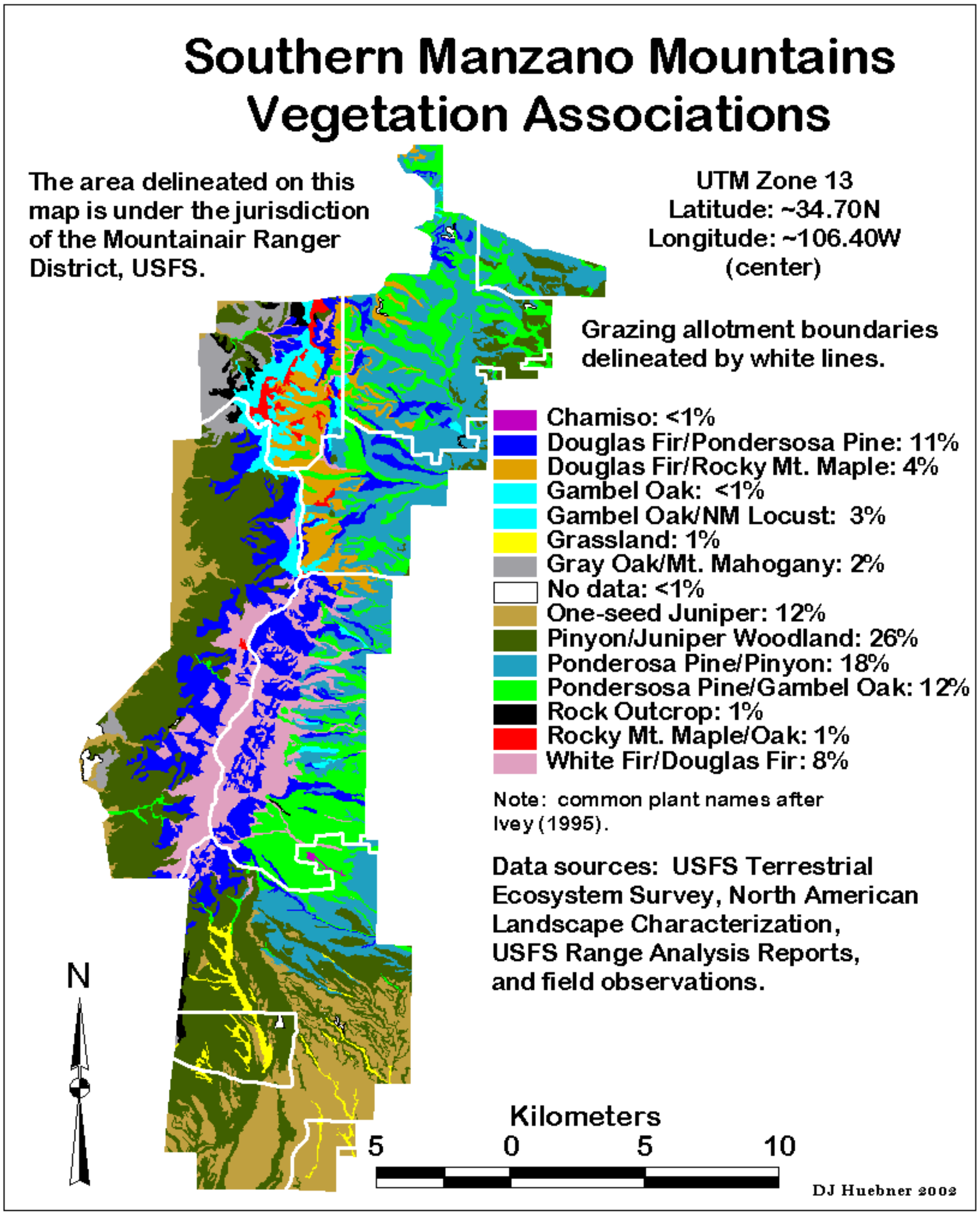


Figure 9. Vegetation associations of the southern Manzano Mountains.

Figure 10. Vegetation associations at higher elevations. This photograph looking north was taken from Capilla Peak in July 1999. It illustrates the variation in vegetation in the upper montane/sub alpine coniferous forest. Gambel, ponderosa pine, Douglas fir, mountain mahogany are visible. The two peaks in the background are Mosca and Guadalupe. The boundary to Isleta Pueblo is near the two prominences.

On the steeper and more arid west side this woodland rapidly shifts at lower altitudes to desert scrubland consisting mostly of cacti (*Opuntia* sp.), Apache plume (*Fallugia paradoxa*), chamisa (*Chrysothammus nauseosus*), saltbush (*Atriplex* sp.), and sage brush (*Artemisia* sp.) that is interspersed with desert grasses and forbs. On both the east and west sides, increases in altitude relate to vegetation change. Particularly on the west side, vegetation changes rapidly as the terrain rises about 12 meters per 100 horizontal meters. Rising from the lower slopes, the juniper and then piñon-juniper woodland changes to a lower montane coniferous forest (<~2600 m) of ponderosa pine and Gambel oak (*Pinus pondersa* and *Quercus gambelii*). This is the predominant vegetation association in the Manzano Mountains. Frequently, Gambel oak occurs in dense, almost monospecific thickets. Interspersing this zone are aspen (*Populus tremuloides*) on fire disturbed terrain, and stands of Rocky Mountain maple (*Acer glabrum*) in moist canyons. Mountain mahogany (*Cercocarpus* sp.) is an important browse plant. The upper montane coniferous forest (>~2600 m) consists primarily of Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), aspen (*Populus tremuloides*), and various pines (*Pinus* sp.). There is no alpine tundra in the Manzanos and tree growth continues to the highest elevations. On several exposed and xeric ridges I have observed stunted (*krummholz*) stands of fir, oak, and pine (Bedkar 1966). Generally, forests are more extensive on the more gradual and moister eastern slopes.

Identifying "natural" mountain meadows (Figure 11) of grasses and sedges (*Poa pratensis, Muhlenbergia* sp., *Sitanion bystrix*, *Bouteloua* sp., *Bromus* sp., *Hordeum jubatum*, *Carex* sp.) is uncertain due to long-term human disturbance from grazing, timber cutting, and fire suppression (Allen 1989; Allen 1996; Allen, Betancourt *and others* 1997). There are patches of fescue (*Festuca*), non-native Kentucky bluegrass (*Poa pratensis*), muhly (*Muhlenbergia*), and various wildflowers and forbs scattered throughout the range (Bedkar 1966; Dick-Peddie 1993) personal observation).

Several *cienega* and bog-like areas also contain numerous species of grasses and sedges (Figure 12). Montane riparian plants such as *Salix* sp.*, Acer glabrum, Populus acuminata,* and *Prunus virginiana* occur around springs and in shaded mesic canyons. Although these moist environments are scarce they are important habitats that attract not only native animals but livestock (Figure 13). Consequently, mesic areas have sustained considerable impact from cattle trampling and subsequent erosion. Bedkar (1966) also noted this pattern.

Figure 11. A mountain meadow. Photographed looking north, meadows such as this are often found in saddles along the crest. The meadow measures about 144 m long by 80 m wide. Vegetation consisted primarily of Kentucky bluegrass, *Bouteloua* sp., yarrow, composites, and sedges. Trees surrounding the meadow are mostly, Douglas fir, limber pine, and aspen. Although some trees have died, others are encroaching on the grass/forb area. Location is UTM Zone 13 0367341E 3829631N. Photographed in July 1999.

Figure 12. *La cienegita.* Located in Section 10 and 11, T4NR5E, this meadow is mostly sedges. Several areas have depressions where water has risen to the surface. The forest service has blocked the road to this area and trying to protect it from grazing damage. Photographed in July 1997

Figure 13. Cattle at *La cienegita*. Cattle loafed in the shade surrounding wet ground. In July 1997 when this photograph was taken, there was evidence of soil compaction by hooves and fecal contamination. Some tree encroachment is occurring at the edges of the wet meadow.

Since the creation of the national forest in the early 1900s, fire suppression has altered species composition and distribution. Late 18th and 19th centuries' tree ring data suggests a mean fire interval of 7.4 years (Baisan and Swetnam 1997). Their study reported no major fires in this area since 1896; however, the samples were collected only from areas above 2500 m. Information at lower elevations closer to settlements is lacking but these data imply more open stands of forest with a grass and forb under story. As in many southwestern forests, tree and woody growth densities have increased while under story grasses and forbs have declined (Allen 1989). This decline places more stress on existing mountain meadows, *cienegas*, and riparian areas due to livestock foraging and recreation.

Modern Fauna

Fifty-five species of mammals were identified as occupying the Manzano Mountains and its foothills (Appendix 1). The species listing is based on reported occurrences and, in some cases, a probable range based on occurrence in the Sandia Mountains immediately to the north, and distribution to the south in the Gallinas or Sacramento Mountains (Findley, Harris *and others* 1975; Hall 1981; Findley 1987; Graham and Lundelius Jr 1994). The wolf (*Canis lupus*) was recently common, but was exterminated during the 20th century (Findley, Harris *and others* 1975).

The majority of mammals are rodents. Twenty-eight of the 75 rodents known in New Mexico occupy this area. Ten species of Chiroptera and 11 species of Carnivora are reported. The largest predator is the black bear (*Ursus americanus*). Elk (*Cervus elaphus*) and bighorn sheep (*Ovis canadensis*) are modern re-introductions with relatively low populations (Findley, Harris *and others* 1975; Findley 1987).

Although there is some overlap, vegetation associations, such as montane forest and piñon-juniper woodland often determine the range and distribution of mammals in the Manzanos. Others are found only on the more xeric foothills of the range. The catalogue of species lists order, family, specie, and common name. I also noted whether I have observed the animal.

Significantly lacking in this area but historically present are beaver (*Castor canadensis*).   Fashion whims in the early 1800s placed beaver in high demand for hat making. Trappers and fur traders were some of the first US explorers of the New Mexico region and Taos and Santa Fe were centers of the fur trade (Cleland 1950; Horgan 1954). As trappers made their way down the Rio Grande they exploited any area having a population of beaver. The population of beaver in the Manzanos was mostly likely small compared to more extensive montane areas of New Mexico and the Southwest. Nevertheless, the extermination of beaver altered riparian areas and wet meadows and has had important long-term effects (Findley, Harris *and others* 1975).

Little evidence remains of beaver activity. A wet meadow on private property in Section 14 T6N R5E is most likely the remains of an area altered by beaver activity (Figure 14). A core sample that I extracted at 2.14 meters depth in July 1997 returned a radiocarbon date of 465 $\pm$ 52 years BP and a corrected date of 423 $\pm$ 52 years BP (TX-9343). Based on isotopic analysis, Salvatore Valastro, then Director of the Radiocarbon Laboratory at the University of Texas, surmised that these sediments had been perennially wet (personal communication). The topography and sediments of the wet meadow is consistent with beaver created habitat (Butler 1995). Notably, this meadow was not incised by the intermittent stream now flowing through it until 1941, an unusually high rainfall year (personal communication, Marvin McKinley, 1997).

In Trigo Cañon on the more arid west side of the range, one can still find beaver gnawed wood (personal observation and Fletcher (1998). This canyon now drains into an *arroyo* that is about 24 km from the Rio Grande. Except during heavy runoff, this is *arroyo* is dry and not suitable

Figure 14. Wet meadow. This meadow in Section 14, T6NR5E exhibits many characteristics of a meadow created by beavers. The wet meadow is located on private property below Forest Road 55. Photographed in July 1998.

beaver habitat.   Conditions 140 years ago may have been different because in 1860, John Garrettson, US Deputy Surveyor noted on his plat of Tomé Grant (Garrettson 1860) that the stream flowing out of Trigo Canon as “a beautiful stream of pure and excellent water” 15 links wide (~10 feet or ~3.0 meters). Nevertheless, his plat shows the stream ending shortly after exiting the mountains. In my thirty years of observation in the Manzano Mountains I have never seen water in this *arroyo* except after heavy rainfall or after heavy snowmelt. Mesic conditions, in part caused by high canyon walls that shade the canyon, do exist at higher elevations.

Beaver may have been a keystone species in this ecosystem (Mills, Soule *and others* 1993) and their extirpation resulted in significant watershed and riparian vegetation changes. Instead of steady but slower release from beaver dammed ponds, runoff became more rapid and episodic. These changes no doubt affected other species dependent upon these resources (Fletcher 1998).

Predator control associated with livestock production eliminated or severely diminished the population of large mammals such as bears, wolves, and mountain lions. Black bears were almost extinct in this area in 1927, and were scarce in the 1950s (Clothier 1957). Clothier noted the absence of Abert's (Tassel-eared) squirrel (*Sciurus aberti*) in his study. Currently, this species is common in ponderosa pine forests.

Fur trapping remained a viable activity in the region at least into the early 1900s. Tenos Tabet operated a store in Manzano and reportedly made a profit of $1000.00 in 1902 (about $18,000 in 2002) from hides and pelts (Hurt 1989). Considering the relatively low price for pelts at the time, his profit and the number of pelts traded were substantial.

Human Occupation and Settlement

Human occupation of the Manzano Mountains and the adjacent Lake Estancia Basin dates to a least 10,000 years ago. Artifacts and fossil remains in caves and at plains kill sites suggest an early presence of paleo-Indian hunters (Hibben 1941; Hibben 1951; Stevens and Agogino 1975; Myers 1977; Cordell 1984; Graham and Lundelius Jr 1994). Permanent occupation by sedentary Native Americans occurred about 1100 to 1300 A.D. along the eastern foothills of the Manzano Mountains. Extensive salt deposits present in the lake bed of Pleistocene Lake Estancia (Figure 15) were a valuable resource until the mid 20th century both for pre-historic and historic settlements (Kraemer 1972).

Figure 15. Salt lakes in Estancia Basin. Salt from these deposits has been used pre-historically and historically. During Spanish colonial rule, salt was exported to Mexico. Numerous small “lakes” similar to the one in the photograph are scattered across Estancia Valley. Photographed in July 1998.

Characterized as the Salinas Pueblos because of proximity to the salt deposits, it was the occupants of these pueblos that Spanish soldiers and explorers associated with Don Juan de Oñate encountered in 1598. By the mid-1600s several Franciscan priests located their missions in association with the Salinas Pueblos. The National Park Service now protects the ruins of several of these substantial structures (Figure 16).

Diseases introduced by Europeans drastically reduced the population of Native Americans (Crosby 1972; Denevan 1992). Because many of Pueblo people died shortly after the Spanish *entrada*, mission settlements may have had fewer detrimental landscape effects than the higher population Native American settlements had prior to contact with the Spanish.

The impact of livestock introduced by Oñate and the Franciscans to this area remains unstudied and unknown. Moreover, the presence of established Puebloan agriculture may be responsible for a diminished role for large numbers of potentially damaging cattle in area missions (Jordan 1993). Nonetheless, mission documents and reports note the presence of sheep, goats, and cattle (Ivey 1988). Reportedly, a number of large *ranchos* occupied land between the various missions (Ivey 1988), however, little is known about them.

Figure 16. Quarai, Salinas Pueblos National Monument. This mission is close to the town of Punta de Agua on the east side of the Manzano Mountains. The Franciscan friars abandoned the mission and area 1675-79. Photographed in July 1999.

By 1679, the Franciscans abandoned the Salinas Pueblo missions due to marginal crops and Apache depredation (Kraemer 1972). In this semi-arid region agriculture was difficult and a few drier than normal years would result in serious food shortages. The abandonment was complete with the Pueblo Revolt against the Spanish in 1680. Until Spanish settlers returned to the area about 1800, the eastern Manzano Mountain region and nearby Salinas Pueblos remained relatively abandoned by European settlers. The Spanish and Mexican colonial period lasted until 1846 when the US Army occupied New Mexico. Small-scale subsistence farming and stock raising communities characterized the area after 1800. Farmers kept their fields close to their homes and tended to raise sheep rather than cattle. Field notes of the public land survey records on file at the Bureau of Land Management in Santa Fe frequently mention “large” or “considerable” numbers of sheep in surveys of various townships of this area. Nevertheless, depredation from Plains Indians remained a problem.

The population of this region was overwhelmingly Hispanic with most residents living in several small land grant villages such as Tajique, Manzano, Torreon, and Chilili on the east side of the mountains. On the west side of the range Tomé Grant, Casa Colorado Grant, Belen Grant, and the Lo de Padilla Grant (Isleta Pueblo) extend to the mountains

(Figure 17). Most residents on the more arid western grants lived in the Rio Grande Valley and practiced irrigation agriculture. The Rio Grande Valley settlements were much further from the mountain area (~24 km). Nonetheless, they used the mountains for grazing, timber, and fuel wood Agriculture changed little in this area of New Mexico until about 1875-1880 with the establishment of large cattle ranches on the plains (Baxter 1987; Hurt 1989).

There are two exceptions to the smaller eastern side village land grants noted above. Both the Bartolomé Baca Grant and the Estancia Grant (Figure 18) were large parcels of land (~500,000 acres or ~202,000 ha) primarily on the plains of Estancia Basin to the east of the Manzano Mountains. Both of these claims were later rejected by the US Government as invalid. Both grants raised large numbers of livestock which no doubt had effects on both mountain and plains landscapes.

Baca received his grant in July 1819 from Acting Spanish Governor Facundo Melgares for his service to the crown. The original grant extended from the summit of the mountains eastward on to the plains of Estancia Valley. Between 1819 and 1833 Baca reportedly grazed as many as 40,000 head of sheep and 900 head of cattle on this grant (Bowden 1969). Based on herding patterns in other areas of New Mexico, herders moved bands of sheep into the mountains late in the

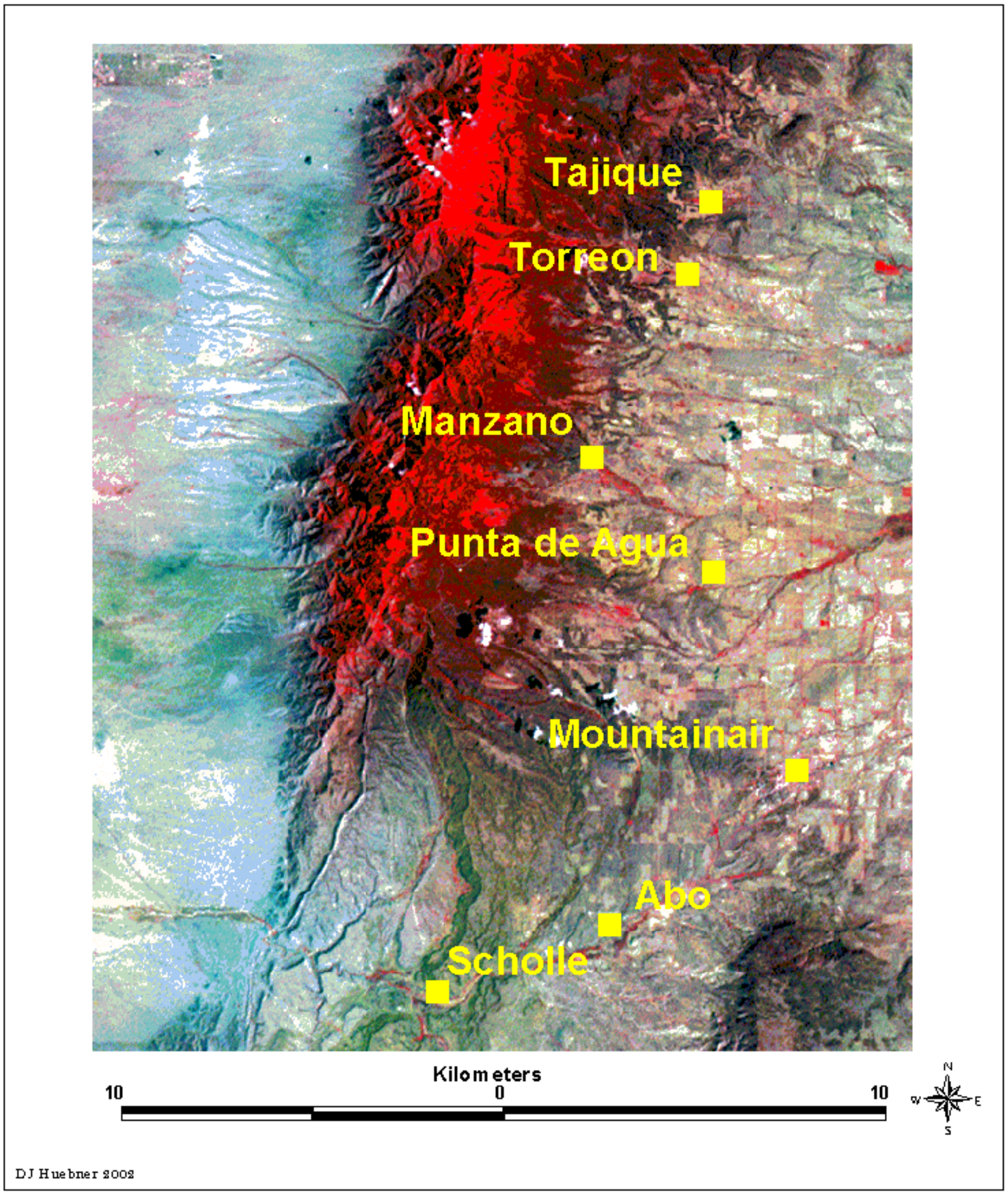


Figure 17. Local villages and towns in the southern Manzano Mountain region portrayed on a color infra-red image. Imagery from North American Landscape Characterization Project, US Geological Survey, 1990 Landsat MSS image (Edmonds 2001).

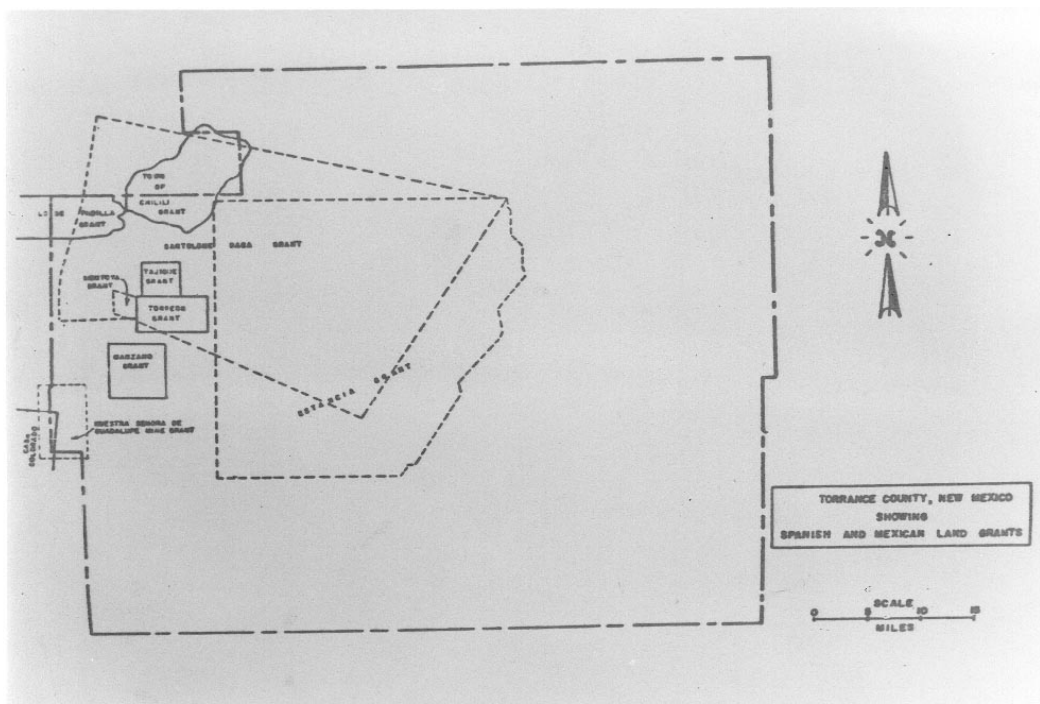


Figure 18. Land grants in Estancia Valley. Confusion over overlapping boundaries created legal turmoil and both the Estancia and Baca grants were not confirmed by the US. The outer border line is present day Torrance County. Courtesy New Mexico Records Center and Archives. SRC Misc. 35519.

spring for summer grazing on more mesic terrain (deBuys 1985; Baxter 1987). Further, the mountains often provided a refuge for the herds from Navajo and Apache raiders (Simmons 1982).

Baca abandoned his grant ~1833 because of Navajo raiding and theft of stock. Many of the herders moved on to the recently established (1829) land grant Town of Manzano. Baca died in 1834 and his heirs did not reoccupy the grant. In 1877 Baca's grandson, Bartolome Chavez y Baca sold the grant to Manuel Otero. Otero tried to patent the grant with the Surveyor General of New Mexico but the claim was subsequently rejected on a number of legal and practical points. During this time of litigation, however, ~35,000 sheep grazed on grant lands. Legal challenges, shootings, and other problems continued over the claim until 31 January 1898 when the Court of Private Land Claims rejected the grant (Bowden 1969).

The Estancia Grant overlapped the Baca Grant. The overlapping areas were part of the legal challenge to the Baca Grant. Although this grant did not extend into the mountain area it affected the Manzanos. Antonio Sandoval received this grant from Governor Manuel Armijo in December 1845 for grazing his large herds of livestock that consisted mostly of sheep. Again, a long series of legal challenges and violence accompanied the attempt to patent this claim. In April 1901, the US

Supreme Court on an appeal rejected the Estancia Grant (Bowden 1969; NMSPO 1971, 1981). For a more complete discussion and history of New Mexican land grants one should consult Bowden's extensive work on this issue.

Beginning in 1857, a number of land grants in the Manzano region were surveyed according to the US Public Land Survey System. The extensive notes made by the Deputy US Surveyors provide information about vegetation, terrain, and settlement.

With the denial of certain land grant claims by US courts in 1898, most of the land in and around the east side of Manzano Mountains became public domain. In 1905, the US Government opened the rejected land grant for homesteading. An executive order dated 6 November 1906 established the Manzano Forest Reserve (Roosevelt 1906). On 3 December 1931 the name was changed to Cibola National Forest (Baker, Mazwell *and others* 1988). With the creation of the national forests, the forest service established land use guidelines that included rules for grazing livestock in the national forest (Pinchot 1905).

Controversy over guidelines, use parameters, and fees would be a major problem for the US Forest Service in the years to come. Stock owners objected to fees and limits on the number of livestock permitted in the forests. A number of legal challenges over grazing fees and fencing of the range hindered early management of the forest reserves. In 1911 the US Supreme Court upheld the government's authority to regulate and charge fees for grazing on public lands (Rowley 1985). Nevertheless, debate over grazing on forestland continues today and remains a major issue between ranchers and environmental organizations.

After settlement and resolution of various land claims, homesteaders began to occupy the area. Although sheep raising remained important for a number of years, irrigated agriculture gradually replaced sheep ranching on the plains of Estancia Valley. Irrigation with ground water commenced in 1910 and large-scale irrigation followed in the 1930s.

The extension of the Santa Fe Central railroad into Torrance County in 1902-03 encouraged settlement of the region. In 1907, the construction of the Belen Cut-off track fostered further population growth. For many years pinto beans were an important crop both on the plains and in the mountain foothills. This is, however, a semi-arid area and much land that was previously in cultivation has now reverted to range land. In a letter to J. Frank Dobie dated 17 October 1960, J.C. Dykes of College Park, Maryland stated that this range was good grass country but had shifted to beans. The long-term drought of the 1950s convinced locals to return to grass range (Dykes 1960).

Anthropogenic Disturbance

Disturbance is an occurrence that causes change or disruption of "normal" patterns in an ecosystem or landscape. These events may be physical such as climate change, landslides, wind, lightning, floods, and fire, or biotic, such as disease, pests, and animal or plant activities. Usually, landscapes have adapted to and evolved with a certain set of disturbance regimes (Forman and Godron 1986; Huggert 1995).

Before European exploration and settlement of the Southwest, it was these "normal" processes that for the most part affected or caused landscape change and perturbations. Undoubtedly, native peoples had an effect, sometimes highly detrimental, on the landscape. Nonetheless, it was, for the most part, confined to their immediate surrounding area (Dahms and Geils 1997). European settlement, however, significantly altered Southwestern forests and in come cases, local geomorphology.

The introduction of livestock and fire suppression coupled with commercial logging would cause considerable change throughout Southwestern landscapes but particularly in two forest types– piñon/juniper woodlands and lower montane forests of ponderosa pine. Furthermore, documentation exists for these two zones. Before widespread settlement by US citizens, a number of scientific and military surveys explored the Southwest in the mid-1800s. Considering their reports, we know that significant alteration of New Mexico forests began in the 1800s and continues today (Cooper 1960; deBuys 1985; Dahms and Geils 1997).

Nonetheless, my work in the Manzanos indicates that considerable landscape change in the Manzanos began prior to changes in other, more remote areas of New Mexico and the American Southwest because of the grazing practices of Hispanic stock raisers before US settlement. A similar pattern appears to exist for the Chuska Mountains in northeastern Arizona where Navajo introduced sheep in the 1700s (Savage and Swetnam 1990).

In many areas of the Southwest, early accounts portray ponderosa forests as open and park-like with a grass/forb under story and wide-spaced enough to ride through them on horseback (Figure 19). The presence of grass was a frequent observation of early travelers and explorers because of their reliance on horses and other pack animals that eat grass (Leopold 1951).

Today's Southwestern pine forests have little resemblance to earlier accounts. Most stands are now thick with immature trees and seedlings. One usually finds little or no grass but instead a litter covered forest floor. No doubt over-grazing and logging are partially responsible. Nonetheless, most of the change is due to fire suppression since the

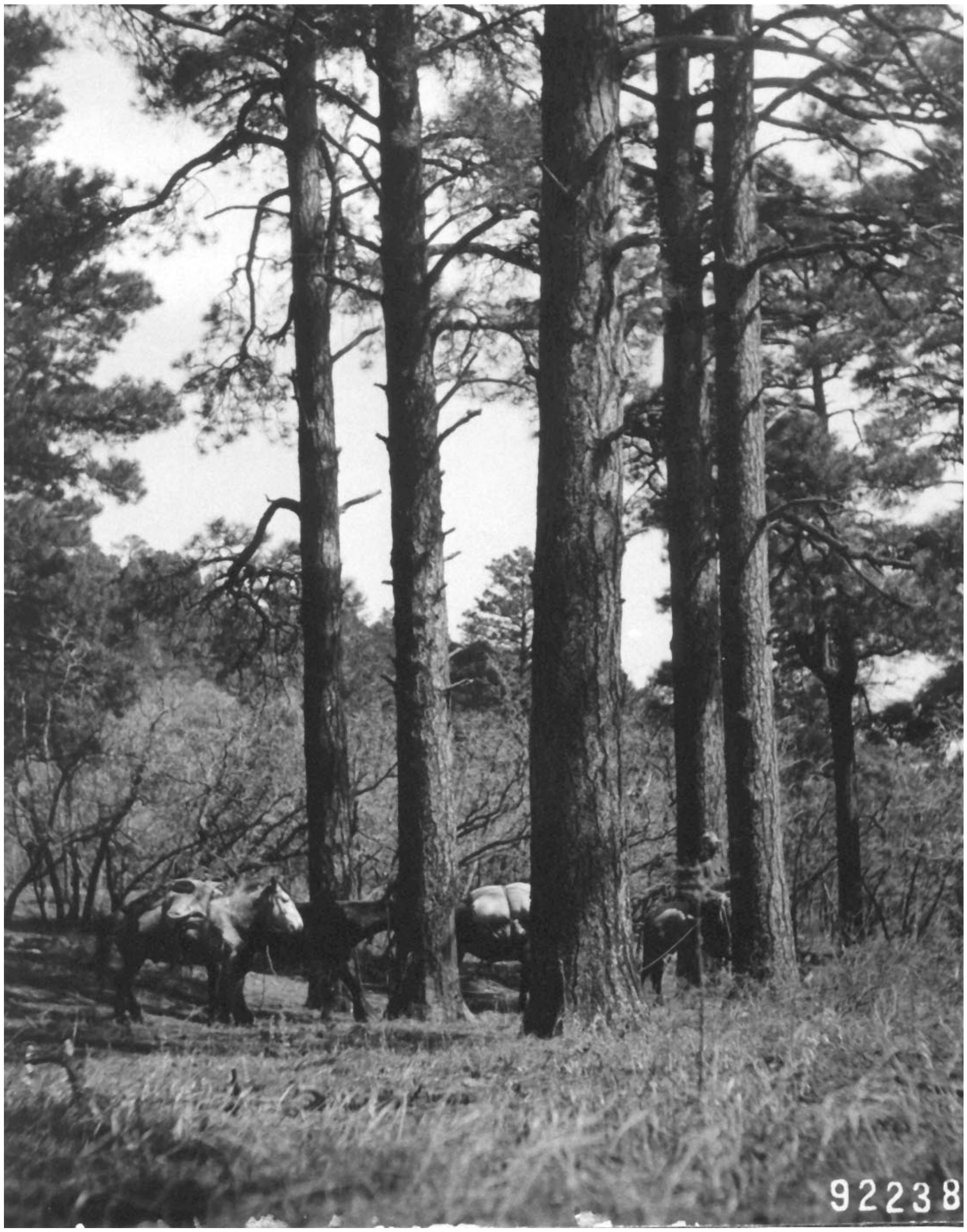


Figure 19. Ponderosa pine forest. The original forest service caption reads, “stand of veteran ponderosa pine trees on east slope of Manzano Mountains, T6NR5E. The trees contain from 1000 to 2000 board feet.” The oaks behind the horses are larger than one would expect for a regularly burned area. Courtesy of US Forest Service, Region 3. No date on photograph but probably taken ~1900 to ~1910.

early 1900s. Early foresters considered the open stands “wasted space” that had not reached its potential productivity. In their view, fire was the culprit. Fire, however, was critical to maintaining the system, a system that evolved under a fire regime (Cooper 1960; Dick-Peddie 1993; Dahms and Geils 1997).

Routine burning, whether naturally caused by lightning or set by Native Americans, kept the forest open (Swetnam and Baisan 1994). Numerous fire history studies document a frequent fire interval in ponderosa forests throughout the Southwest. Tree ring data suggests that mean fire intervals were about 5 to 15 years (Cooper 1960; Stokes 1980; Allen 1989; Allen 1996; Baisan and Swetnam 1997). Although fires were frequent they were not necessarily catastrophic. Rarely did fire spread to the canopy and cause extensive destruction. Normally, most fires occurred in the under story of grass that quickly recovered. Over-grazing by livestock contributed by eliminating grass, a low intensity fuel that burned close to the ground. Nevertheless, the open stand forest existed during Spanish rule when livestock numbers were also very high (Dahms and Geils 1997). Transhumant livestock practices may have mitigated to some extent the large number of Spanish sheep and cattle present in the area (Butzer and Butzer 1995). Further, because of Native American depredation and the presence of large mammalian predators, livestock was generally kept close to settlements and tended by herders. Sheep almost without exception required herders that would direct them to grazing, water, and provide protection from predators.

Without periodic but low intensity fires, Southwestern forests now contain substantial amounts of litter, ground fuel, low branches, and thick stands that are highly susceptible to destructive canopy fires. When fires do occur they spread rapidly and often destroy not only entire trees but because they burn “hotter” much of the under story vegetation recovers more slowly. This type of fire has an effect on geomorphic processes. Without vegetative protection, accelerated erosion usually occurs until the surface is stabilized by new growth. Furthermore, higher combustion temperatures radically affect soil chemistry (Allen 1996).

Although not as well adapted to fire, particularly juniper due to its sclerophyllous attributes the nature of the piñon/juniper woodland also changed. In this case, overgrazing and fuel gathering probably played a more important role. Because of this zone’s more xeric environment, recovery of grass vegetation is slow. Livestock production, particularly sheep and goats, in this area also has a much longer history because the locale is closer to settlements along the Rio Grande. Consequently, much of the erosion and *arroyo*-cutting we see today is a consequence of over-grazing (deBuys 1985; Dahms and Geils 1997)

In summary, agriculture, grazing, logging, and nearby railroad construction would all have significant effects on the mountain landscape. Detrimental grazing effects began ahead of widespread US settlement of the area. Hispanic and Native American sheep grazing began the transformation of vegetation and local geomorphology. Anglo settlement, cattle grazing, and fire suppression continued the alteration of the landscape. The 20th century growth of nearby Albuquerque would place new demands such as recreation, water withdrawal, and habitat fragmentation on this locality. As agriculture becomes less important on lands close to the mountains, these new demands will create new and perhaps more detrimental changes to the landscape. Land managers must be cognizant of these “new” agents of change and work to mitigate their effects.

Chapter 3

US Military and Biological Surveys: notes, commentary, and findings

Two military surveys or reconnaissance missions in the Manzano Mountain region provide some information regarding environmental conditions present in the mid-19th century. Lt. James Abert (Galvin 1966) and Major James Carleton (Carleton 1965) both journeyed through the area and compiled notes regarding their observations. Their observations, though brief, remain valuable contributions for historical ecology study.

Vernon Bailey's 1913 description of flora in the Manzanos (Bailey 1913) occur after Anglo settlement and the commencement of wide-spread timber-cutting. It provides an early 20th century account of vegetation.

Abert's account

Lt. Abert's troop began their journey into the Manzano Mountains on 30 October 1846 when it left the Rio Grande. Their penetration into the mountains was through *Cañon Infierno*, now known as Hell's Canyon. In this canyon, Abert noted a "stream of clear cold water" that sometimes disappeared into the sand. Cottonwoods and grapevines lined the bank. Enduring a severe snowstorm that night, Abert commented on the lack of grass for pack animals. Grazing areas were a commodity usually noted by pre-20th century travelers because their horses and pack animals depended on grass for sustenance.

On 31 October, he met with “Mr. Chavez’s wagons that were out to procure pine logs for rafters.” As he ascended the canyon, he noted the presence of cedar, post oak (Gambel’s oak), fir trees (Douglas fir), and as he approached the crest, they “met with large specimens of long-leafed pine” (ponderosa pine). He also noted the presence of “holly,” which was probably a species of *Mahonia* or *Berberis*. Later that day, the soldiers camped in a dense grove on the east side of the range and turned their animals out to graze. He did not comment on the presence of grass, however.

The next day, 1 November, the salt lakes of the Estancia Basin came into view. Abert knew that these lakes were a source of salt for the region. He commented about the excellent grazing grounds in the valley suitable for “government and volunteer horses.” He also noted the presence of a number of flocks of sheep. Reaching the town of Chilili, he found it abandoned and the settlers now a few miles north. At the new location, Abert observed a large flock of four-horned sheep. These sheep were *churros*, a breed descended from sheep in southern Spain and known for its meat qualities and a fleece suitable for hand processing (Baxter 1987).

Leaving Chilili, the force continued on to the village of Tajique arriving late in the day. West of the town, he camped his men along a creek (Tajique Creek) that he described as a “fine stream.” Only rarely does this “creek” now have water. On the next morning, 2 November 1846, Abert described ruins, mounds, potsherds, and other archaeological evidence left from previous Native American occupants. Later in the day, Abert traveled south to the village of Torreon.

At Torreon, he found a “fine stream” emanating from a large spring. Today, this stream is barely a trickle. Crops noted were corn, and probably tobacco because the residents were “well supplied with corn shucks and tobacco for their *cigarritos*.” On 3 November, Abert purchased corn in Torreon before proceeding on to the village of Manzano.

Vegetation described on the trip to Manzano was “desert holly, the piñon, and the cedar.” Abert noted two varieties of cedar (*Juniperus*), one known as s*abina* and the other as *cedro*. *Sabina*, he wrote, had “large berries” that were “good to eat.” US Surveyors would later use these same two descriptions of *Juniperus* in their field notes. *Juniperus sabina* is not native to North America and it appears that early New Mexico colonists used the term *sabino* to refer to what is known as *Juniperus scopulorum* (Julyan 1996). Nevertheless, the distinction is unclear.

In Manzano, the largest settlement on the east side of the mountains, Abert remarked on an *acequia* (Figure 20) and water to a grist mill both supplied from a reservoir. The dam was “12 ft. wide, 9 ft. high, and 100 ft. long.” The origin of the water was *Ojo del Gigante*, a large spring (Figure 21). Today an earthen dam creates Manzano Lake, a somewhat popular recreation site. Abert also noted the apple trees growing in Manzano that gave the village and the mountains their name (Figure 22). The origin of these trees is not certain but when Abert visited Manzano, they were worth noting. Local legend claims that Spanish missionaries planted the trees but other accounts dispute this claim and surmise later residents were responsible for planting them or they sprouted from the roots of earlier plants.

While in Manzano, locals mentioned to Abert that there were three mines in the mountains supplying, silver, gold, and iron. Later mineral reports would only find small traces of precious metals in this area so the presence of these mines remains a mystery.

On 4 November, Abert explored, measured, and sketched the mission remains of *Qurra* (Galvin 1966) (*Quarai*, Salinas National Monument, National Park Service). There is no commentary of

Figure 20. Manzano 1916. The *acequia* in the foreground is full of water for irrigating crops. The round tower-like structure on the left is the *torreon* constructed in the mid 1800s for a defensive position while fighting Navajo and Apache raiders. Photograph courtesy of Historic American Building Survey, Library of Congress. Jesse Nussbaum, Photographer. Museum of New Mexico. HABS, NM,29-MANZ,1-5

Figure 21. *Ojo gigante* at Manzano. This photograph taken about 1900 illustrates the source of irrigation water for Manzano. The spring still flows and now supplies a small reservoir in the town. Courtesy of Museum of New Mexico. Neg. No. 37436.

Figure 22. Apple orchard in Manzano. The caption on this US Forest Service photograph stated, " closeup of 300 year old apple orchard at Manzano." Although the origin and age of these trees remain unclear, it was these trees that gave the town and the range its name. Photo by George Russell, 19 April 1938. Courtesty of US Forest Service, Region 3.

vegetation around the mission. Abert's measurements and drawings, though would prove valuable to later archaeological and restoration efforts. From Quarai, the party continued on to Abó. Before departing the area on 5 November 1846, Abert sketched and painted a water color of the ruins at Abó (Figure 3). Again, these data would be useful for later archaeological work. Proceeding on a "fine road" through Abó Pass, Abert commented on the presence of "*Palmello angosto* (Huddleston 1951)." In Spanish, *angosto* means narrow and he was probably referring to Narrow-leafed or Soap Tree Yucca (*Yucca elata*) currently found in this region. Abert noted again the presence of *Mahonia* or *Berberis* that looks like "holly."

The explorers proceeded through the pass and continued on to the Rio Grande Valley. His travels through the Manzano region ceased on 5 November 1846.

Although this reconnaissance lasted but one week there are several pertinent observations that Abert made relating to landscape conditions.

- Presence of a number of settlements flanking the eastern foothills, specifically, Chilili, Tajique, Torreon, and Manzano. These four villages remain occupied today.
- Flowing streams. Aware of mountain passes.
- Limited timber-cutting (Mr. Chavez) and presence of "large" pines.
- Sheep grazing.
- Subsistence agriculture.

Carleton's account

On 14 December 1853, Carleton's party left Albuquerque and proceeded down the left bank of the Rio Grande that he described as "100 yards wide and no more than 18 inches deep." He noted that the bank and valley was no more than two feet higher than the water surface. Major Carleton and his dragoons began the journey to the Manzanos at the town of Casa Colorado (Carleton 1965). Whereas Abert approached the east side of the Manzanos from the north, Carleton entered from the south. While Abert commented favorably about most Hispanics in the area, Carleton had a much different view and labeled them indolent, lazy, filthy, and "ignorant of everything beyond their corn fields and *acequias*."

Proceeding eastward from Casa Colorado towards Abó Pass, Carleton noted several herds of cattle but little forage and was told that the cattle had to be driven back to the Rio Grande for water. He entered Abó Pass (*Los puertos de Abó*) on what he described as the finest road in New Mexico. Until he was close to the summit of the pass, he found no timber and at the summit only "dwarf piñon and stunted cedar."

East of the summit, Carleton noted a large canyon north of the road that had water and was known as "*Agua de Juan Lujan*." Farther east, the stream leading to Abó ruins crossed their path. He described the creek as flowing and lined with a grove of cottonwoods. Carleton also measured the church ruins at Abó and noted that fire had destroyed the woodwork still present. He also commented on the lack of arable ground surrounding this place of rolling and broken land covered with piñon and cedar.

From Abó, Major Carleton proceeded northeast towards the village of Manzano traveling through cedar and piñon. As did Abert, Carleton mentioned the stream, dam, and irrigation works in Manzano. Likewise, he visited the apple orchard. Snow covered the high peaks of the Manzanos and he remarked on the “excellent forest of pine” west of the village. Carleton had to buy forage in Manzano for his horses but does not mention anything about the lack of grass surrounding town. Carleton also visited Quarai but his primary mission was to scout the route to Gran Quivira to the southeast.

Enroute to Gran Quivira, Carleton’s troops encountered shepherds or *pastores* on the plains east of the mountains. After finding Gran Quivira, Carleton returned to the village of Manzano that he describes as the “Botany Bay of New Mexico,” presumably a reference to the Sydney, Australia region settled by a criminal under class.

Carleton’s ride northward to Torreon has little description, probably because they journeyed through a snowstorm. Both Torreon and Tajique had flowing streams. Traveling northward towards Chilili, he crossed well-timbered country. The stream in Chilili he noted was a "mere rivulet."

The rest of Carleton's expedition contains few references to vegetation or landscape characteristics. As he ascended the east side before arriving at *Cañon de Infierno*, Carleton spoke of extensive grove of large pines. His route was the reverse of Abert's, descending to the lower elevations west of the range through *Cañon de Infierno*. The group found a spring half way down the canyon but once entering the flatter piedmont land found no water for the next 20 miles back to Albuquerque. Carleton arrived in Albuquerque on 24 December 1853.

Carleton's reconnaissance lasted two weeks but most of his travels were to and from Gran Quivira. One wonders if his lack of commentary at the end of the trip had anything to do with arriving back in Albuquerque just before Christmas Day. Although Carleton's account is a briefer, it does confirm some landscape conditions:

- Presence Hispanic villages that Abert described
- Flowing streams
- Extensive forests of large pines
- Foothills and lower elevations covered with piñon and "cedar"
- Sheep grazing
- Subsistence farming
- Sheep herders far from villages

Bailey's description (Bailey 1913)

Bailey notes that although the surrounding area is arid, the mountains are high enough in altitude to "induce considerable precipitation," resulting in wide-ranging forests. Bailey found numerous springs, but "streams are few and mainly ephemeral." On the highest elevations, he notes the presence of white fir, blue spruce, Douglas spruce (Douglas fir), limber pine, aspen, and Rocky Mountain maple.

Lower in elevation (Transition Zone), Bailey describes a forest of "open yellow pine" (*Pinus ponderosa*), Gambel oak (*Quercus gambelli*), New Mexico locust (*Robinia neomexicana*), with an undergrowth of Buckbrush (*Ceanothus fendleri*), Creeping mahonia (*Berberis (Mahonia) repens*), Sericotheca, probably Mountain spray (*Holodiscus dumosus*), and *Opulaster*. *Opulaster* is now known as *Physocarpus monogynus* (Rosaceae). Bailey commented that there was good grazing in this zone, and that it had value for timber, livestock, game animals, and "summer camping," but limited agricultural value.

In the foothills (Upper Sonoran Zone), Bailey found forests of piñon, juniper, scrub oak, barberry, and cacti. He found numerous small farms and ranches in this piñon/juniper woodland. Cultivation requires irrigation in this zone. Lastly, he described good growths of grass and fine grazing.

Bailey's account of the Manzanos is combined with comments about the higher and more mesic Sandia Mountains; therefore, it is difficult to ascertain an exact description for the Manzano Mountains. For example, except for ornamentals planted around residences, blue spruce (*Picea pungens*) does not occur in the Manzanos (personal observation, and Bedkar (1966). His descriptions are more appropriate to the Sandia Mountains.

Comments, findings, and comparison to recent conditions

Unfortunately, neither Abert nor Carleton spent significant time in the mountains *per se*. Except for noting antelope on the plains and some waterfowl, their descriptions lacked any notes regarding wildlife. While it is difficult to infer much from his brief comments, Carleton's purchase of forage may be indicative of overgrazing close to settlements. This would not be unusual. Similar conditions existed around Santa Fe during the same time. Several accounts by officers assigned to the Army of the West during the Mexican War commented on the lack of grass for horses around Santa Fe (Leopold 1951).

The presence of roads indicates that there was trade between the Rio Grande Valley and the eastern mountain region. This is not surprising since the settlers that moved into this area and requested land grants came from towns and villages along the Rio Grande.

The presence of sheep is also not surprising given that sheep were the predominant livestock type in early New Mexico (GPO 1864; GPO 1910; Baxter 1987; Jordan 1993). It is foolhardy to infer much regarding the apparent lack of cattle, but for the whole of Valencia County from which Torrance County was created, the 1860 agricultural census enumerated only 1543 cattle in an area much larger than the current aggregation unit. By contrast, there were 193,723 sheep at the same time in Valencia County (GPO 1864).

Abert and Carleton both noted flowing streams. Logically, the settlements on the east side depended on a reliable source of year-round water for drinking and crop irrigation (White 1994). Their visits occurred before deep well drilling and windmill technology was widely available. Stream flow is now episodic and associated with heavy rain or snowmelt. Detailed information regarding stream flow is sparse, however, in July 1915 a heavy thunderstorm resulted in runoff discharge of 1220 cubic feet per second in *Cañon Colorado* close to the village of Manzano. Snowmelt runoff the next spring, May 1916, produced a discharge of 55 cubic feet per second. Between 1917 and 1918, only three months had stream flow in *Cañon Colorado* (Neel 1925).

From December 1985 to September 1987, Robert R. White, USGS, performed a number of stream flow measurements on drainages in the region. White placed his measurement stations at crossing points along Highway 55 (then HW 337), essentially the same route that existed between land grant villages on the east side of the mountains when earlier surveys and expeditions traveled through the region. White found that discharge rates are highly variable and dependent on precipitation (White 1994). Table 3 summarizes White's results for the drainages between Tajique and the village of Punta de Agua that is close to Quarai:

Discharge rates are greatest during April and associated with snowmelt runoff. Abert visited the region in the fall of 1846 and Carleton in December of 1853. Although these data are limited, it appears that stream flow has declined from about 1853. At least four explanations for this decline are plausible.

First, a change in climate since the end of the Little Ice Age (~1850), resulted in drier conditions (Ghil and Vautgard 1991), Second, increased livestock grazing following Anglo settlement has changed riparian vegetation and stream morphology. Third, fire suppression related to forest management and grazing resulting in denser forests with greater water interception by coniferous trees (Gholz 1990). Fourth, increased logging changed runoff and infiltration characteristics (DeBano, Folliott *and others* 1996; Fletcher 1998).

Table 3. Discharge in cubic feet per second for various dates. Measurement stations are on drainages that cross NM Highway 55 on the east side of the Manzano Mountains. For conversion to cubic meters per second, multiply the value by 0.02832. Adapted from White (1994).

Stream or Spring	4 Dec 85	26 Mar 86	23 Oct 86	2 Apr 87	16-17 Jun 87	24 Sep 87
Cañon de Tajique	0.24	0.26	0.15	23.1	4.55	0.29
Cañon de Torreon	0	0.1 est	0.43	20.5	5.29	0.51
Arroyo de Cuervo	0	0	0	0	0.13	0
Arroyo de Manzano	0	0	0	6.53	0.20	0
Manzano Spring	0.47	2.46	1.51	9.57	1.80	0.29
Cañon de Los Pinos Reales	no data	no data	0	3.0 est	0.01 est	0
Cañon de Chato	no data	no data	0	2.0 est	0	0
Cañon Colorado	no data	no data	0	6.0	0.73	0.2
Cañon Sapato	no data	no data	0.08	0.29	0.11	0.11

The problem, however, is multivariate and probably no one factor is solely responsible. Nonetheless, historic stream and spring flow amounts have declined except for intense episodic events. I have noticed a marked decline since 1968 regarding water availability. Springs considered reliable in the past are now dry or have minimal and sporadic flow. The stream flowing through *Cañon de las Palas* had enough flow in 1968 to support a small reservoir that was stocked with rainbow trout by the Recreational Land Company as part of their subdivision development. The dam was breached and the pond is now essentially dry but stream flow in the *cañon* is now marginal except during heavy snowmelt years.

Regarding commercial timber cutting, widespread logging began before Bailey's report but after Abert and Carleton traveled through the area. It is difficult to understand how Bailey could have missed a conspicuous activity such as logging in the Manzanos that began about 1908 with railroad tie contracts for the extension of the Santa Fe line through Abó Pass (Hurt 1989). A review of logging and its effects in the Manzanos follows in Chapter 5.

Chapter 4

US Public Land Survey Field Notes and Landscape Reconstruction

The US acquired New Mexico in 1848 after the conclusion of the Mexican War. One provision of the Treaty of Guadalupe Hidalgo was that the US would uphold confirmed land grants from Spanish and Mexican governments. Furthermore, New Mexico, as most of the lands in the west, would be subdivided into townships and ranges according to the US Public Land Survey System. Thomas Jefferson's report to Congress in 1784 called for subdividing land into organized townships and ranges. This orderly process would avoid the pitfalls of metes and bounds boundaries. The 1785 Land Ordinance and the Land Act of 1796 set up the basis for the system still in place today. The Act of July 4, 1836 placed the responsibility for surveys with the US General Land Office (GLO) where it remained until 1946 when the Bureau of Land Management assumed cadastral survey duties (Cazier 1976; White 1983)

The history of GLO surveys in New Mexico began with the appointment of William Pelham as Surveyor General of New Mexico on 1 August 1854. As with other surveys, the first task before subdividing the new land was the establishment of an "initial point." This is the intersection of an east-west "base line" and a north-south" principal meridian. On 9 March 1855, Pelham hired John Garretson to establish the “initial point.” On 3 April 1855, Garretson monumented this point on a butte nine miles downstream of the Rio Puerco near the Rio Grande. According to White (1996), the Rio Grande has shifted “greatly” since the establishment of the initial point in 1855. The US Geological Survey publishes the location of this point on the “San Acacia”, 7.5 minute quadrangle map. All GLO surveys in New Mexico and a portion of Colorado begin at this point (White 1996). Garretson would later survey some areas in the Manzano Mountains.

As stated previously, US Deputy Surveyors remarked on landscape conditions in addition to establishing township and section corners. Further, they referenced corners to bearing trees whenever possible. These are first hand accounts of conditions encountered and provide details about local environmental conditions. The first surveys in the Manzano Mountains began ~1857 before Anglo settlement and the notes help establish landscape reference conditions.

Methodology

I acquired microfiche copies of all the townships and land grants bordering and within the Mountainair Ranger District, Cibola National Forest from the Bureau of Land Management Regional Office, Santa Fe, New Mexico. Dates for field notes of surveys in this area range from 1857 to the 1990s. Henceforth, I will abbreviate townships with the following notation. For example, Township 7 North, Range 5 East abbreviates to T7NR5E. Figure 23 illustrates the townships or grant boundaries in the research area. Each of the following land grants and townships received detailed scrutiny for landscape conditions:

- Isleta Pueblo (Lo de Padilla Grant)
- Tomé Grant
- Casa Colorado Grant
- Manzano Grant
- Torreon Grant
- Tajique Grant
- T7NR5E
- T6NR5E*
- T5NR5E*
- T4NR5E*
- T3NR5E*
- T7NR6E
- T6NR6E
- T5NR6E
- T4NR6E
- T3NR6

**Note: detailed synopses of surveys for these townships follow*.

Several publications provide useful information and techniques for reviewing land survey records (Bourdo 1956; Vale 1982; Egan and Howell 2001). Before proceeding with a review of survey notes, one should thoroughly understand procedures and rules outlined in pertinent survey manuals. Early surveys in this area followed the guidelines of the

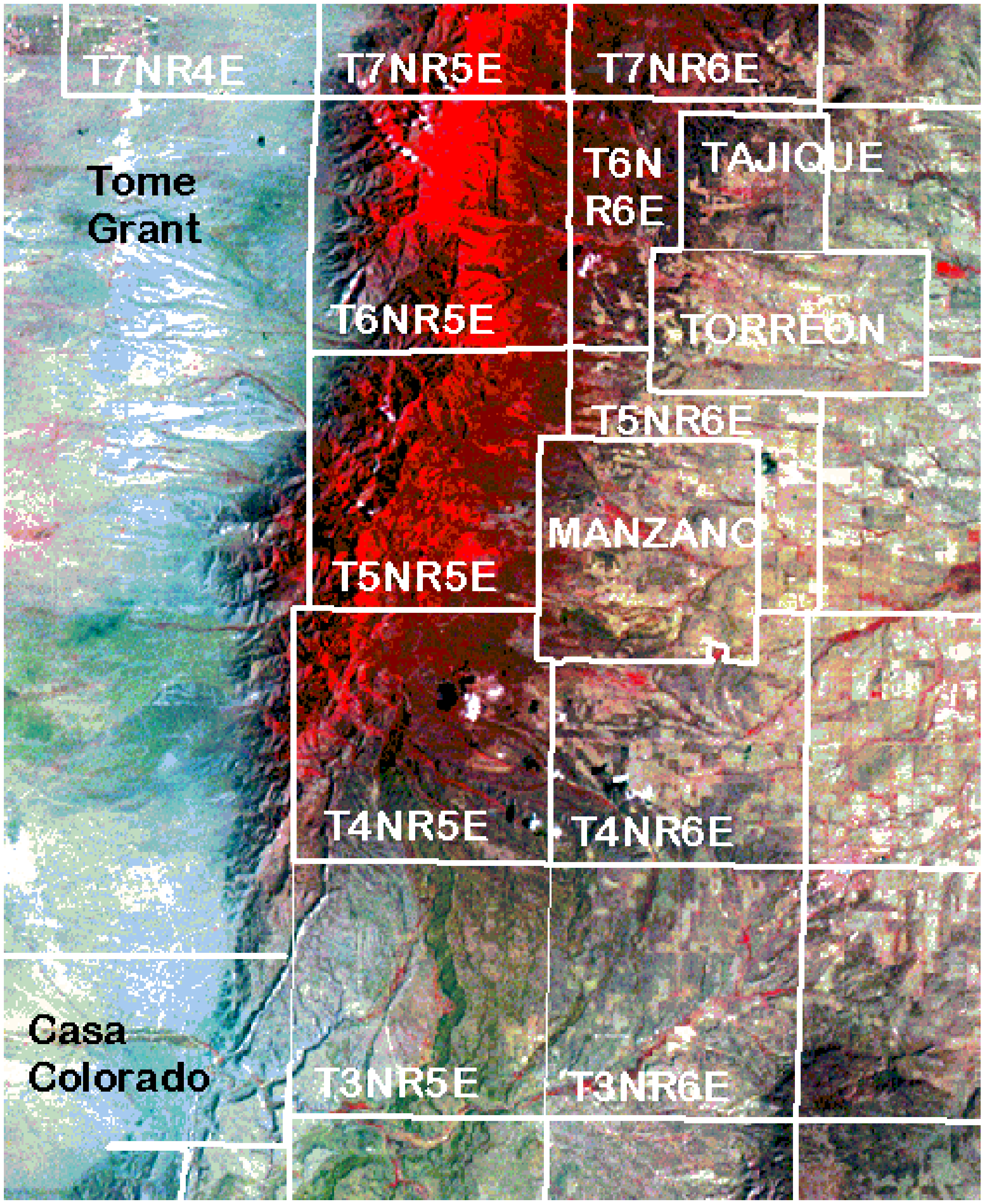


Figure 23. Township and range boundaries in the Manzano Mountains. Also depicted are Spanish and Mexican Land Grant boundaries. Township and ranges do not extend through grants. Each township is nominally six miles square or 36 square miles unless it is a fractional township, e.g., bordering a land grant.

1855 Manual of Surveying Instructions promulgated by the US General Land Office. This is now a rare document; therefore, I relied on a reprinted edition in White (1983). For later surveys, I used the 1894 version (GLO 1894). Recent surveys use the instructions found in the *1973 Manual of Surveying Instructions* (BLM 1988).

One must exercise certain restraints when using these data. Tree identification varied between surveyors and some appeared to have biases towards certain species. Instructions suggested that surveyors pick "durable" species for witness and bearing trees. The selection may not be random and would skew the results of a quantitative analysis. In some cases, the field notes indicate that no "suitable" bearing trees were present. Certain statistical tests can check for these biases (Bourdo 1956) but my goal was not a quantitative assessment of forest stand. My objective was to ascertain presence or absence of certain trees, grass condition, soil condition, stream flow, erosion, undergrowth, and cultural features and activities, such as grazing or logging. Although the process is tedious, clues regarding landscape emerge.

As noted earlier, there is some creativity and difference in naming tree species. Further, grass identification was normally designated "bunch" or "grama." This description no doubt referred to *Bouteloua* sp. Surveyors easily identified this grass by its "flag-like" inflorescence.

Generally missing from descriptions are shrubs and forbs. The term "heavy" denoted large trees not density of the stand. Surveyors noted the trees in order of estimated abundance. Most surveyors working in the area before ~1910 adopted Spanish spellings for several terms. Surveyors described streams as *arroyos*. The usage did not necessarily refer to an entrenched drainage in valley alluvium, as the term now implies. *Cañon* was used instead of canyon and *piñon* in place of pinyon. *Sabino(a)* and *cedro* described species of *Juniperus*. Although seemingly unimportant, this terminology emphasizes the Hispanic influence on this region. Many surveyors employed local Hispanic men as part of their crews.

Unfortunately, notes to some of the earliest surveys by Robert Kelley in the late 1850s appear to have pages missing and are incomplete. These surveys are only marginally useful to this project but occasionally provide baseline data.

While township boundary line surveys provide useful information, the ~6 mile interval between different townships results in a rather crude pattern. Subdivision surveys that divided a township into 36 sections of one square mile each (640 acres or ~259 hectares) had more detail and are more valuable. Moreover, each section received a "quarter section" monument every 0.5 miles. Surveying instructions also required a plat of the township. This plat was to record topography, drainages, and cultural features. When available, they are landscape “snapshots” for a given period. Figure 24 is an example of a plat using hachures to portray relief.

The process of surveying land grants was slightly different. Surveyors received instructions from the Surveyor General with descriptions based on original grant documents. Land grants did not require subdivision but only the establishment of corners, mileposts, and connecting lines. Confusion over Spanish and Mexican documents, inexact starting points, and different units of measurement frequently resulted in numerous resurveys of some land grants. Unlike many grants in northern New Mexico (deBuys 1985), most land grants in the Manzano Mountain area were eventually accepted and patented by the US Government.

Given that fraud occurred in some public surveys, particularly the notorious actions of the “Benson Syndicate” in California (Cazier 1976; White 1983), I had concerns regarding fraud in this area. I used topographical maps that had public land survey lines printed on them to verify boundary location, topography, and drainage features. Referring to digital ortho quarter quad (DOQQ) aerial photography was also on occasion necessary. With a few exceptions, most surveys match topography.

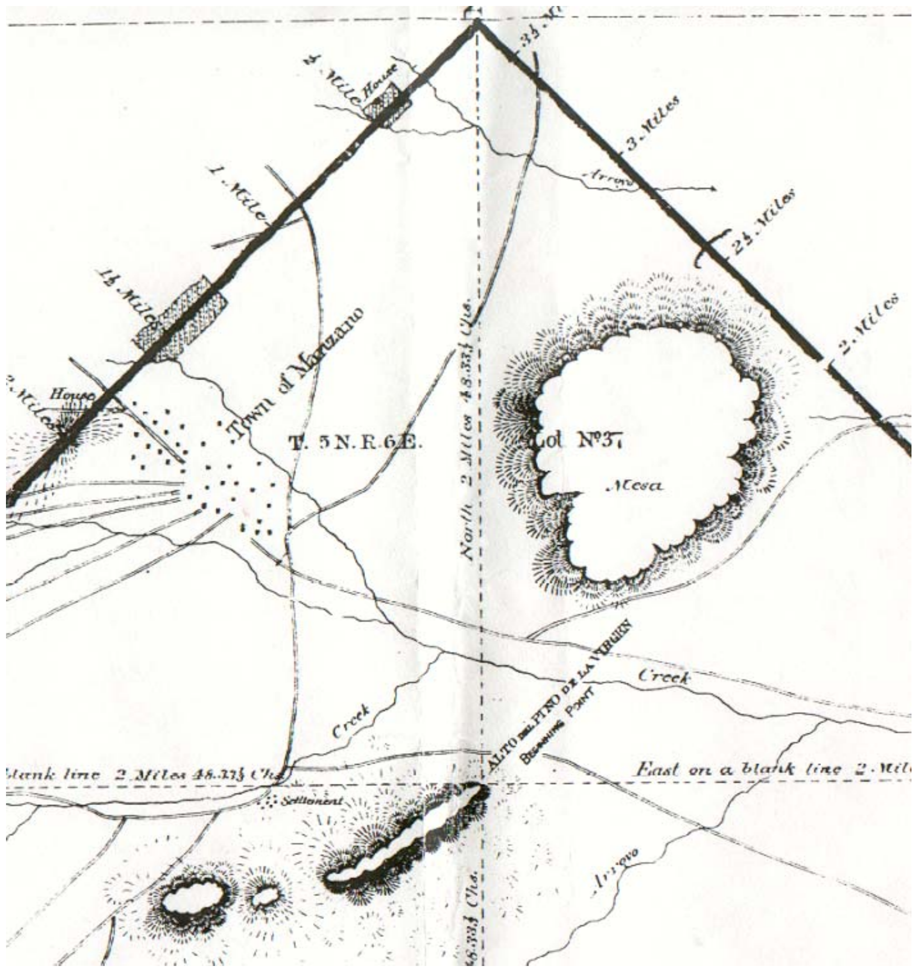


Figure 24. Hachured plat. The figure illustrates a portion of the Manzano Land Grant as surveyed by Charles Ratliff, US Deputy Surveyor, in 1887. Subsequently, the boundaries of the land grant would change to reflect east west lines for the boundary instead of the “diamond” shape portrayed above. Early surveys used hachuring to portray topography. From US BLM files for Manzano Land Grant.

As a further check on the veracity of early surveyors in this locale, I contacted Mr. Richard Glaze, US Cadastral Surveyor, Bureau of Land Management, Santa Fe. Glaze performed resurveys in the area in the 1990s. One of the tasks of a resurvey is to review all previous notes of a township or grant and locate older monuments. With some exceptions on the establishment of quarter section corners, Glaze believed most of the Manzano area surveyors performed their jobs correctly. Glaze was particularly praiseworthy of US Deputy Surveyor Wendell Hall and regarded his surveys as excellent. Glaze stated, “if Wendell Hall wrote it down, it was there.”

A concern I raised with Glaze was surveyor’s use of the term “dense underbrush.” The Surveyor General paid surveyors extra for surveys in mountainous area, and areas with “dense underbrush.” This factor is a concern. Did surveyors note dense underbrush truthfully, or as a means to collect higher fees? Glaze believed that there was probably some “stretching of the truth” but believed that most surveyors noted what they encountered.

I also expressed my concern to Glaze about the short time spent on some surveys. For example, Thomas Holland completed a subdivision of T3NR5E in 6 days. This seemed unlikely as Holland would have to establish ~80 to ~133 corners depending on whether adjacent township corners were in place. According to Glaze, this was possible but Holland probably “short cut” the quarter section corners. The required process was to proceed east or west from one section corner to the next section corner on a random line and then correct the quarter section corner on the back azimuth. By only running east 40 chains (0.5 miles) and placing the corner, surveyors could avoid a great deal of work. Surveyors worked on a contract basis, therefore, “short cutting” the quarter sections was likely (Glaze, personal communication). Bourdo (1956) also comments on this error. Glaze concluded that while Holland moved rather quickly, it was possible for him to complete the survey, albeit with some “short cutting.”

Surveyors worked with a crew of several men. Some cleared brush along the line, others carried equipment, and they worked from sunup to sundown seven days a week, while cooks and others kept up with the camp. After dark, in camp, surveyors transcribed their notes from pocket “tablets” to proscribed field notebooks. Undoubtedly, surveyors “set” some corners on steep and precipitous terrain from “afar.” Nevertheless, these early accounts are surprisingly accurate.

Another difficulty with the public land surveys is that the system is not based on geographic coordinates but on measurements from the initial point. A “monument” marks the corner, not a grid coordinate. The monument takes precedent in later surveys even if it is in error. Mistakes in measurement, short corners, and standard correction lines every 24 miles complicate finding corners, particularly in brush and dense timber. Although the Bureau of Land Management is now establishing geographic coordinates for the public land surveys and new surveys determine coordinates of monuments with precision Global Positioning System equipment, the process is far from complete.

One must also bear in mind that the intent of the GLO surveys was to subdivide land for orderly settlement. The process was acreage driven and employed units of measurement no longer in common use except for public land surveys. Measurements were in chains and links. Eighty chains equal one mile. One chain is ~66 feet (20.117m). There are 100 links per chain. Each link is ~7.92 inches (0.2012m). Therefore, 20 chains equal 0.25 mile, and 40 chains equal 0.5 mile. I will retain this terminology when referring to specific measurements to avoid confusion or mistakes when extracting information from the field notes. Figure 25 is a generic diagram of a standard township.

The following is a summary of each township and land grants within or bordering the study area. There is overlap between these boundaries due to common exterior lines. I am primarily interested in surveys completed before ~1890, ones that help establish baseline

Township _North, Range _ East

6	5	4	3	2	1
7	8	9	10	11	12
18	NW NE SW SE	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Figure 25. Generic township reference diagram. A township is ~36 square miles. Each section (1-36) is one mile square and contains 640± acres. Each section can be further divided into quarter sections and so forth.

conditions for this region. As noted above, only T6N R5E, T5N R5E, T4N R5E, and T3N R5E have detailed synopses. These townships constitute the central "core" of national forest lands. Following the detailed comments, I will add general comments regarding other townships and land grant boundaries. I begin each synopsis with the original subdivision survey for a given township.

Synopses and comments

T6NR5E: 1883 Subdivision Survey by Thomas Holland (Holland 1883)

***General description*:**

- Land was rough and mountainous.
- Heavy timber noted in eastern and southern portions consisting of pine, piñon, cedar, oak, and juniper.
- Central and northern portions had dense scrub underbrush.
- The soil was 3rd and 4th rate.
- Grass was "good and considerable" where found.
- The township contained little arable land and was used for grazing sheep.
- Antonio Castillas had a sheep ranch in the NW ¼ of Section 23.

Consistent in Holland's notes was the presence of "dense underbrush" of oak and pine. The largest pine noted was 15" in diameter; most were in the 12" range. A number of *arroyos* and canyons had water, as one would expect in late spring snowmelt. On the line between sections 15 and 14, Holland noted fences, a house, corrals, and cultivated land. This would border the postulated beaver meadow area discussed previously. The ranch mentioned in Section 23 remains private property.

Tree species described by Holland are consistent with present composition of the forest. Holland's use of the term "heavy timber" implied large trees and he completed the survey before significant logging began. The relative lack of grass and presence of dense underbrush was consistent with heavy sheep grazing. In September 1883, Holland surveyed a north south township line between T6NR4E and T6NR5E (Holland 1883). This is the western boundary of T6NR5E that generally follows the base of the mountains. Most of this line had no trees noted and he described it as having poor soil and grass with dense underbrush. This location was closer to Rio Grande Valley settlements and received heavy summer grazing pressure from sheep (Kessell 1979; Simmons 1982). Holland found "good water in many places, and described Comanche Creek as "a good running stream." Only rarely does this stream now have water.

In 1880, William McBroom established the north boundary of this township. Trees noted were similar to Holland's account and on the northeast corner he noted "dense underbrush" (McBroom 1880).

Hugh DuVal's survey of Small Holding Claim #372 stated that this township was in the forest reserve and there are no homesteaders in this township in 1908 (DuVal 1908). DuVal noted "heavy timber" in the township. Narciso Montoya held this claim of about 33 acres. DuVal described the claim as "small, partly cultivated, and used for a goat ranch." A small mud and pole house (*jacal*) was on the claim.

In retracing the north township line between T6N and T7N in June 1913, Hervey Bardsley commented on "dense timber and underbrush." He further noted that there was one settler in section 36 and one in section 30. Bardsley noted several "good springs" and a spring in section 30 used for watering livestock (Bardsley 1913).

L. R. Mercer surveyed Homestead Entry Claim #412 in 1917 but did not complete the plat until 1920. The claim is in section 1, land now owned by the Inlow Youth Camp. At the time of the survey, Mercer noted heavy timber of pine and scrub oak, including a 28" pine and a 30" juniper, probably *Juniperus deppeana*. He also described a "pole pig pen" and commented that there was no water for irrigation on this claim (Mercer 1917).

In 1924, Charles Devendorf completed a survey of the south boundary of the Lo de Padilla Grant (T7NR5E). This is about 2 miles north of T6NR5E but pertinent to this synopsis. Devendorf noted "considerable stream flow" in sections 29 and 32 (October 1923) that was used to water sheep during lambing season and a ditch extended to the west mesa for irrigation. Further, he stated that J.R. Salazar grazed sheep in section 30 in a private holding. He also stated that Mrs. Archibald Rea [*sic*] was the widow of the patentee of sections 4 and 9, T6NR5E (Devendorf 1924). These parcels are near Bosque Peak and remain privately held. The Rays raised sheep and goats on this high ridge. In a special edition of the *Valley Express* there are two captioned photographs (Figures 26 and 27) of the Ray Ranch but little information other than the Ray family made goat cheese which they sold to "folks in the Valley" (Hoelscher and Hoelscher 1959). Only ruins are left of their cabin and pens (Figure 28).

The above notes regarding this township reveal several key factors regarding landscape condition:

- The majority of surveys commented on the "presence of dense underbrush."
- Timber was described as "heavy."
- Predominant trees noted are pine, piñon, oak, and various junipers.
- Grass condition ranged from poor to fair with a few locations having good grass.
- Soils were 2nd to 3rd rate
- Surveyors noted sheep and goats grazing but not cattle.
- Very few settlers were present.
- Water was flowing in streams and from springs.
- The west boundary essentially had no trees.
- No mention made of logging or timber-cutting.

RAY RANCH ON TOP OF BOSQUE. This "mountain top" ran was the home of the John Ray family, who are well remembered by many of the old-timers. **(Terry Photo)**

Figure 26. Ray Ranch. Photograph from the early 1900s. Much of the Bosque Peak area was then covered by aspen. Note the straight-rail pens built of aspen possibly indicative of Texan influence (Jordan, Kilpinen *and others* 1997). From a special edition to the *Valley Express* (Hoelscher and Hoelscher 1959). Courtesy of the Dobie Collection, University of Texas at Austin.

GOATS ON RAY RANCH. Mr. Ray made goat cheese which he sold to folks in the Valley. (Terry Photo)

Figure 27. Ray Ranch on Bosque Peak Area. Goats required less tending than sheep. They could be turned out in the morning and would return in the late afternoon to their pens. Goats forage on browse more so than sheep or cattle. Photograph from a special edition to the *Valley Express* (Hoelscher and Hoelscher 1959). Courtesy of the Dobie Collection, University of Texas at Austin.

Figure 28. Remains of the cabin and pens on Bosque Peak built by the Ray family. Little remains today and unfortunately some hikers use the wood for fires. Photographed in July 1999.

T5NR5E: 1883 Subdivision Survey by Thomas Holland (Holland 1883). T5NR5E is a fractional township as Manzano Land Grant takes up a portion of the east side (Figure 23). The 1st Standard Parallel North, New Mexico Principal Meridian is the southern boundary of the township.

General description:

- A large number of sheep were present.
- Water was in nearly all canyons and arroyos.
- Some valleys were cultivated.
- Jose Seiz ranch and improvements in NW ¼ Sec. 24 consisted of a house, corrals, and several acres of cultivated land.
- Soil are mostly 3rd rate and rocky.
- Heavy timber covered the township.

Holland completed this subdivision in six days, an amazing accomplishment considering the steep terrain at higher altitudes. Equally amazing is that his terse topographical descriptions match or are very close to topography portrayed on current USGS maps. This township had more cultural features and activities mentioned. Its proximity to Manzano Land grant on the east accounted for these characteristics. The running water in "nearly all canons and arroyos" was probably the result of snowmelt in April 1883. In this township, Holland noted roads and a sheep corral one chain wide (66 feet). In section 26 there was a log house and an *acequia* to a cultivated field.

Vegetation at lower elevations was a mix of pine, piñon, juniper, and oak. At higher altitudes, Holland noted more "heavy pine and oak." On the east side of the range, Holland consistently mentioned the occurrence of "grama grass." After crossing the crest to the drier west side, he no longer remarks on the presence of grass. He noted dense undergrowth along the west boundary of Manzano Land Grant. West of the boundary, undergrowth was more scattered until he reached higher elevations along the crest. On the west side, "dense undergrowth" is a common entry. Holland mixed the terms juniper and cedar without explanation.

Earlier in 1882 Holland established the northwest and southwest corners to T5NR5E. The notes stated that there were no trees but that the undergrowth was dense (Holland 1882). In July 1903, Wendell Hall resurveyed portions of the 1st Standard Parallel in sections 34 to 36 on the south boundary of T5NR5E. Hall located monuments and bearing trees placed earlier by Holland although several were "some distance away." More than a few of the bearing trees had been destroyed but the stumps remained indicating logging activity since Holland's 1883 survey. In section 36 he searched for the western line of Manzano Land Grant but "cannot find corner or grant lines." Hall noted heavy pine and cedar (Hall 1903).

In July 1903, Hall also resurveyed the west boundary line of Manzano Land Grant. Proceeding south from the northwest corner, Hall encountered dense undergrowth, described several large pines (20 to 24 inches), a 30 inch diameter cedar, and cultivated areas. Bearing trees were missing from some milepost monuments. Grass was poor to fair and terrain was rocky and broken (Hall 1903). Hall retraced the line between Sec.12 T5NR5E and Sec.7 T5NR6E in November 1904. Along this line he noted numerous *arroyos*. Proceeding south, he intersected the north boundary of Manzano Land Grant, near Milepost 2 Manzano Land Grant and Forest Road 245. Hall found dense underbrush, scattered pine and juniper at this point (Hall 1904).

An interesting development occured in 1920. Charles Devendorf resurveyed the 1st Standard Parallel (south boundary of T5NR5E). Devendorf was a federal employee, not a contract surveyor. First, he could not find the corner at the intersection of T5NR4E, T5NR5E, T4NR4E, and T4NR5E. He described the area as scrub cedar, piñon, and pine with dense underbrush. He continued east on the 1st Standard Parallel through dense underbrush and oak, locust, pine, spruce (probably Douglas fir), and aspen. This was the first instance of aspen mentioned in this township. The presence of aspen and Douglas fir in this area matches my field notes made in July 1999.

Continuing east on this line, he did not find the corner of sections 32 and 33 but did find the quarter section corner on the south boundary of section 33. He described dense underbrush, "spruce" (Douglas fir), pine, aspen, and oak. In his general description for this survey, he stated that he found the 1st Standard Parallel corners on each side of the mountains at the foot of the range but not in between. Devendorf commented that the survey establishing the 1st Standard Parallel was not actually run but "guessed based on sparse topographical information and no actual measurement" (Devendorf 1920). Bourdo (1956) found that in difficult terrain surveyors established lines with hand compasses and by pacing distances, instead of using a chain and solar compass. Bourdo's observation may account for the speed in which some surveys were completed. Significantly, Devendorf found the quarter section corner in section 33 but misplaced north by 279 links (~184 feet) and instead of being at 40 chains distance from the section corner it was at 48 chains 74 links, an east/west error of 8 chains 74 links (~577 feet or ~0.11 miles). Although the line may be somewhat inaccurate and monuments misplaced, other descriptions such as vegetation and terrain remain useful considering the "error bar" for vegetation description in GLO surveys is about 0.5 miles.

T5NR5E shares some of the characteristics noted for T6NR5E and a few new observations:

- Frequently mentioned the “presence of dense underbrush.”
- Heavy timber of pine was noted.
- Predominant trees noted are pine, piñon, oak, and various junipers.
- Aspen and Douglas fir were present.
- Grass (grama) condition ranged from poor to good. Grass condition was not described on west side of range.
- Soils were 2nd to 3rd rate
- A large number of sheep used the area.
- More settlers were present in this township, due to of its proximity to the village of Manzano.
- Log home, *acequia*, and corrals for sheep were noted.
- Irrigation agriculture was present
- Water was flowing in streams and from springs.
- The west boundary had few trees.
- Evidence of logging taking place between 1883 and 1903.

T4NR5E: 1883 Subdivision Survey by Thomas Holland (Holland 1883). Manzano Peak, the highest point in the range (3078 meters), is in the northwest portion of T4NR5E. The southwest corner of Manzano Land Grant is in the NE$^{1/4}$ Section 12. The eastern boundary of Casa Colorado Grant is in portions of sections 18, 19, 30, and 31 making this a fractional township. This was another of Holland’s “speed surveys” completed in eight days. Terrain in this township made a transition from high mountains to broken foothills as one travels southward. Vegetation also changed southward from ponderosa pine forests in the north to piñon/juniper woodlands in the south.

***General description*:**

- The country was rough, broken, and mountainous.
- Heavy pine, piñon, cedar, scrub oak, and juniper predominated.
- Good grass but soil 4th rate was noted.
- Used for sheep grazing.
- Water flowed in some canyons.
- Isidro Saiz had ranch improvements in the NE1/4 NE1/4 Section 29 (remains private today).

Holland commenced his survey on the east side of the township on the south boundary running north between sections 35 and 36. Timber on the eastern portion of the township was mostly pine and piñon. Holland noted numerous *arroyos* but none with water. Between sections 10 and 11, near a location currently known as *La Cienegita,* Holland described a large frame house seven chains (462 feet) east of the north south line. A little farther north, he noted both a house and sawmill. Both of these locations are close to the drainage emanating from Ox Canyon. He did not mention water being present. Roads from the southeast terminate at these houses. Underbrush, when noted, was scattered oak. As he approached the center of the township, underbrush became denser. When he noted grass, he called it "bunch and grama."

Piñon and "cedar" dominated drier areas of the southwest portion of the township and southwestern aspect ridges. On the western half as elevation rose, he observed pine and underbrush more often. At higher elevation, pine and piñon dominated and he noted dense underbrush. For reasons unknown, he failed to mention Manzano Peak although the north south line between section 7 and 8 is due west and reasonably close.

As part of a resurvey of the Manzano Land Grant in September 1903, Wendell Hall retraced the lines set by Holland from the southeast corner of T4NR5E north to the south boundary of the grant (Hall 1903). Hall noted a "good" growth of pine, piñon, cedar, and an "unknown timber" with good grama grass. Between sections 7 and 12, he described a road from a sawmill to "*cienega*." This *cienega* is on private land east of the national forest in Sec. 8 and 9, T4NR6E. A 1975 version of the national forest map plots this location as La Cienega Missions (USFS 1975). Archaeological concerns preclude newer editions of the forest maps from displaying this information.

In August 1882, before subdividing T4NR5E, Holland surveyed the 1st Standard Parallel. This is the line disputed by Devendorf in 1920 as discussed above. Holland's vegetation descriptions of pine, fir, and aspen, however, reasonably matched Devendorf's descriptions. Noted more often was dense undergrowth. In section 33, Holland remarked on an *arroyo* with flowing water and five chains (330 feet) east of the *arroyo*, a "flume of hewn logs." It is not clear from his description if this was a flume to transport logs or more likely to direct water for irrigation (Holland 1882).

The description of flowing water matches the current course of what is today an intermittent stream in Ox Canyon. The environment in this locale is more mesic than many other spots in the Manzanos. The aspect is northeast and retains snow much longer than more exposed areas. A small intermittent stream flows from a U-shaped valley in the NW¼ of Section 5, T3NR5E and discharges into the stream in Ox Canyon. The valley has evidence of what is probably an inactive rock glacier (Maxwell and Light 1984) and (personal observation, July 1999). Characteristics of this township are:

- Considerable variation noted in geomorphology.
- Observed heavy pine, piñon, and cedar (*Juniperus*) but mostly cedar.
- Dense undergrowth observed in many areas.
- Grama grass grew in some area.
- Noted active sheep grazing.
- First mention of a sawmill in local surveys
- Some ranch improvements present.
- Water improvements, i.e., "flume of hewn logs."
- Water was flowing in some canyons and arroyos, in particular, Ox Canyon.

T3NR5E: 1883 Subdivision Survey by Thomas Holland (Holland 1883). T3NR5E constitutes the southern portion of Mountainair Ranger District, Cibola National Forest. This township has several private holdings and

Casa Colorado Grant bounds on the west side creating a fractional township. Forest Road 422 bisects the area on a north south direction. Section 25 contains the ruins of Abó mission. Portions of the Santa Fe Railroad cross the southern most sections adjacent to Abó Arroyo, a deeply entrenched watercourse. In 1853, Major Carleton proposed this route for future rail lines. Holland surveyed this township in five days in August 1883.

General description:

- Very rough broken country with a heavy growth of cedar and piñon present
- Good growths of grama grass noted.
- Some dense underbrush noted.
- Running water found in some sections.
- P. Belen has ranch improvements in SE1/4 SE1/4 Sec. 32.

Holland commenced the survey at the southern boundary on line running north between sections 35 and 36. The starting point was ~0.25 miles south of Abó Arroyo. Holland measured the *arroyo* at 12 links wide (~8 feet) and noted no problems crossing it. Two years ago, with a laser ranger finder, I estimated the width of this *arroyo* as ~125 feet (38m), and now it is deeply entrenched ~20-30 feet (6-9m). After crossing the *arroyo*, Holland encountered the road used by Lt. Abert and Major Carleton as discussed earlier. Continuing north the terrain was rough, broken, and vegetation was predominately “heavy cedar.” The crew moved south to the corner of section 34 and 35 on the south boundary.

Current topographic maps depict this point as in Abó Arroyo but Holland did not describe it as such. He did note crossing the east west road mentioned above. Vegetation continued to be "heavy cedar" and most bearing trees were "cedar." On the line between sections 22 and 23 Holland would have had to make his way down and up a very precipitous drop-off from an extensive sandstone ridge. No mention was made of this ridge and the survey at this point became what surveyors call a "forty eighty" line. In other words, he probably did not actually "chain" the line but estimated it and only noted the required points at 40 chains and 80 chains. It does not necessarily mean the description is inaccurate but that he did not really "walk the line" according to standard procedures.

The "forty eighty" lines occurred in several other instances in the survey of the township. If a surveyor found a point inaccessible he was, according to instructions, expected to triangulate or traverse around it and record these data (GLO 1894). Executing a triangulation or a traverse was a lengthy process and required annotation in the field notes. No notes of such procedure exist in this survey. I suspect that Holland "observed" these points but did not accurately measure them.

Between sections 28 and 27, on flatter terrain, Holland correctly noted Salado Arroyo, another entrenched drainage that is now wider. The plat of the township portrayed this *arroyo* following the general course that it has today. Based on his plat and knowing the current location of the *arroyo* it has made considerable headward progression since 1883. Farther upstream in this *arroyo* was a spring located slightly north of the section line between sections 22 and 27. Holland noted water at this spring. This area is heavily eroded today (Figure 29)

In section 32, Holland observed a house (P. Belen). He also remarked on water in Cañon Salado which was ~20 feet wide. The only time I observed water in this *arroyo* was after heavy thunderstorms (Figure 30). Farther west on the line between sections 31 and 32, Holland noted that Canon Salado maintained water flow.

In contrast to some of the steeper terrain on the east side of the township, Holland described a great deal of topographic information for very rough country associated with Priest Canyon. His notes compare favorably with current data on topographic maps and these lines do not appear to be “forty eighty” sections.

Vegetation was predominately cedar (*Juniperus*) with piñon appearing at higher altitudes. For some corners he stated that there were “no bearing trees within limits.” According to instructions, this would mean that there are no trees within 300 links (~200 feet or 61 meters). The only grass noted was grama. Holland observed several roads in this township and indicated them on his plat of the survey.

Figure 29. Erosion around spring at Salado Canon in southern portion of the national forest (T3NR5E). The forest service is in the process of restoring the area. Cattle are now kept out with a fence and tamarisk eradication is underway. Nonetheless, the area is heavily eroded. Photographed in July 1999.

Figure 30. Canon Salado at FR422 (T3NR5E). This runoff resulted from a brief but intense thunderstorm that lasted about one hour. A “Nalgene” one liter water bottle dipped into the muddy water contained about 0.25 liters of sediment after settling. Photographed in July 1999.

Charles Devendorf retraced a portion of the west boundary of this township in July 1920. Vegetation remained mostly cedar and piñon but he also remarked on some dense oak underbrush and *chamisa* (*Chrysothamnus nauseous),* an indication of heavy grazing pressure (Dick-Peddie 1993). Devendorf failed to locate some original monuments but reestablished them by using bearing trees. He commented that some bearing trees had died (Devendorf 1920).

In September 1983, John Whiting executed a dependent resurvey of a portion of T3NR5E in the southeast corner near Abó ruins. Whiting found some original corners established by Holland. Most bearing trees were dead or missing. Some of the corners were not at the proscribed intervals of 40 and 80 chains but no more than ~3 chains off (~200 feet or ~30 meters). Whiting's findings confirmed the validity of Holland's survey but suggest that Holland probably did not use precision instruments to determine some measurements and lines (Whiting 1983).

T3NR5E exhibits different patterns and characteristics than more montane areas, in summary:

- The lower elevation results in a dominance of "heavy cedar (juniper) and piñon."
- The term "heavy cedar" implies larger individuals.
- Some dense underbrush noted.
- By 1920 *chamiso* had invaded.
- More open terrain indicated by lack of bearing trees.
- Surface water is scarce.

- The arroyo courses noted on the plat remain present.
- Abó Arroyo is not deeply incised.
- Except for roads crossing the township, only one cultural feature was noted (ranch in section 32).

Each land grant bounding the national land grant has several surveys but the patterns outlined above remained. Dense underbrush is a routine observance. Closer to the settlements, grass and soil quality usually declined. The notes indicated the occurrence of surface water in some riparian areas. Hispanic villagers kept livestock, particularly sheep. By the early 1900s, surveyors noted more wire fences and "logging roads" crossing grant boundaries. Several canyons on the western side that intersect Tome Grant had "running streams."

Robert Kelley's 1857 survey on the west side of the mountains between the 1st and 2nd Correction Lines west of R5E stated that the best grazing was "back from the valley" (Rio Grande) or on the *Llano de Manzano* which is a series of broad coalesced alluvial fans, a *bajada*. He described bunch grass separated by bare ground that might have been indicative of heavy grazing from "valley" livestock. He further stated "it is a known thing for these prairies to be on fire" (Kelley 1857).

Conclusions regarding survey notes and landscape change

As stated previously, original survey notes provide baseline data regarding landscape conditions. They become a "snapshot" of what these men saw and measured. Nonetheless, one must be careful about making sweeping assumptions or generalizations from the field notes. A surveyor's primary duty was establishing corners of townships. Surveyors were not necessarily botanists, geologists, or geomorphologists. Most comments were brief and observations documented features on or close to the survey line. Local residents, hired to work on the crew, undoubtedly provided information not recorded in the notes. Nevertheless, considering these constraints, a pattern for the Manzano Mountain region emerges.

Except for the land grant villages, there was very little settlement in the mountains. Homesteaders did not arrive until the early 1900s, after the US created the forest reserve. The population in the region was overwhelmingly Hispanic (Ritch and Caypless 1882) and land use different from Anglo-American custom. Hispanic settlers used the mountains as a "commons" for grazing, fuel wood, building materials, and other resources (deBuys 1985; Hurt 1989; Garcia 1996). One could use the area without actually living or owning property in the mountains. A discussion of grazing follows in Chapter 6 but the livestock noted by surveyors were sheep and goats, not cattle. Herders continuously moved bands of sheep to better grazing; in other words, fences did not contain the stock and *pastores*, assisted by herding dogs stayed with the sheep

(Gregg 1844). Flocks from settlements on both sides of the mountains fed on mountain forage.

Logging, discussed further in Chapter 5, was small scale as noted by the surveys. Extensive logging would follow the turn of the century. Charles Kusz, the editor of the *Gringo and the Greaser*, a newspaper published in Manzano from 1883 to 1884 commented on the foot hills near Manzano as being covered with a “fine growth of timber” that could support sawmills (Ritch and Caypless 1882; Hertzog 1964).

Qualitatively, surface water appeared to be in more abundance in 1882 than now. Surveys indicated flumes and irrigation improvements to provide water to small cultivated areas. For whatever reason, climatic or anthropogenic disturbance, surface water is now less common.

Surveyors used the term *arroyo* to describe streams in general, not as a description of an entrenched channel. Holland made no note of the now deeply incised Abó Arroyo. Further, Cañon Salado and Cañon Saladito *arroyos* in T3NR5E that are now in many places incised to bedrock were not described as entrenched. Based on Holland’s plat, they have eroded headward. In July 1997, 1998, and 1999, I observed roots from trees ~100 years old projecting into these channels confirming that the most significant erosion has occurred since the surveys in 1882. This pattern is common in the American Southwest (Bryan 1925; Bryan 1928;

Bryan 1940; Leopold 1951; Antevs 1952; Shumm and Hadley 1957; Leopold, Wolman *and others* 1964; Hastings and Turner 1965; Cooke and Reeves 1976; Graf 1983; Hall 1990; Dick-Peddie 1993; Vogt 1997). There is a wealth of literature on the “arroyo problem” searching for a specific causal agent. My intent in this study is not the “arroyo problem.” Nevertheless, the ~1882 surveys suggest that gullying was not a significant feature on the Manzano landscape.

The flora described in the early surveys matches species present today but the tree stand density changed. As noted before, “heavy timber” described large trees not density. The increase in stand density occurred for the most part since ~1882. Most of the mountain forests now fit the colloquial description of a “dog hair” forest denoting high density stands.

Further, the presence of dense underbrush is not consistent with open stand pine forests with a grass understory as described in the Southwest before major settlement (Cooper 1960). Realizing that there are certain caveats regarding the term “dense undergrowth”, surveyors consistently used the term. Further, many of the areas described now have Gambel oak with ages that pre-date 1900. The early presence of sheep had a role in fostering oak growth, the species most associated with “dense undergrowth” descriptions. Heavy grazing by sheep eliminated grass, the low intensity fuel for surface fires, and allowed woody species to take hold. Reportedly, large fires may also increase the presence of oak in the mountain environment as well (Huddleston 1951).

As the early surveys suggest, human disturbance in the Manzanos, except for sheep grazing and limited fuel-wood cutting, was not omnipresent. Nearby railroad construction, logging, and increased cattle and sheep grazing by Anglo settlers would quickly affect this environment after ~1900.

Chapter 5

Logging in the Manzanos

Native Americans and Hispanic settlers used the forest of the Manzano Mountains for fuel and building construction material. Technology and local use limited the amount of wood harvested, however. Although their impact was much less than later commercial lumbering activity, local use did affect forests and woodlands.

Piñon/juniper woodlands received much heavier use by early occupants than higher elevation montane forests, pre-historically and historically. The woodland remains useful for fuel, small construction material, and for food, such as piñon nuts. Human use of woodland resources can result in relative depletion (Hall 1988), particularly as human population in an area increases. Notwithstanding earlier local use, widespread commercial logging commencing about 1885 resulted in significant change to Manzano Mountain forests, particularly the lower zone of the montane coniferous association (Figure 31).

As reviewed earlier, the 1882 public land surveys noted only minor logging activity. Charles Kusz's entry in the 1882 New Mexico Business Directory touted "fine growths of timber" that could support local sawmills (Hertzog 1964). Apparently, Kusz's observation was correct and large-scale logging activity began shortly thereafter. Reportedly, Benjamin B.

Figure 31. Characteristic secondary growth stand of ponderosa pine forest located in east half of T4NR5E. This area is undergoing thinning to reduce fuel load and decrease stand density. Road erosion and slash disposal present problems in thinning operations. Photographed in July 1999.

Spencer, who homesteaded a tract of land in Barranca Canyon in 1887, began logging in the Manzanos and built a sawmill in the mountains. Spencer supplied lumber to Gross-Kelly Lumber Company in Albuquerque and during peak times employed ~60 men. In 1908 Spencer contracted to supply cross ties and timbers for the construction of the Santa Fe Railroad's Belen "Cut-off" through Abó Pass (Foster 2002).

In ~1902, Eugenio Romero of Las Vegas, New Mexico contracted with the Santa Fe Railroad to provide 1.5 million railroad ties from Manzano Mountain timber. Railroad construction spawned a local lumber boom and five sawmills were soon operating in the Manzanos. Table 4 summarizes the landscape effect of this ***one*** contract.

Table 4*.* Railroad tie cutting and forest area required for 1.5 million ties (Webster 1992)***.*** Based on the caption to an early forest service photograph (Figure 19), "veteran" stands of pine contained about 16000 board feet measure (BFM) per acre (1 board foot is 144 cubic inches or 2359.74 cubic centimeters). Each pine contained 1000 to 2000 BFM per tree (*mean*=1500 BFM). A "standard" railroad tie contains ~32 BFM (Pinchot 1905; RTA 1993). The following summarizes the forest area needed at various levels of waste. One acre based on the above values would yield ~500 crossties with no waste, an unlikely proposition.

Waste Level (%)	Acres	Hectares
0	3000	1214
10	3300	1336
20	3600	1457
30	3900	1578
40	4200	1700
50	4500	1821

Waste from tie-cutting was in all probability more substantial than Table 4 indicates. For example, a 40 foot (12.19m) long pine log would yield five

8 foot (2.44m) long “tie blanks or sections” from which the tie-cutter would saw or hand hew individual ties (Figure 32 and 33). Each railroad tie was about ~6 inches by ~8 inches by ~96 inches. A common value for ponderosa pine diameters cited by US Surveyors in 1882 was ~20 inches (51 cm). Therefore, based on the above values each “tie blank” would yield a maximum of four railroad ties and the ~40 foot log would yield 20 ties instead of ~47 based only on board footage values per tree. To increase the number of ties per tree would require an exponential increase in log radius. If we assume an average of 12 twenty inch diameter “veteran” pines per acre, one acre would yield about 240 ties. Based on this value, the acreage required to produce 1.5 million ties would be about 6,250 acres. Furthermore, this assumes an unlikely uniform distribution of trees of the same approximate diameter.

While one can adjust the values above for a number of variables, the result is essentially the same: it required a large amount of forestland resulting in significant disturbance. George Bard, a local lumberman, remarked in 1908 that most of the Manzano forests in three townships had been cut for railroad construction purposes (Baker, Mazwell *and others* 1988). Based on photographic evidence (Figure 34) this was likely the east portions of T4N, T5N, and T6NR5E that were mostly ponderosa pine forests.

Figure 32. Splitting a log section with wedges. Although this photograph was taken near Pie Town, NM in 1940, it illustrates the process of producing railroad ties. Photograph by Russell Lee, Office of Wartime Information Collection, Library of Congress No. LC-USF33-012792-MR.

Figure 33. Hand hewing a railroad tie near Pie Town, NM. Hewing ties required less capital than a sawmill operation. Hewing ties, though simple, wasted considerable wood. The process of hand-hewn ties was similar in the Manzano Mountains. Photographed in July 1940 by Russell Lee, Office of Wartime Information Collection, Library of Congress No. LC-USF33-012776-M1.

Figure 34. Clear-cut area on the east side of Manzano Mountains. This photograph taken on 14 March 1911 illustrates widespread logging on the lower foothills. The men in the picture are re-seeding the area in "yellow pine" (ponderosa pine). Photograph courtesy of US Forest Service, Region 3.

In 1908, I.K. McKinley assumed operation of Eugenio Romero's mills. McKinley arrived in the Tajique area in 1905 as a homesteader shortly before the Forest Reserve proclamation by President Theodore (Roosevelt 1906). As McKinely's business expanded, he bought out competitors and became one of the areas largest employers. As McKinley described to Hurt (1989), small mills moved from canyon to canyon as each area was depleted. He stated that Gross, Kelly, and Company in Albuquerque bought the higher grades of lumber and Santa Fe Railroad purchased the railroad ties.

In Estancia, New Mexico, Romero had a planing mill, a box factory, and a dimensional lumber yard stocked from two saw mills in the mountains. Romero claimed to have one million board feet of lumber on hand and shipped several carloads of lumber per week (Hoelscher and Hoelscher 1959). Romero and McKinley were not the only lumbermen that exploited forest resources. J.W Byrd's mill operation depicted in Figure 35 and 36, was probably characteristic of many operators. A. P. Ogeir had an advertisement in the Estancia News-Herald in Feb 1913 stating that he had "lumber on supply at all times." His operation was three miles west of Tajique near the newly built ranger station (Ogeir 1912). English Manufacturing had two mills in the Manzanos to supply

HAULING LOGS TO THE SAWMILL of J. W Byrd **in the Manzano Mountains about** 1904-1905. Oxen were a very necessary beast of burden in the lumber business. **Notice size of log. There is still some lumber cutting business in the Manzanos** but not to the extent it was in the early 1900's. (Mrs. J. M. Terry Photo)

Figure 35. J.W. Byrd logs. This photograph illustrates the size of logs being cut from the Manzano Mountain forests in the early 1900s. If the caption is correct and this photograph was taken in 1904-05, this cutting preceded the establishment of the Manzano National Forest and forest service scrutiny. Photograph from a special edition to the *Valley Express* (Hoelscher and Hoelscher 1959). Courtesy of the Dobie Collection, University of Texas at Austin.

J. W. BYRD'S SAWMILL IN THE MANZANO MOUNTAINS, 1904-1905. Lumbering was an important business in the early days of the county. (Terry Photo)

Figure 36. Byrd's sawmill operation. Saw mills of this era operated on steam power supplied from wood fired boilers known for causing fires in forests. Byrd's mill appears to have two smoke stacks for steam boilers. Photograph from a special edition to the *Valley Express* (Hoelscher and Hoelscher 1959). Courtesy of the Dobie Collection, University of Texas at Austin.

lumber for boxes, crates, and milled lumber (Hoelscher and Hoelscher 1959).

Doubtless, many other small operators logged in the Manzanos. Supplying hand hewn crossties required little capital investment other than felling and bucking saws, axes, wedges, and a team and wagon. Further fuel wood collection remained a constant activity for local residents on both sides of the range (Figure 37).

A range analysis report written in 1980 regarding the Gross-Kelly grazing allotment stated that the "allotment was heavily logged during the early 1900s. It appears that every accessible tree large enough to make a 2x4 was cut." Logging caused major erosion and soil loss on this allotment (Little and USFS 1980).

Apparently, logging was a highly profitable operation involving a large number of workers, as Tenos Tabet, a Syrian-born store owner in Manzano made a reported profit of $10,000 mostly from sales to employees of the various mills (Hurt 1989). If Hurt reported this income in 1903 dollars, $10,000 would be the equivalent of ~$180,000 2002 dollars, a significant amount of money that is indicative of the size of lumbering activity.

Because of its rugged terrain, the upper montane forest received less logging pressure, as did the more precipitous west side of the range.

Figure 37. Wood haulers. The original forest service caption reads, "Manzano N.F., Hell Canyon, Bernalillo Co., NM 11/16/09. Indians and Mexicans hauling dead wood out of Hell Canyon. The Mexicans had permits. The Indians were caught this morning in trespass. Pueblo Indians from Isleta." Photograph courtesy of US Forest Service, Region 3.

Unlike logging in the Pacific Northwest, the Manzanos did not have large streams or rivers to help move logs from higher elevations. Much of this area is inaccessible to wagons for moving the timber to mills. Further, no early accounts mentioned “skid chutes,” “high-lead rigs”, or similar devices to move logs down slope. Logging on steep slopes would require technology not present, or at least, unused, in the Manzanos in the early 1900s.

On a visit to a private tract in Section 14 T6NR5E in July 1999, I noticed a number of large diameter ponderosa pine and Douglas fir trees. I asked Mr. Marvin McKinley, at the time the owner, how these trees escaped cutting. He said that “we didn’t cut our own land, there was enough public land” (personal communication, 1999). Whether this was true of other private landowners is not known.

Until the forest service began to enforce timber-cutting regulations, early lumbermen operated with very few, if any, constraints. Even after forest reserve establishment, much of the cutting was unauthorized but there was no real enforcement power available. After 1906, when the area became the Manzano National Forest, regulation began but it would take several years to establish effective control (Baker, Mazwell *and others* 1988). The *1905 Use Book* that set guidelines for national forests stated that “the prime object of the forest reserves is use” (Pinchot 1905).

As the forest service took over, regulations and the provision for timber contracts, although resisted, evolved. The forest service sold timber by competitive bid (Frome 1971) but had set fees for grazing livestock. Logging in the Manzanos continued at lesser scale well into the 20th century (Figure 38). By 1939 lumbering was not "an extensive industry in Torrance County" (WPA 1939). The Great Depression of the 1930s, World War II, and a scarcity of suitable saw logs were contributing factors to logging's decline. A few operations lasted until at least the late 1950s (Hoelscher and Hoelscher 1959) but the shift has been towards personal use of forest products not commercial use (USFS 1999). Area residents use forest resources for fuel wood, construction material such as *vigas*, *latillas*, and fence material. Land grant villages have traditionally considered the forest as a source of building material (deBuys 1985).

Increasing population, particularly in Albuquerque, could put further demands on forests for these type of activities. In federal fiscal years 1986 through 1990, personal cordwood harvest was 5,382 thousand board feed versus a commercial cordwood harvest of 1,857 thousand board feet (USFS 1991). The traditional measure for fuel wood is the cord, which is 128 cubic feet or 3.62 cubic meters. Increasingly, firewood cutters travel from as far as Santa Fe to use forest resources in the Manzanos.

Figure 38. George and Nash timber sale. Caption reads, "new cutting on George and Nash timber sale." Note the highly disturbed surface of exposed soil. Photographed by K.C. Kartchner August 1924. Courtesy of US Forest Service, Region 3.

Probably due to its limited area, the Manzanos escaped the much more extensive logging that other areas of New Mexico sustained. Unlike the Zuni Mountains and the Sacramento Mountains, logging railroads never penetrated the Manzano Mountains (Fletcher 1998; Kaufmann, Huckaby *and others* 1998). Nevertheless, landscape degradation from logging occurred. Although unquantified, logging caused or contributed to fires (Figure 39). Many of the early mills used steam engines, fueled by wood, to power saws. Slash left from trimming limbs left large amounts of flammable material on the ground. Although early foresters considered all fires detrimental, there was little they could do to control major fires because of the lack of fire-fighting forces and technology. In the early days of the forest service the policy was to put out every fire possible. Not cognizant of the role of fire in the forest ecosystem, early foresters considered fire a waste of timber. Further, their leader, Gifford Pinchot considered open stand forests as "understocked" (Pinchot 1947; Pyne 1982).

Intensive logging combined with fire suppression and grazing would help transform the secondary growth forest into dense stands of timber now approaching 500-700 stems per acre, a considerable difference from pre-logging stands. Uncontrolled fire is now a serious

Figure 39. Fire damage on private land in Cibola National Forest (Manzano area). Note burned railroad ties in foreground. Photographed by E.W. Kelley on 2 May 1923, exact location not given. Courtesy of US Forest Service, Region 3.

threat to these dense stands and surrounding private lands and private residences (USFS 1999).

Additionally, major fires in dense stands can promote significant episodes of soil erosion increasing sediment supply in drainages (Reneau and McDonald 1996). Runoff increases as does local flooding during heavy precipitation. Reneau (1996) postulated that major fires and their relationship to geomorphic change, such as channel incision, may provide an analogue for these processes in the past.

Commercial logging was a short-term activity but it had widespread ecosystem effects still evident on today's landscape. Most of the ponderosa pine forest is dense secondary growth timber comprised of much smaller diameter trees than existed before logging. Instead of the larger pines (~20-24 inches dbh) often described by early surveys, most ponderosa pines are now in the range of 5-12 inches. Fuel loads greatly exceed "natural" conditions creating the potential for disastrous forest fires (USFS 1999). Grazing practices instituted by early Hispanic settlers and later by Anglo-Americans exacerbated the decline of a more open stand forest characteristic of pre-~1880 conditions.

Chapter 6

Livestock and Landscape

In the early 1800s, when Hispanic settlers returned to the east side of the Manzanos, sheep were the livestock of choice (Figure 40). This was true throughout New Mexico. New Mexico was sheep country with cattle playing a much smaller role (Carlson 1969; Jordan 1993). The number of sheep in New Mexico when it became a territory of the United States numbered at least in the hundreds of thousands (Carlson 1969; Baxter 1987). As discussed earlier, agricultural census data for the Manzano region are difficult to establish. Not until the 20th century would cattle gradually assume the dominant role that sheep had for hundreds of years of New Mexico livestock production.

Sheep and cattle raising in the Manzanos modified the environment. Long-term sheep grazing in the mountains helped change the grass understory to an oak understory noted by early surveyors. The change in forest vegetation occurred in the Manzanos earlier than many other areas of the Southwest, perhaps by forty or more years, and predates Anglo settlement about 1900. A similar pattern probably exists in the Jemez and Chuska Mountains (Savage and Swetnam 1990; Touchan, Allen *and others* 1996). Cattle, and facilities associated with cattle,

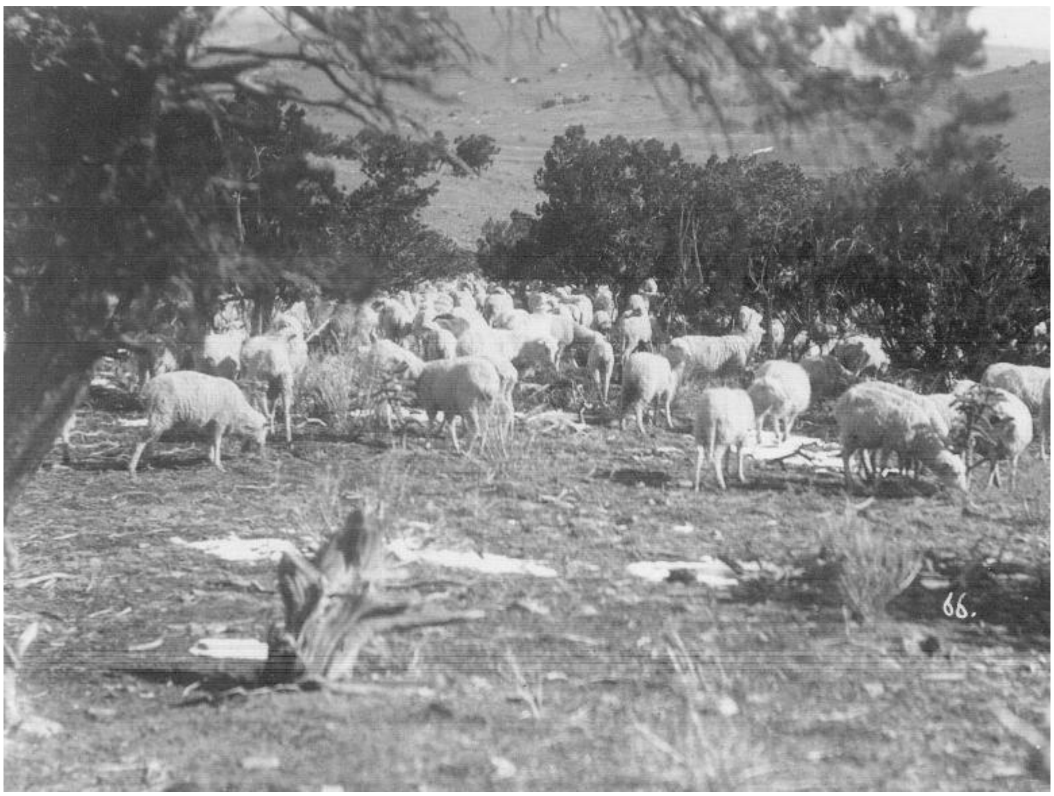


Figure 40. A band of sheep from Isleta Pueblo grazing on the foothills of the Manzano Mountains ~1890. The photograph is characteristic of traditional sheep herding activities. Vegetation is sparse and appears to consist mostly of woody herbaceous growth and juniper. Photographed by Charles F. Lummis. Courtesy of Museum of New Mexico. Neg. No. 42044.

continue to affect forest alteration processes that began in the early to mid-1800s.

Much of the literature I cited earlier regarding *arroyo* formation is a commentary on livestock numbers and overgrazing. Officers associated with the Army of the West during the Mexican War (1846-48) commented on the scarcity of forage for their mounts and pack animals (Leopold 1951; Galvin 1966). Will Barnes, Inspector of Grazing for the Forest Service, documented and provided a warning about over-used ranges (Barnes 1913; Barnes 1926).

Range deterioration was prevalent in many areas of the southwest by 1880 and in some locales much earlier. Sheep and cattle numbers increased as settlers and stockmen moved to the region. Railroad extensions provided access to new markets. Subjugation of Native Americans contributed to the increase in livestock population (Wildeman and Brock 2000). The threat of raiding disappeared and many Native Americans adopted livestock raising as a livelihood. In many cases, agencies such as the Forest Service inherited already deteriorated ranges.

Establishing control over grazing was an early problem faced by the newly formed US Forest Service and the lands they administered. The *1905 Use Book* provided guidelines for administering grazing within forest reserves (Pinchot 1905). Ranchers and traditional users objected to regulations and fees imposed for grazing animals on what was previously “free land.” Trespass was common and regulations difficult to enforce by a small group of rangers that patrolled the area. Furthermore, in the Manzanos, the district office was some distance away in Mountainair. In 1908, the forest service built a cabin along Tajique Creek, northwest of the town of Tajique (Figure 41). This location placed “guards” closer to the forest areas but many areas still required considerable travel time to inspect and monitor. Gradually, however, the forest service achieved regulatory control and at least tacit approval by those using the forests for pasturage (Rowley 1985; Baker, Mazwell *and others* 1988).

Grazing allotments

The US Forest Service administers grazing in the southern Manzano Mountains through grazing allotments (Figure 42). The allotments vary in size, topography, available moisture, number of livestock, and forage present. Some families have had multi-generational use of an allotment. The unit of measurement for stocking an allotment is the animal unit month (AUM). The forest service defines an AUM as “1) the amount of feed or forage required by an animal unit for one month. 2) tenure of one animal-unit for a period of one month.” An animal-unit is

Figure 41. Tajique Ranger Station. The original caption states that fencing is underway. The house measures 26 x 28 feet. Tajique Creek is in the foreground. The cabin was built in 1908 and this photograph is dated 13 November 1909. Courtesy of US Forest Service, Region 3.

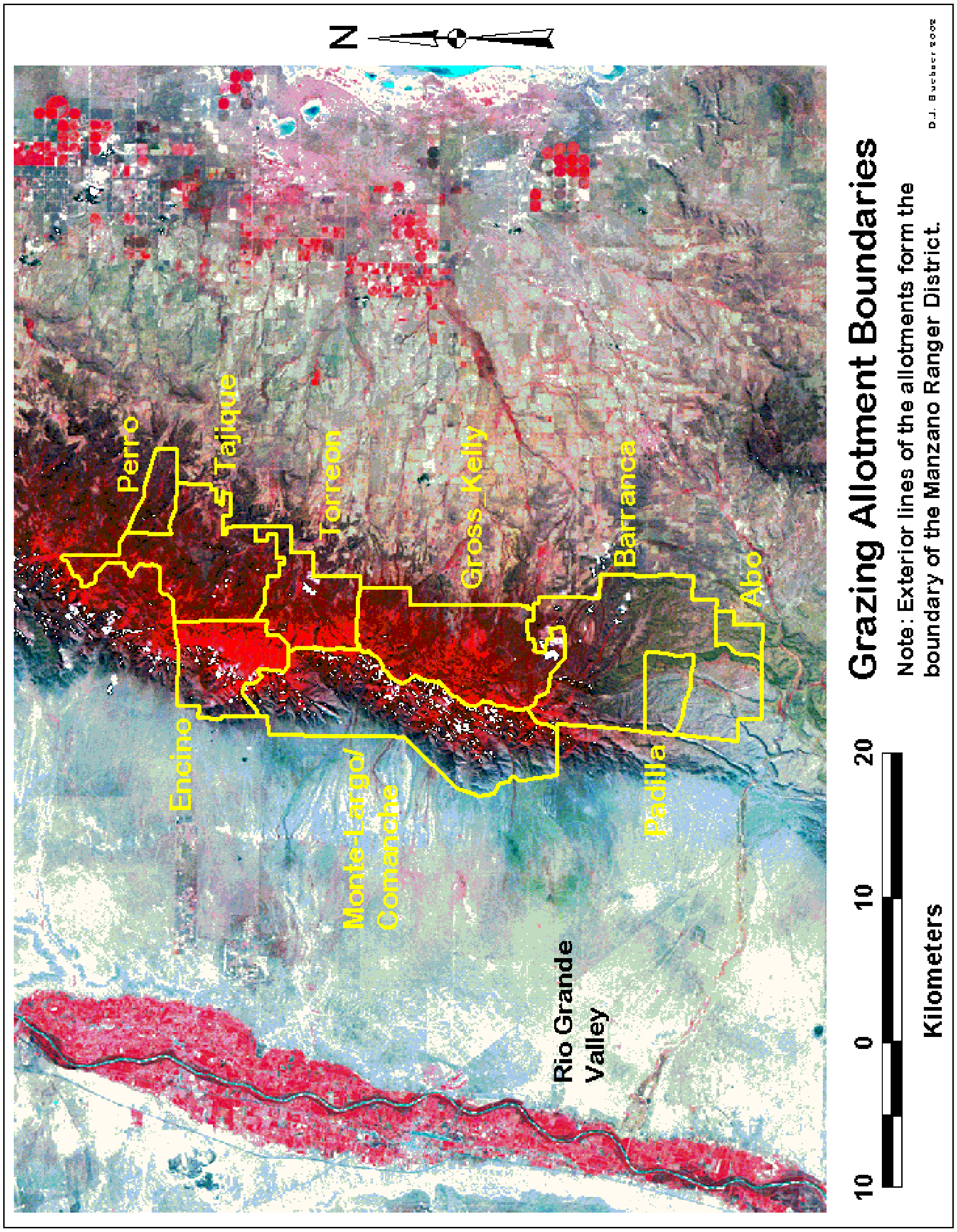


Figure 42. US Forest Service grazing allotments in the southern Manzano Mountains. Gross Kelly is closed to grazing. Significant portions of Encino and Monte-Largo/Comanche allotments fall within the Manzano Mountain Wilderness Area. The allotments pre-dated the establishment of the wilderness area.

“one mature (1000 pound) cow or the equivalent based on the average daily forage consumption of 26 lbs. dry matter per day.” In 2002, the “per head month” fee is $1.43. Therefore, based on various “conversion factors” the agency computes a total fee for the allotment (USFS 1992; USFS 1999). For example, one mature cow has a conversion factor of 1.00 and the fee per year for one mature cow would be $1.43 times 12 months or $17.16 per year.

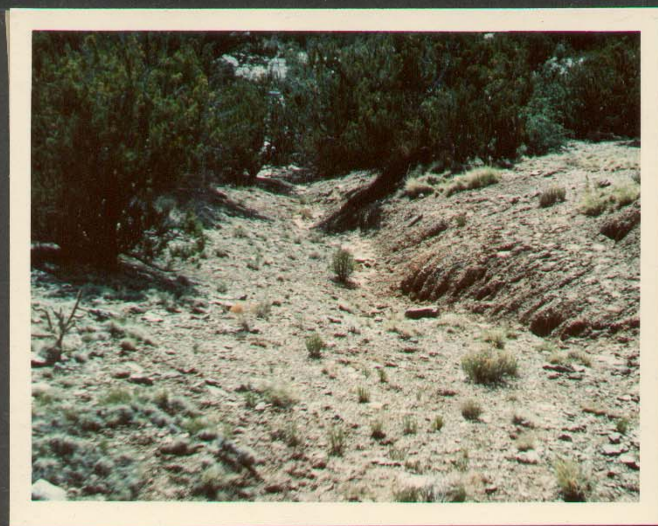
Unlike timber contracts that require bids, grazing fees are set for a given area and time in cooperation with other agencies such as the Bureau of Land Management. One of the criticisms of US Forest Service grazing policy is the low rate charged compared to leasing private land. For example, in 1913 the per head fee was forty cents (Barnes 1913). Adjusted for inflation using the Consumer Price Index, forty cents equals about $7.25 in 2002 dollars, five times more than the current fee per month. Clearly, grazing fees have declined since 1913.

Will Barnes (1913) raised the issue of competitive bids but the fixed fee system remains, perhaps to avoid monopolization of the range allotments by large operations. The counter-argument to charging higher fees is that public lands have less available forage and are not worth as much. Administration of grazing by the US Forest Service and Bureau of

Land Management remains a contentious issue between environmental groups, ranchers, and rural communities. Increasingly, a growing urban population is questioning the grazing allotment system and placing pressure on Congress to reform the system (Balzar 2001).

Arguments against livestock grazing in the Manzanos are not recent. In 1974, The Rio Grande Chapter of the Sierra Club expressed their concerns regarding grazing and landscape degradation in the Comanche Allotment (now combined with Monte-Largo). A member complained about numerous problems that he associated with livestock use (Figure 43). In the forest service response, Forest Supervisor W.L. Lloyd admitted to the poor conditions on this allotment. He attributed the problem to heavy and long use by sheep, goats, horses, and cattle but assured the Sierra Club that the matter would receive attention (Lloyd 1974). Many environmentalists would argue that conditions have only slightly improved since 1974.

The permit holder at the time of this complaint was a source of constant problems for the forest service. A number of the documents in the Comanche allotment file in the 1970s related to disputes regarding usage, improvements, poor condition of the range, and other problems. A range inspection report written in 1974 was exceptionally direct in its



MOUTH OF COMANCHE CANYON. EROSION & VERY POOR VEGETATION. 6/77.

NEAR THE MOUTH OF JARAMILLO CANYON. (CLASSIFIED SHOULD BE CLOSED). NOTE THE LACK OF GROUND VEGETATION, HEAVY USE ON BROWSE- SPP. AND SHEET EROSION. 6/8/77.

Figure 43. Range analysis photographs taken in 1977 of Comanche allotment documenting range abuse. Note that the caption recommends closing the allotment. US Forest Service.

criticism of the permit holder's actions (Hickey 1974). Wayne Hickey, Range Conservationist stated at the end of the report that:

> It is doubtful if the permittee ever undertakes the maintenance of any of the improvements; or provides any management requiring time or effort. He probably will buy a bull or two of a different breed to cross with his purebred Herefords. It would appear that the permittee is hanging onto the Comanche Allotment for the following reasons:
>
> 1. To ride among the high rocks and dream in his own private wilderness.
> 2. To have a padlocked hunting presence for his immediate family and a few select friends.
> 3. To own a few cows, horses, wear a cowboy outfit and talk about his "ranch."
> 4. As a future investment.

Most likely, Mr. Hickey could not submit such a candid report today but his frustration with conditions on this allotment was apparent throughout his report and those of others. Allotment files reveal a history of problems with some permit holders, deteriorated range conditions, and allegations of discrimination against Hispanic permit holders. Complaints to congressmen, senators, and forest supervisors often hinders allotment management and requires considerable time and effort by employees. The US Forest Service, in many ways, is "caught between a rock and a hard hoof" for their role in administering policies set by Congress.

Some allotments in the Manzanos have a long history. Many had established boundaries by 1908. Since then some have changed or been combined but most have remained relatively intact since 1908. Table 5 summarizes characteristics of grazing allotments in the southern Manzano Mountains in 2002:

Table 5: Allotments in the southern Manzano Mountains. Size data are derived from a GIS database furnished by the USFS. AUMs, Pemittee, and Season data (USFS 1999) and (personal communication, 2002).

Allotment	Size Acres (Hectares)	Permittee	AUMs Permitted (cow/calf)	Season
Abo	1748 (707)	Smith, R. Smith, P.	39	5/1 to 12/31
Barranca	29319 (11865)	McKinley, W.	134	yearlong
Padilla	3698 (1497)	Garley, B. Garley, J.	25 18	6/1 to 10/31 yearlong
Torreon	8291 (3355)	Chavez, J.	29	6/1 to 10/31
Tajique	19094 (7727)	Tajique Grazing Assn.	81	5/1 to 10/31
Perro	3209 (1299)	Blatnik, J. Blatnik, J.	25	6/1 to 10/31
Monte Largo/ Comanche	27005 (10929)	Baca, J.	134	yearlong
Encino	9988 (4042)	Cordova Ranch	120 30	6/1 to 12/31 yearlong
Gross-Kelly	16520 (6726)	Closed in 1980	n/a	n/a

The Cibola National Forest Supervisor's Office, Albuquerque maintains files for each grazing allotment in the national forest. The amount of data for each allotment varies considerably. Some contain a wealth of information; in other allotments, the record is less complete. Based on my review of forest service records, ~1954 was the last year that sheep grazed on forest service allotments in the southern Manzano Mountains. Because it has been about fifty years since sheep grazing ceased on national forest lands, it is more difficult to separate their effects from cattle's. Some early records do comment on numbers of sheep and specific problems caused by sheep but the record is scanty. Nevertheless, as they had previously, large numbers of sheep grazed the area even after forest service management began ~1908.

Sheep grazing

Large land grants such as the Baca and Estancia grants discussed earlier contained huge flocks of sheep, perhaps upwards of one half million or more animals. When Anglo-Americans arrived in New Mexico, they encountered a system of livestock production unfamiliar in the United States. New Mexican grant holders, and other men of wealth (*ricos*), operated under the *partido* system. *Partidarios*, that is, sheepherders *(pastores),* received a certain amount of sheep from the *patron.* From this band, the *patron* expected about a 20% return through increase in flock size. Herders were responsible for losses from their share of the increase. The system created a situation where most herders remained in perpetual debt to the *patron*. This system remained in place until well after the US acquired New Mexico (White 1994). Under the *partido* system, numbers of sheep were more important than quality and mutton was more important than wool until the late 19th century (Barnes 1913; Carlson 1969; Baxter 1987).

Hispanic sheepherders moved their bands of sheep (1000-3000 head per herder) on a vast open range often far from settlements (Carleton 1965; Galvin 1966). Herding dogs and close attention to the band helped ameliorate losses but weather, predation, and losses to Native American raiders were a constant factor. As herds depleted forage in a given locale, the herder moved the sheep to new forage areas. Mountain areas often provided summer pasturage. The only "range management" was sheepherders directing their bands to forage and water. Early breeds of sheep in the area, such as *churros* (Figure 44) were hardy animals but nonetheless needed the care and protection provided by herders.

In 1833, Bartolomé Baca abandoned his large grant in Estancia Valley. Many of the families "employed" by him moved closer to the mountains from the exposed plains. This group of people formed the nucleus of settlers requesting village grants. Nevertheless, sheep herding remained the predominant agricultural system. The proximity of villages to the mountains increased grazing effects on montane areas. Although Native American depredation continued, village residents could move their herds into the refuge of the mountains. Furthermore, village residents often fought back and pursued raiding parties. The village of

Figure 44. *Churro* sheep. This photograph taken on the Navajo Nation depicts the sheep breed common to New Mexico in the 19th century. US Department of Agriculture Image 97C33550.

Manzano organized a militia and built a *torreon* (Figure 20) from which they could defend their homes and livestock (Hurt 1989).

Little changed until Anglo homesteaders arrived in the Estancia Valley about 1900. The new settlers quickly acquired sections of land with water and effectively ended the open range on the plains and in the mountains that Hispanic residents traditionally used. Homesteading by Anglos and the arrival of railroads helped shift livestock preference to cattle (Carlson 1969).

Sheep, however, remained an important component of livestock production well into the 20th century. Capital investment was small and the herder could readily move the band from place to place. Early sheepherders required little more than dogs and a few pack animals. Trespass by "tramp sheepmen" may have been a common occurrence in the Manzanos as it was on other western ranges before the forest service instituted effective control (Barnes 1913). Nonetheless, sheep and their impact on landscape remained a problem in the mountains.

In many ways, sheep are better adapted to mountain and semi-arid environments than are cattle. Sheep require less water, may go two or more days without drinking, and will travel farther to water. Sheep will forage on steeper slopes than cattle and have a more varied diet than cattle. Furthermore, herders can force the band to areas not used by cattle (McDaniel and Tiedeman 1981; Holechek, Pieper *and others* 1998). Areas where sheep bed for the night sustain heavy grazing. Sheep may remove up to ~65% of the forage in these locations (McDaniel and Tiedeman 1981). John Muir referred to sheep “as hoofed locusts” regarding their ability to quickly denude a landscape of vegetation (Muir 1911). Overgrazing of cool-season grasses, such as June grass (*Koeleria cristata*), accounts for their relative scarcity in the Manzano region and other parts of New Mexico (Bohrer 1975). Heavy grazing by sheep in the Manzanos caused a number of environmental problems, some noted in early forest service documents.

A 1932 grazing allotment report for Tajique allotment notes sheep from state lands encroaching on the allotment (Boyle 1932). Allotment files frequently referred to sheep and goats as factors in range decline. A 1973 range inspection report stated that sheep heavily grazed the Comanche allotment in the late 1930s and early 1940s creating numerous sheep trails and erosion features then present (USFS 1973). Walter Hickey’s inspection of the Padilla allotment in 1973 remarked that the much of area was in “very poor condition” and “sheeped out” (USFS 1974). A photograph from a 1977 inspection report illustrates grazing problems on the allotment (Figure 45).

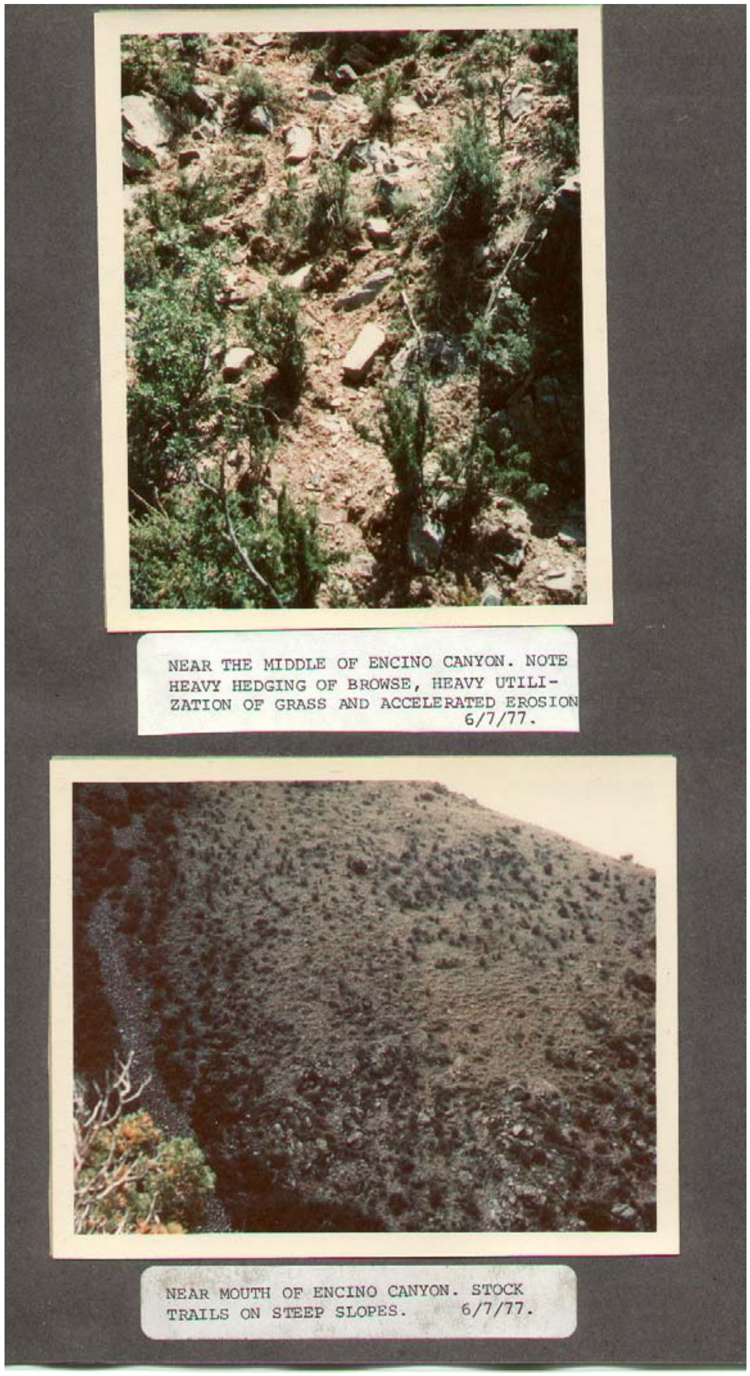


Figure 45. Photograph from range analysis report illustrating poor conditions in 1977. The lower photograph indicates terracette formation on steep slopes.

Many allotments had substantial numbers of sheep grazing on them until cattle began to dominate grazing in the Manzonos. Table 6 synthesizes information known about sheep use on Manzano allotments. The record is incomplete but the information presented provides insight on the importance of sheep grazing on national forest lands, particularly in the early 1900s.

While the record is incomplete, the data indicate a significant number of sheep grazed the national forest lands. Monte Largo appears to have had the largest numbers but the deficient record for other allotments prevents a more precise analysis.

As one would expect, the more arid western and southern portions of the Manzanos exhibit more of the damaging effects caused by years of sheep grazing. Vegetation recovers more slowly at these locations. *Piñon*/Juniper woodlands (Figure 46) have low resistance to grazing and may not recover from overgrazing for 50 years or more (Holechek, Pieper *and others* 1998). Although conditions are improving, the effects caused by heavy sheep grazing persist. Cattle helped to complete the landscape deterioration process.

Cattle grazing

William deBuys (1985) observed that the combination of sheep use of higher and steeper terrain and cattle's penchant for valleys and riparian

Table 6. Allotments and number of sheep permitted. On some allotments actual use may have been significantly higher. Data derived from forest service records on file at Supervisor's Office, Cibola National Forest, Albuquerque (USFS 1931-1999).

Allotment	Years, number of sheep permitted, and notes
Abo: ~700 ha	No record in file.
Barranca: ~12000ha	1932: 200 goats
Padilla: ~1500 ha	No record but 1974 report indicated that the area had "been sheeped out" in the past
Torreon: ~3400 ha	No record in file.
Tajique: ~7700 ha	No record in file, except for "trespass" stock in 1932.
Perro: ~1300 ha	Prior to 1957 part of Tajique allotment
Monte Largo: Combined: ~11000 ha Comanche	1908: 1800 sheep 1909 to 1922: ~5400 sheep/year 1942: 450 sheep 1943: 600 sheep 1944: 765 sheep 1946: 700 sheep 1947: 700 sheep 1948: 486 sheep 1949: 514 sheep 1950: 514 sheep 1951: 514 sheep 1952: 486 sheep 1954: 423 sheep Grazed heavily by sheep in 1930s and 1940s 1932: 1000 sheep
Encino: ~4000 ha	1932: 1000 sheep 1943: 1268 sheep 1944: 1499 sheep
Gross-Kelly: ~6700 ha	1910: 1300 sheep 1920: 1096 sheep 1932: 3596 sheep

Figure 46. *Piñon*/Juniper woodland in T3NR5E. The view is to the southeast. Saladito drainage is in the center of the photograph. Much of this area in undergoing juniper encroachment on grasslands. Photographed in July 1999.

zones resulted in almost all available range being used by livestock. DeBuys was referring to the Sangre de Cristo Range of northern New Mexico but the pattern in the Manzano follows his basic observation.

After about 1900, cattle gradually replaced sheep as preferred livestock. Early allotment records document the presence of cattle by 1908. Undoubtedly, cattle were on the range before this time. Traditionally, families in local villages often kept a few milk cows and logging operations depended on oxen as draft animals. Raising cattle had advantages. Cattle did not require tending by a herder. Essentially, they could be turned loose in an area and periodically checked. Predators are less likely to prey on mature cattle compared to sheep. Furthermore, the practice of cattle raising was more common with Anglo settlers new to the area.

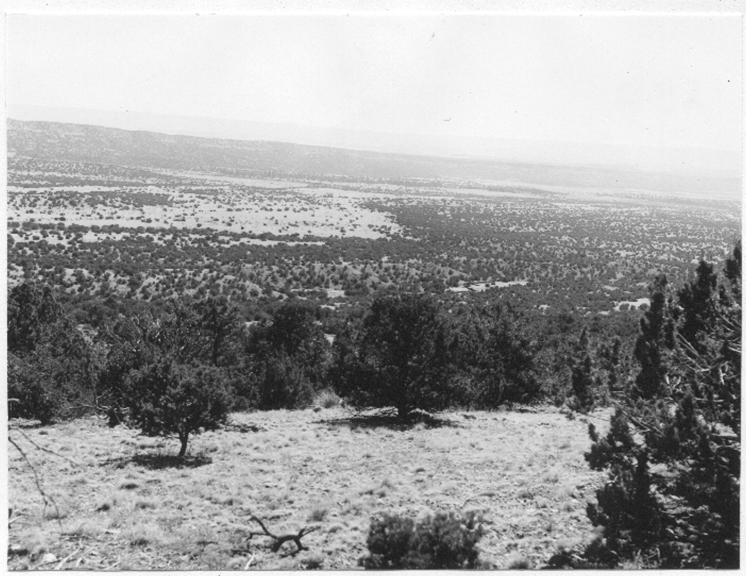
The forest service may have preferred cattle to sheep. Early foresters deemed cattle as less damaging to forest areas. Furthermore, cattle ranching required a local base of operation whereas the transhumant practices of sheep production did not (Barnes 1913). Whatever the reason, cattle production increased while sheepherding declined in the Manzanos and throughout much of New Mexico

Cattle require more water than sheep and will not range as far to water, usually less than 2 miles (3.2 km) (Valentine 1947; Holechek, Pieper *and others* 1998). Steep terrain decreases travel distances. To encourage cattle to travel away from water supplies, forest service management plans require salt placement away from water sources in an effort to encourage cattle wander over a greater portion of available land. Nevertheless, this tactic does not ensure that cattle will range farther from water points. As discussed later, cattle require a greater infrastructure of fencing, water supply, and equipment to handle cattle, such as corrals than can have important landscape effects.

From 1997 to 2001, I frequently encountered cattle while conducting research in the southern Manzanos. Based on these observations and familiarity with the area for thirty years, it was obvious that livestock are responsible for a number of landscape modifications. Most of the cattle in this area are semi-feral and usually left the immediate area when they detected my presence. Nonetheless, by observing cattle "sign" such as tracks and feces, one can easily determine particular places where cattle congregate. Although cattle favor lower valleys, riparian and wet meadow areas (McDaniel and Tiedeman 1981), it is not unusual to find them on higher elevation ridges (~2800 m) in spring, summer, and fall. Some high meadows had evidence of heavy grazing. Cattle in the national forest were essentially free-ranging and not usually contained by fencing except at allotment and pasture boundaries.

I made observations and measurements of a number of disturbances and terrain features associated with cattle near Bosque Peak (Sec. 4 and 9, T6NR5E; Altitude ~2865 m), a site known locally as *La Cienegita* (Sec. 11, T4NR5E; Altitude ~2300 m), and on *piñon*/juniper woodland areas in T3NR5E. In these areas, I followed cattle trails that radiated from water sources or grazing areas and noted geomorphic and other effects caused by cattle. I measured and photographed erosion features, such as trails and "pawed" out areas and the condition of vegetation. Also noted were other details such as the presence of fences, water point improvements, salt or mineral blocks, and access trails or roads.

Grazing allotment files more often than not classify many of the allotments as "fair to poor in range condition." Rangers knew about the problem early on. An inspection report prepared in 1932, noted numerous problems associated with overgrazing up to the highest elevations of the Gross-Kelly Allotment (Woods 1932). Since the ~1970s, photographs in the files frequently document these conditions (Figure 47). Passage of the National Environmental Policy Act in 1969 placed new requirements on public land managers such as the US Forest Service to perform environmental assessments of actions regarding forest lands and activities (NEPA 1969). Current management of the forest seeks to



General views of allotment from west below "Priest Knob" (SE¼,S6). Upper photo taken across center and lower toward the North. Vegetation at site is Ardis, Muto, Hija, Bahi, Bogr. Condition poor, much sheet erosion.

Figure 47. Allotment inspection photogaph taken in March 1974 commenting on poor conditions present.

correct many mistakes made in the past and a few allotments are showing improvement, although recovery will take many more years.

Livestock and Landscape Change

Unfortunately, many of the environmental problems associated with livestock production continue today. Moreover, livestock grazing may be the most important human caused disturbance to ecosystems in the Manzanos and other areas in the American Southwest (Fleischner 1994). Although cattle numbers have declined in Cibola National Forest over the past thirty years (personal observation and USFS allotment files), and sheep are gone, some areas remain overgrazed, trampled, contaminated, and certain livestock facilities foster soil erosion and vegetation damage. Furthermore, access roads built for loggers and stock raisers fragment the landscape and encourage vehicle traffic by recreational users (Allen 1989). Many of these problems exist in other mountain areas of New Mexico and the Southwest. The following discusses some of the problems associated with livestock, primarily cattle, and their facilities in the Manzano Mountains.

Overgrazing and Trampling

Essentially, overgrazing removes the protective covering of vegetation from the soil thus exposing it to erosion (Ellis and Mellor 1995). David Pratt of Ranch Management Consultants has a simple but reasonably accurate rule for evaluating the existence of overgrazing on a range, “Soil, it is not supposed to be seen. It is supposed to be covered” (Pratt 2002). When vegetation is reduced by human or natural agency, erosion increases (Figure 48). Historically, many workers attribute *arroyo* formation in New Mexico and the Southwest to overgrazing by livestock, drought conditions, or combinations thereof (Bryan 1940; Antevs 1952; Cooke and Reeves 1976). The existence of prehistoric *arroyos* and later, large numbers of Spanish livestock, complicates the *arroyo* arguments and is beyond the scope of this project (Denevan 1967; Hall 1990). Nonetheless, cattle and sheep grazing correlates with many denuded, eroded, and shrub-encroached areas of Manzanos, particularly in the foothills and piñon/juniper woodlands, and is similar to conditions reported elsewhere (deBuys 1985; Forman and Godron 1986; Dick-Peddie 1993).

Furthermore, fire suppression has fostered the growth of dense woodlands and forests that often lack a grass and forb understory. Low intensity fires helped to maintain a grass understory and discouraged tree reproduction. Livestock grazing altered this regime by eliminating fine fuels that burned rapidly but at lower temperatures than fires that spread to trees and heavy brush (Allen 1989; Swetnam and Betancourt 1990; Swetnam and Baisan 1994; Allen 1996; Allen, Rouchan *and others* 1996; Touchan, Allen *and others* 1996). Heavy tree growth now predominates

BARRANCA ALLOTMENT

C. Sloughing of soil in the Salado drainage.
L. D. Sansom

D. View from Salado drainage looking east. Note the amount of bare soil. L. D. Sansom

Figure 48. Barranca allotment inspection photograph ~1974. This area remains in poor condition today. Sansom comments on bare soil.

many areas (Figure 49). Previously, cattle could graze in the open woodlands but they must now feed in much smaller patches of meadow and riparian habitat. Currently, these sites exhibit detrimental effects from cattle grazing.

Fourth of July Canyon (Section 34, T6NR5E) is west of Tajique. In 1966, Bedkar commented on the extensive erosion due to overgrazing in this narrow canyon. Thirty years later, these effects were still obvious. Cattle continue to congregate in this area due to the availability of water. A pipe from a spring supplies water to a tank. The water supply is reliable and potable. My measurements in July 1999 revealed a flow of about 15 liters per minute. Because of the sensitive riparian environment, the forest service rerouted a portion of the hiking trail. Not surprisingly, cattle continue to use the water source. Close to this locale, a maze of oak thickets has replaced much of the grass and forb cover. These thickets are so dense, and the cattle trails through them so numerous, that a popular local hiking guide warns backpackers about becoming lost or mislead in this area (Matthews 1995). *Cañon de las Palas* (T6NR5E) riparian zones also exhibit the detrimental effects of livestock grazing as they did thirty years ago (Figure 50).

Although there are now fewer cattle grazing in the national forest than forty to fifty years ago (USFS 1999), many meadows continue to

PHOTO POINTS — TORREON ALLOTMENT

TORREON STATUS INSPECTION 5/6/77

Heavy stand of Ponderosa Pine reproduction, typical of the allotment. Gambel Oak and some Rocky Mountain Juniper are present. There is no understory of grasses or forbs. Pine needles & Oak leaf litter cover the ground. Heavy thinning of the Pine stand with complete slash disposal is needed for both timber & forage production. 6-Pipo, Quga, Jusc - PG.

Figure 49. Torreon allotment 1977. This photograph comments on dense stands of ponderosa pine with little grass or forb undergrowth. This scene prevails over much of the ponderosa pine association in the Manzano Mountains. US Forest Service photograph.

TORREON STATUS INSPECTION.

5/7/77.

Riparion Area on Canyon Las Palas. Riparian vegetation has been almost totally destroyed by livestock grazing. Kentucky Bluegrass grows along the stream. Blue Grama & Snakeweed dominate the rest. 10 - Bogr, Popr, Acer, Quga - VP↓

22.

Figure 50. Canon de Palas area. This 1977 inspection comments on riparian zone damage done by cattle. Much of this area remains degraded in 2002. US Forest Service photograph.

show the effects of overgrazing.

This is most evident towards the end of the summer and early fall before snowfall forces cattle down into the lower valleys or stockmen remove their animals from the grazing allotments. Besides overgrazing, cattle have trampled many of these meadows thereby reportedly increasing soil bulk density and fostering favorable conditions for erosion (Butler 1995). Also noted are turf exfoliation processes similar to those reported in Andean alpine areas (Figure 51). Unknown in this area are the effects of needle ice or a similar condition affecting the depth of freezing temperatures on trampled ground (Perez 1992; Perez 1993). Turf exfoliation exposes areas to wind and runoff erosion. A flat, non-timbered ridge northeast of Bosque Peak has several depressed areas where cattle both wallow and appear to seek shelter from wind (Figure 52).

Cattle trails to and from grazing and watering areas show the destructive effects of trampling and compaction (Figure 53). Soil penetrometer tests performed on trails and adjacent soil off the trail revealed in many cases an almost ten fold increase in compaction (~2.0 kg/cm^2 vs. ~0.25 kg/cm^2). Local observation during rain storms confirms that trails, which are usually barren of vegetation, act as water conduits and facilitate rill erosion and increase the likelihood of gully formation.

Figure 51. Wallow area created by cattle. This area on an extensive wind-swept ridge near Bosque Peak exhibits many "cattle created" features. The depression is about 0.25 m lower than surrounding terrain. Before photographing this feature, I observed a cow in the wallow. I also observed cattle "pawing" the ground in wallows. View is looking north. Photographed in July 1998.

Figure 52. Cattle trails and disturbed ground on Bosque Ridge. A number of cattle trails and wallow areas are present at this locale. In the summer cattle were usually present at this location. Mosca and Guadalupe Peaks are in the near background. The Sandia Mountains are in the distance. Photographed in July 1998.

Figure 53. Eroded cattle trails near Cave Spring in Section 10, T6NR5E. Many of these trails converge on the spring which serves as a water point for cattle. Some of the erosion is greater than 1 meter deep. Photographed in July 1998.

Rivulets form in these paths within a few minutes during a moderate thunderstorm. Particularly susceptible to erosion are trails on deeper alluvium in valleys. Livestock are less damaging to trails on rocky terrain.

Furthermore, trampling may directly relate to terracette formation on slopes (Butler 1995). These features are present in the Manzano Mountains and show the effects of soil erosion. The base of cattle trails is often significantly lower (~15 to >30 cm) than the surrounding ground (Figure 54). Cattle trails become dense and convergent in areas surrounding riparian zones and springs. Due to the wet nature of the soils in these areas, compaction becomes a greater problem. Wet meadows and *cienegas,* although uncommon in the Manzanos, exhibit compacted and trampled areas. One wet meadow examined had numerous cattle trails leading to its location (Section 14, T6NR5E). Furthermore, cattle tend to congregate in these kinds of places and are, for the most part, difficult to drive away. A local rancher, Mr. Manuel Chavez of Torreon, commented that the only thing that keeps them out of the wet ground and mud is the presence of black bears (*Ursus americanus*) and even then the cows remain close by and ready to return when the bears leave the area.

Another site, known locally as *La Cienegita* (Section 11, T4NR5E) exhibited soil compaction by cattle hooves throughout its extent (Figure

Figure 54. Cattle trail near Bosque Peak in T6NR5E. This trail is incised about 0.25 m. Rock hammer provides scale. Compaction on trails is markedly higher than surrounding terrain. Noticeable “trailing” is normally a sign of range overuse (Holechek, Pieper *and others* 1998). Photographed in July 1998.

55). In July 1997, I visited this site with Frank Martinez, US Forest Service District Ranger. At the time he told me that the Forest Service had recently acquired this property but cattle continued to frequent the *cienega*. Indeed, on several occasions while collecting soil core samples, I chased cows from this area and spoke to cowhands trying to round up stray cattle in the area. Numerous cattle trails lead to this location and they are generally barren of vegetation. In this locale, erosion may be a smaller problem due to the lower gradient of the trails compared to the steeper slopes. Nevertheless, several depressions, some as deep as ~0.75 m contain water (Figure 11). Whether cattle or ranchers created these depressions is unknown. In any case, water collects in these spots. A water trough also attracts cattle to the area (Figure 56). After 1997, the US Forest Service instituted measures to preclude cattle and vehicles from this sensitive site.

The effects described above are mostly geomorphic in nature. Cattle grazing and trampling also adversely affect not only common plants but damage rare and endangered plants often present in riparian and spring habitats (Dick-Peddie 1993). Because cattle tend to gather in these areas browsing of woody plants is more common around these features. Other locales exhibit similar patterns (Perez 1992). These effects are unmeasured and unknown for this area but the browse line

Figure 55. *Cienegita* in T4NR5E. In July 1997, a number of cattle frequented this site for grazing and water. The vegetation is mostly *Carex* sp. At the time, vegetation compaction and fecal contamination were problems noted. The water table in 1997 was <1 m deep. At 1 m, a dense gravel layer was encountered while trying to extract a core sample.

Figure 56. Water trough at *La cienegita*. In July 1997, this trough was supplied by a covered spring box. A fenced area protected the water source. Note the encroachment of trees adjacent to the concrete trough. The ground water supply emanates from the mountains in the background. In 1882, Thomas Holland noted a frame house and sawmill near this location.

created may open the understory for colonization by other plants and foster “disturbance” type communities (Forman and Godron 1986).

The detrimental effects of overgrazing and trampling are apparent in the Manzano Mountains. Fortunately, removal of cattle or a substantial decrease in their density can ameliorate some of the effects. Although species composition may differ (Bedkar 1966), grass cover may return over time when fewer or no cattle graze an area. Overgrazing and trampling directly affect the local landscape but facilities associated with cattle raising also aggravate these processes. Furthermore, the “infrastructure” of cattle raising is often ignored as a factor in landscape modification.

Livestock Facilities

Although rarely discussed, range “improvements” associated with livestock production such as water tanks, spring development, corrals, fencing, and fire suppression have negative effects on the “natural” landscape. Some facilities encourage uneven use of the range by livestock unless properly planned. Unfortunately, range infrastructure is cheaper to build than forage and often becomes a panacea to solve grazing problems (Holechek, Pieper *and others* 1998).

Closely related to the processes of overgrazing and trampling is the installation of water tanks and the development of natural springs.

Many of the mountain valleys in the Manzanos have water tanks installed by the Forest Service or by local ranchers (Figure 56).

Cattle need large quantities of water. Depending on weather and feed conditions, beef cattle may drink more than 20 liters per day (Brown 1985). Due to the lack of perennial streams in the Manzanos, the installation of water tanks became a necessity. Water tanks attract and keep cattle close to them (Figure 57). Generally, cattle prefer traveling no more than 1.0-2.0 km to water (Valentine 1947; Wenger 1984). Any valley with a permanent water source has a network of trails leading to its location and concentrates cattle in the immediate area. Stock tanks have the same effect (Figure 58). Overgrazing and trampling rapidly degrade the immediate area around the water resource. Furthermore, fecal contamination reaches high levels at these locations.

Water tanks and troughs accelerate local soil erosion. Water tanks installed at two springs observed in the Manzanos (Fourth of July Canyon and Cave Springs) both exhibit trampling around the perimeter. While the cattle drink, they may paw the ground with their hooves which results in a “moat” of disturbed soil around the water trough (Figure 59). This depressed “moat” connects to the cattle trails leading to the water source. Consequently, there is a web of erosion channels created. The effects are long-lasting (Figure 60 and 61). Other features such as corrals also

Figure 57. Cattle at *La cienegita* being held by a blue heeler cattle dog (lower left). The water supply was obviously important to these cows because they repeatedly tried to dodge the herding dog and approach the water trough illustrated in Figure 55. Photographed in July 1997.

Figure 58. Degraded area surrounding a stock tank in T3NR5E. Very little vegetation remains around this water source. Photographed in March 2000.

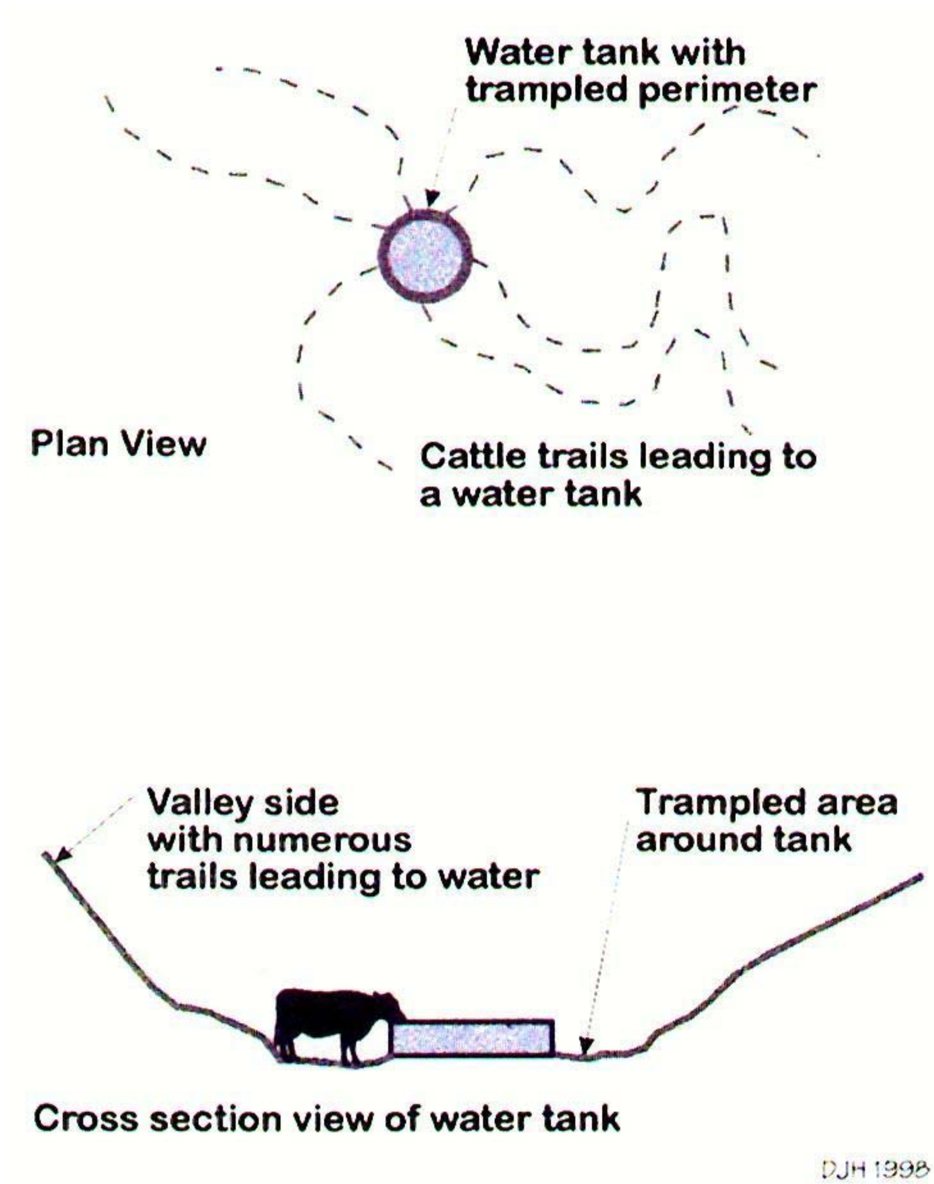


Figure 59. Diagram of processes associated with livestock at water points. Cattle will converge on reliable source of water. The immediate area normally exhibits considerable degradation.

Figure 60. Metal water trough located in T3NR5E. Note the considerable erosion surrounding the metal tank. Numerous "cow trails" converge on this location. Photographed in July 1998.

Figure 61. Considerable sheet erosion not far from the water tank depicted in Figure 59. This area in Barranca allotment suffers from overgrazing. Grass is isolated in “bunch islands.” The plants are above the surrounding eroded terrain and only the grass roots bind what soil is left. Photographed in July 1999.

have a persistent signature on the landscape even after abandonment and deterioration of the structure.

Although infrequently used, corrals concentrate large numbers of cattle in a small area. In one to several days, the cattle eat or trample most of the vegetation within the confines of the pen. Again, fecal contamination is unusually high due to the concentration of animals. On this disturbed surface, exotic plants, that are often introduced in animal feed or brought in by “new” cattle from other locations, take hold and subsequently displace native species (personal observation).

Fencing, although not a significant feature within the national forest, has a direct effect on forest and surrounding lands. In addition to containment of livestock, fences have a more subtle subsidiary effect. Several private inholdings and surrounding ranches bordering the national forest customarily use “cedar” posts (*Juniperus*) for stock fences. Traditionally, national forest lands and the rancher’s property are a source for this material. Because of their ease of installation, metal fence posts are becoming increasingly common. Nevertheless, juniper or *piñon* posts are readily available, do not require a trip to town to purchase, and are frequently perceived as “free” material. Fence construction alters landscape conditions. The fence itself may fragment landscape, changes local vegetation patterns along the fence line, interferes with native animal movement, and requires materials.

It is more efficient and cost effective to obtain fence posts close to the area being fenced. The following (Table 7) outlines the posts required for one kilometer of fencing and the potential area affected to obtain these materials.

Table 7. Fence post cutting and potential area affected by post cutting. This analysis makes the following assumptions: Length of fence post=2 m; spacing of fence posts=5 m; 10% additional posts for corners and gates; 2 posts can be cut from one tree. Per mile data is included because land measurement is in acres according to Public Land Survey System.

Tree density per hectare	Posts per Km of fence	Trees Required per km	Hectares Required per km	Posts per mile of fence	Trees Required per mile	Acres Required per mile
420	220	110	0.26	355	178	1.05
690	220	110	0.16	355	178	0.64

*Note: Tree density per ha varies according to locale. Data derived from (Dick-Peddie 1993).

While the number of hectares required for 1 km of fence appears low, one must note that the *piñon*-juniper woodlands of the Manzanos serve as a source area for much of the surrounding area that is privately owned. Because most private lands are fenced at least along section boundaries (640 acres or 259 ha), the impact of fence post harvesting on *piñon*-juniper woodlands in the national forest may be more significant than indicated by the above table.

Whether or not post cutting has an unfavorable impact on *piñon*-juniper woodlands is unknown at this time but deserves further study and analysis. Most ranchers and range managers consider juniper a non-desirable species that encroaches on grasslands. Juniper cutting may help ameliorate the effects of juniper encroachment. Nevertheless, based on my observations, junipers that grow in a mixed woodlands tend to be single-stemmed and straighter thereby more suitable for posts as opposed to multi-stemmed trees that prevail on former grassland areas.

Although livestock facilities may heighten the detrimental effects of cattle, with appropriate design and placement they may also aid in decreasing the overall effects of cattle. Proper construction, spacing, and location of these facilities can encourage cattle to range over a much larger area thereby lessening their impact overall as long as livestock densities remain low (Brown 1985). Fencing can protect sensitive area such as Tajique Creek, *cienegas*, and wet meadows. Water point improvements may benefit wildlife, or a least wildlife frequently depend on them. Wildlife dependence on developed water points also has a negative effect. Predators, such as mountain lions, quickly learn that these locations make excellent “ambush” points for predation (personal observation).

The local presence of ranchers on allotments provides daily to weekly monitoring of activities in the national forest. Often they are the first to notice activities such as vandalism and other detrimental human behavior that frequently occur on lands that are essentially unpatrolled by law enforcement officials.

Summary

By reducing fine fuels such as grass and forbs, sheep and cattle were instrumental in modifying the fire history of Manzano forests. The transformation of a fire-adapted ecosystem, combined with active fire suppression beginning in the early 1900s, resulted in the high density of trees, particularly in ponderosa pine associations. Cattle and sheep grazing changed vegetation characteristics, instigated geomorphic change, spawned efficient predator control efforts, and seriously degraded riparian habitat. Because the area has been grazed for at least 200 years it is difficult and perhaps impossible to establish pre-livestock conditions. Furthermore, the damage frequently goes unnoticed because it has existed for so long (Fleischner 1994). Restoration is uncertain for in many cases we are not sure what we are trying to restore. Furthermore, restoration is analogous to removing one’s burned hand from a fire. The causal agent is gone but the injury remains for some time and healing may create a different and unknown pattern in the damaged site.

Cattle production in the Manzano Mountains is marginal at best but most local stockowners are unwilling and probably cannot afford substantial corrective measures. Raising cattle is a “way of life” more than an economic necessity on many allotments. Expenses incurred by the forest service vastly outweigh any income accrued. Using 2002 stocking rates and total AUMs, the income derived for all allotments in the Manzanos was less than $9000.00. Cattle prices continue to decline as other commodities rise in value. Using 1970 as a base year, cattle prices declined almost $30.00 per hundred weight by 1996 measured in real dollars (Holechek, Pieper *and others* 1998). Continuing to subsidize range cattle production becomes less tenable each year.

Based on current market prices, the total number of cattle using the Manzanos on an annual basis has an approximate liquidation value of $300,000 (NASS 2002), a small amount of money considering the amount of land used and effects to the range. Nevertheless, for those engaged in and depending on the business it remains an important activity. The matter goes beyond ecological concerns. Any solution to the problem must address economic and sociologic factors.

Established uses in the national forest such as cattle raising are declining while recreational use of this area continues to accelerate. Pressure to remove cattle grazing from the Manzanos will continue to grow. As one forest service employee stated, “hikers don’t like cows or cow manure.” A recent study, however, in the Uncompahgre National Forest, Colorado indicated that the initial reaction of visitors to cattle was positive. Nevertheless, cattle on trails, around campsites and streams, and cow manure on trails detracted from a visitors experience. Notably, facilities and cattle infrastructure had little affect on respondents to the survey (Wallace, Mitchell *and others* 1996). The problem is complex and the solution proposed by many, total elimination of grazing, may create additional problems.

Without national forest grazing privileges, some ranchers may choose to liquidate their base properties in and close to the forest. The consequences of subdividing the land into smaller parcels or “ranchettes” (Figure 62) may equal or surpass the problem created by grazing (Mitchell, Knight *and others* 2002). Demands for roads, water, fire protection, and waste disposal will continue to grow in the lands surrounding the southern Manzano Mountains. Land managers and planners must address the issue before the process becomes irreversible.

Figure 62. Ranchettes for sale on the east side of the Manzano Mountains. As ranches and farms are subdivided, landscape fragmentation is often the result. Some ranchette owners keep small numbers of livestock, mostly horses and cattle. Photographed in July 1999.

Chapter 7

Concluding Remarks and Recommendations

The Manzano Mountains are subject to many of the same anthropogenic disturbance processes noted elsewhere in the American Southwest. Nonetheless, my research reveals several distinctive differences from other areas:

- Landscape alteration by livestock began before widespread introduction of cattle by Anglo ranchers after ~1900. As documented by archival evidence discussed in previous chapters, heavy sheep grazing by Hispanic settlers occupying land grants and village grants east and west of the mountains resulted in a change in forest understory from grass to dense undergrowth before the subdivision surveys of 1882. The impact of grazing was apparent on the landscape much earlier in the Manzanos than more remote and less settled mountain ranges in the Southwest.
- Commercial logging occurred before the area became a US Forest Reserve. In other words, the newly formed USFS acquired lands in 1906 that had already undergone considerable timber-cutting and overgrazing before the USFS instituted management policies. This condition resulted in reactive rather than pro-active management of forest lands, particularly before major federal environmental legislation established guidelines.

- Railroad construction, although not penetrating the mountains, had a significant effect on forest vegetation. The mountains became the "lumber yard" of the Santa Fe Railroad. This is not uncommon in the American Southwest but does place the Manzanos in a different category than mountainous areas that escaped the immediate effects of logging for railroad construction.
- Unlike many areas in the west, mining has had little effect on this landscape and can be dismissed as a significant disturbance factor.
- Few homesteaders claimed land in the mountains *per se*. The time between opening the area to homesteading and the federal government's establishment of the forest reserve was about six years. Instead, the mountainous area is managed primarily by the US Forest Service. This results in uncertain consequences. In some areas of the west, private lands escaped much of the abuse that public lands have sustained as a "commons" for many users. On the contrary, private lands are often subject to much more landscape degradation than regulated public lands.
- Significantly, the two primary factors of landscape degradation, grazing and logging, are in serious economic decline and may disappear without government action. These two agents are gradually being replaced by an increased demand for recreational use that will place new demands on this landscape.

Landscape change caused by disturbance is a continual earth process. Therefore, a "snapshot" approach, such as pre-European contact, or for that matter, pre-aboriginal contact, does not necessarily define a natural environment. We can often reconstruct past vegetation and landforms based on geologic, biotic, or, in some cases, archival records but categorizing the reconstruction as a "natural" environment assumes environmental stasis. Furthermore, these reconstructions are often inferences based on limited data. If one looks at landscape change over millennial timescales, stasis or equilibrium is certainly the exception. Pre-historic, Spanish, Mexican, and Anglo settlers altered this landscape as did climatic change and other earth processes. Nevertheless, the most significant landscape and ecosystem change of the last 1000 years occured after ~1800 and relates directly to livestock raising and commercial logging in the Manzano Mountains. Closely allied, and synergistically associated with these two activities, is fire suppression. The combination of agents caused biotic and abiotic change to ecosystems and geomorphology.

Stock raising and its effects caused much of the change and damage now apparent on the local landscape. Unfortunately, solving the problem is more difficult than recognizing it. Although cattle numbers continue to decline, ranchers persist in grazing their herds on public lands. Largely, the right to graze stock on these “common” lands is a socio-cultural issue with local Hispanic residents. From their point of view, these rights considerably predate those of Anglo-American settlers and the creation of national forest lands (deBuys 1985). Furthermore, multi-generational Anglo ranchers often perceive grazing allotments as a “right” or entitlement. In actuality, it is a subsidy that presently will require considerable changes. Regrettably, the political and cultural issues involved with grazing complicate needed research efforts regarding environmental change and degradation due to livestock in this and other areas. Economics alone may bring about the demise of grazing.

While overgrazing by sheep and cattle reduced much of the grass and forb forest understory, extensive late 19th and early 20th century logging, particularly on the eastern side of the range, removed most of the old open stand forest. The reduction of low intensity fuel such as grass and forbs by livestock, combined with active fire suppression, resulted in today’s densely timbered forest that is dissimilar to pre-settlement era forests. Before substantial human settlement, frequent but mostly low intensity fires created an ecosystem resilient to fire, fostered an open stand forest, and perpetuated high mountain meadows. Many of these meadows are in serious decline with tree encroachment unchecked by periodic fire (Figure 62). Dense forests result in less surface water and

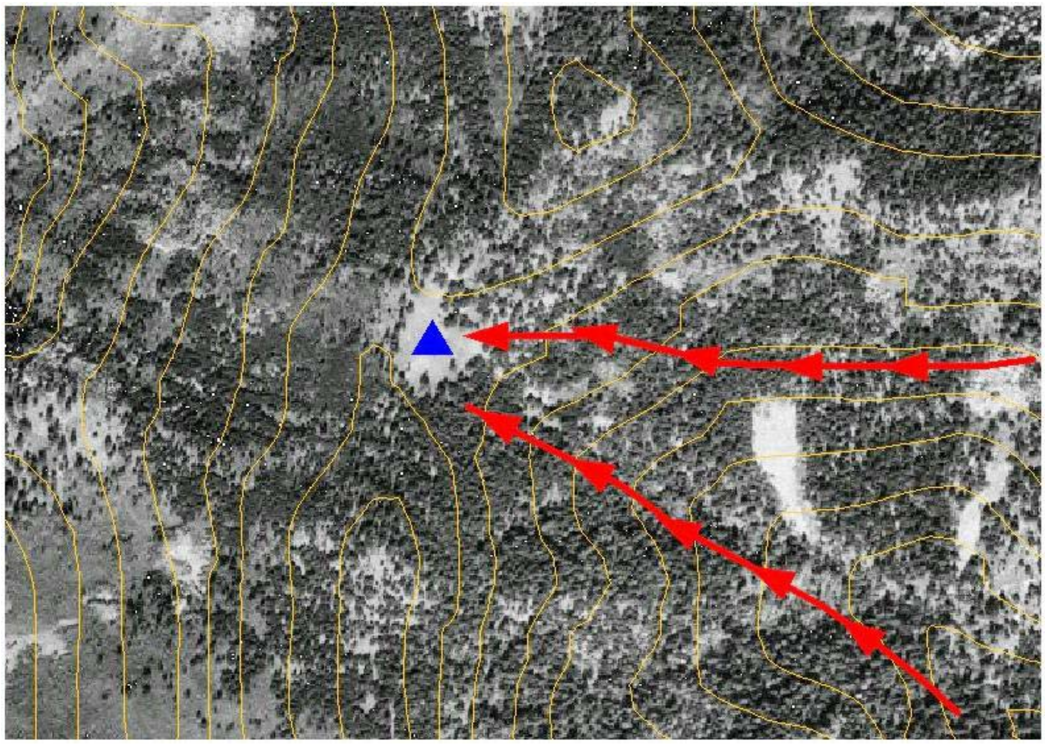


Figure 63. Meadows, saddles, and fire. Saddles along the crest of the mountains frequently have meadows (blue triangle). Fire suppression is causing these meadows to decline. Saddles act as wind funnels (red arrows) that create fire hot spots. Consequently, I contend that these locations probably burn more often or at least more intensely without fire suppression thereby precluding tree growth. Saddles that are at the head of narrow canyons are dangerous areas for fire fighting crews due to wind characteristics (Tie 1994). The UTM coordinates of the above meadow are 0367341E 3829631N Zone 13. The contour interval depicted by the yellow lines is 30 meters. Elevation of the meadow is ~2993 meters.

lower rates of groundwater recharge. While fire has been suppressed, the potential for seriously damaging burns now exists.

Efforts to restore periodic fire are complicated by not only the density of the forest and a real danger of catastrophic fire but by the interface between homes and subdivisions in and adjacent to the forest. Local residents often oppose proscribed burns because of the inherent danger of the fire spreading to their property and concerns over smoke. Moreover, many residents oppose controlled burning for aesthetic reasons. Many perceive controlled burns as a tool to enhance grazing rather than a method to reduce fuel loads and the dangers of uncontrolled fire (USDA 1995).

In numerous areas, the density of the stand and proximity of residences does limit proscribed burns as a management tool. Cooperative agreements with local, mostly Hispanic, land grant residents and the forest service provide a method for traditional forest users to harvest fuel and timber and accomplish necessary thinning. In addition to thinning, controlled burns often follow selective cutting to further reduce fuel loads. Because of the low value of the timber removed, villagers require some remuneration for labor and equipment expenses (US Senate 2000). Thinning of dense stands may be the only option in some areas but limited data suggests that thinned areas may lack the diversity of unthinned areas and have greater single species dominance (Table 8).

Table 8. Comparison of diversity indices and dominance for two point-quarter point samples. Each sample consisted of 8 points and 32 quadrants on a 100 m transect of forest trees. Location #1's altitude is ~2255 m and Location #2's altitude is ~2438 m (Brower, Zar *and others* 1977).

Transect Location	Total Density	Simpson Diversity Index	Shannon Diversity Index base 10	Simpson Dominance Index
1. Corner of Sec 35/36 T7NR5E Unthinned	0.44/m^2	0.5988	0.4317	0.4012
2. FR 275 Sec 9 T4NR5E Thinned	0.26/m^2	0.2802	0.2221	0.7198

Clearly, the above data are limited and there are substrate and altitudinal differences but the information does suggest that more research is warranted to establish the relationship between mechanical tree removal and biodiversity.

Traditional use of mountain and foothill lands was for grazing, timber cutting, and food resources; however, increasing pressure from urban areas for recreational facilities places new strains on the "multi-use" policies of the U.S. Forest Service (Matthews 1988). Increasingly, the US Forest Service is subject to the political pressures of an ever-growing urban constituency that is not particularly interested in more established land use practices of local residents. Unfortunately, many recreational users fail to recognize the damage created by their increasing presence and amenities constructed to accommodate their activities. In the long term, heavier recreational use may prove to be more damaging to the landscape ecology of this area than hundreds of years of livestock presence and ~1900s logging.

Management recommendations

One of the objectives of this project was to provide land managers with recommendations for consideration. A number of steps and actions can help ameliorate two centuries of land degradation in the southern Manzano Mountain region. These are not all single agency actions and in some cases may require legislative approval. Furthermore, social and political issues will compound ecological decisions.

- **Watershed protection**: The increasing population of Albuquerque and Estancia Valley is dependent on ground water. Whether the population growth is sustainable is uncertain. What is certain is that the Manzano Mountains are the most important watershed for Estancia Valley and portions of the Rio Grande Valley. Water is the most critical natural resource in the American Southwest. Sustaining a viable watershed are the mountain's "highest and best" use. Watershed and riparian zone protection should have the highest priority in any multi-use management scenario. All other uses must be secondary.

- **Livestock grazing:** The forest service should not renew grazing allotments on wilderness area portions of the national forest. The wilderness area allotments, because of their nearness to the Rio Grande Valley, have sustained overgrazing for a much longer time. Range analysis reports for many years have commented on deteriorated conditions in this area, particularly at lower elevations. As other allotment terms expire, the forest service should reduce stocking rates to allow recovery of overgrazed areas. Grazing is not inherently damaging and has a function in forest management. Nevertheless, much of the area has suffered under too many livestock for too long and serious reductions must be considered. Although the forest service cannot unilaterally raise grazing fees, the fees charged do little to cover expenses incurred. Congress must act to correct this questionable subsidy. If subsidized grazing continues, as it probably will, the fee structure must reflect direct and indirect expenses associated with livestock production. Watershed management must have priority over range management for grazing.

- **Fire:** While there are problems with private structures and lands within the boundaries of the national forest, naturally caused fire must return to this ecosystem. This forest evolved under a periodic fire regime. Fire suppression has had a direct impact on forest structure and composition and has created fuel load conditions that favor more damaging burns. Furthermore, fire has a role in watershed management and aspen regeneration. Unless a fire threatens residential areas, extinguishing it should not be a priority. Increased use of proscribed burns can help prevent or limit the damaging effects of wildfire. The issue is contentious and many landowners and visitors will protest controlled burns but the long-term effects benefit both the forest ecosystem and people.
- **Stand thinning:** The tempo of tree thinning must increase, particularly in areas not suitable for controlled burns. Thinning must not be limited to smaller trees but should extend to larger trees in an effort to create an open canopy forest more characteristic of pre-settlement conditions. Existing meadows must receive priority for removal of encroaching trees. Landowners within the forest may need an incentive to thin stands surrounding their property. In any case, with or without

their cooperation, the forest service must reduce fuel loads up to the private land interface.   The forest service should expand cooperative agreements with private groups such as the Las Humanas Cooperative as a means to decrease fuel load in the forest.

- **Roads:** Although roads provide access to many areas of the forest for both management activities and recreation, the forest service should not consider any new road construction projects. Currently, no roads are paved and this policy should continue. Pavement increases vehicular traffic and the number of people using the area. Moreover, paved roads encourage large recreational vehicle users who require more expensive and larger facilities to meet their needs. Over the past several years, the forest service has closed or blocked off several non-essential roads or two-track trails in the national forest. This effort is commendable but more closures must occur. In some cases, these closures may need to be only seasonal to protect terrain during vulnerable periods. A “no maintenance” policy for back roads creates limits on vehicle use without incurring costs. Additionally, all-terrain vehicle (ATV) traffic must be restricted to existing roads and vehicle trails with serious penalties for off-road or hiking trail use. Although difficult to enforce, the forest service may have to institute a program of licensing and permits for ATV use on national forest land.

- **Land acquisition:** The forest service must have the funds and authority to purchase private inholdings before subdivision occurs. Conservation easements may be another option for private lands. In any case, property owners will require fair payment for their lands to avoid claims of "takings" which the US Supreme Court views skeptically. For future benefit, buyouts at over market price will prove to be economically and ecologically sound. Importantly, the forest service upon purchase must obtain the water rights of the private tracts.
- **Recreation:** Recreation has a role in human well-being and forest management. Indeed, people who visit, hike, hunt, and camp on forest lands frequently take an interest in or assume "ownership" values towards the locale. They gain a stake in its future. Without adequate limitations and planning beforehand, increased recreational use has unfavorable landscape effects. Roads, parking, trash removal, sewage disposal, drinking water availability, and vandalism become problems that are more serious when more people visit an area. Trash and vandalism

are already a problem in improved and unimproved campsites in the Manzanos. Having more people in the area will require greater law enforcement presence to ensure compliance with policies and regulations. Some local area residents perceive a benefit from having more visitors to the area, while others deem increased recreational use as a threat to their lifestyle. Balancing these needs is crucial and local cooperation is critical.

Closing

Population continues to grow in central New Mexico. There is little that local land management agencies can do to slow this growth. Furthermore, many residents view increased population and growth favorably as a means of improving their employment opportunities and providing new sources of wealth. Nevertheless, increased population can have negative effects for mountain area ecosystems.

Agencies, governmental entities, and non-governmental organizations must insist on landscape level ecosystem management. Ecosystems are complex but some ecological processes have greater effects (Holling 1992). I identified many in this research project. Identifying and understanding these processes provides the means for ensuring forest health and sustainability for the Manzano Mountain region. The ecological “health” of the area is as important as social, economic, and political needs. Land managers must take action quickly to correct past abuses to this vitally important landscape.

Appendix 1

Order	Family	Species	Common Name
Artiodactyla	Bovidae	*Odocoileus hemionus*	Mule Deer*
Artiodactyla	Bovidae	*Ovis canadensis*	Mountain Sheep*
Artiodactyla	Cervidae	*Cervus elaphus*	Elk*
Carnivora	Canidae	*Canis latrans*	Coyote*
Carnivora	Canidae	*Canis lupus*	Gray Wolf
Carnivora	Canidae	*Urocyon cinereoargenteus*	Gray Fox*
Carnivora	Felidae	*Lynx rufus*	Bobcat*
Carnivora	Felidae	*Puma concolor*	Mountain Lion*
Carnivora	Mustelidae	*Mephistis mephistis*	Striped Skunk*
Carnivora	Mustelidae	*Mustela frenata*	Long-tailed Weasel
Carnivora	Mustelidae	*Taxidea taxus*	Badger*
Carnivora	Procyondidae	*Bassariscus astutus*	Ringtail
Carnivora	Procyondidae	*Procyon lotor*	Raccoon*
Carnivora	Ursidae	*Ursus americanus*	Black Bear*
Chiroptera	Molossidae	*Tadarida brasiliensis*	Brazilian Free-tail Bat
Chiroptera	Vespertilionidae	*Antozous pallidus*	Pallid Bat
Chiroptera	Vespertilionidae	*Eptesicus fuscus*	Big Brown Bat*
Chiroptera	Vespertilionidae	*Lasionycteris noctivagans*	Silver-haired Bat
Chiroptera	Vespertilionidae	*Lasiurus cinereus*	Hoary Bat
Chiroptera	Vespertilionidae	*Myotis auriculus*	Southwestern Myotis*
Chiroptera	Vespertilionidae	*Myotis leibii*	Small-footed Myotis
Chiroptera	Vespertilionidae	*Myotis thysanodes*	Fringed Myotis
Chiroptera	Vespertilionidae	*Myotis volans*	Long-legged Myotis
Chiroptera	Vespertilionidae	*Plecotus townsendii*	Townsend's Big-eared Bat
Insectivora	Soricidae	*Sorex merriami*	Merriam's Shrew
Insectivora	Soricidae	*Sorex nanus*	Dwarf Shrew
Insectivora	Soricidae	*Sorex vagrans*	Vagrant Shrew
Lagomorpha	Leporidae	*Lepus californicus*	Black-tailed Jack Rabbit*
Lagomorpha	Leporidae	*Sylvilagus auduboni*	Cottontail*
Lagomorpha	Leporidae	*Sylvilagus floridanus*	Cottontail*
Rodentia	Cricetidae	*Microtus longicaudus*	Long-tailed Vole
Rodentia	Cricetidae	*Microtus mexicanus*	Mexican Vole
Rodentia	Cricetidae	*Neotoma albigula*	White-throated Woodrat*
Rodentia	Cricetidae	*Neotoma mexicana*	Mexican Woodrat*
Rodentia	Cricetidae	*Neotoma micropus*	Southern Plains Woodrat
Rodentia	Cricetidae	*Onychomys leucogaster*	Northern Grasshopper Mouse
Rodentia	Cricetidae	*Peromyscus difficilis*	Rock Mouse
Rodentia	Cricetidae	*Peromyscus leucopus*	White-footed Mouse
Rodentia	Cricetidae	*Peromyscus leucopus*	Brush Mouse

Rodentia	Cricetidae	*Peromyscus maniculatus*	Deer Mouse*
Rodentia	Cricetidae	*Peromyscus truei*	*Piñon* Mouse*
Rodentia	Cricetidae	*Reithrodontomys megalotis*	Western Harvest Mouse
Rodentia	Erethizontidae	*Erethizon dorsatum*	Porcupine*
Rodentia	Geomydidae	*Thomomys bottae*	Botta's Pocket Gopher
Rodentia	Heteromyidae	*Dipodomys merriami***	Merriam's Kangaroo Rat
Rodentia	Heteromyidae	*Dipodomys ordii***	Ord's Kangaroo Rat
Rodentia	Heteromyidae	*Dipodomys spectabilis*	Banner-tailed Kangaroo Rat
Rodentia	Heteromyidae	*Perognathus flavus*	Silky Pocket Mouse
Rodentia	Heteromyidae	*Perognathus intermedius*	Rock Pocket Mouse
Rodentia	Muridae	*Mus musculus*	House Mouse*
Rodentia	Sciuridae	*Ammospermophilus interpres*	Texas Antelope Squirrel*
Rodentia	Sciuridae	*Cynomys gunnisoni*	Gunnison's Prairie Dog
Rodentia	Sciuridae	*Eutamias quadrivittatus*	Colorado Chipmunk*
Rodentia	Sciuridae	*Eutamis minimus*	Least Chipmunk*
Rodentia	Sciuridae	*Sciurus aberti*	Abert's Squirrel*

*observed in field

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Vita

Donald James Huebner was born in San Marcos, Texas on 10 September 1948. His parents are Reginald J. and Betty L. Huebner currently of Comfort, Texas. Donald graduated from Middletown Township High School, Middletown, New Jersey in June 1966. He attended Texas A&M University in 1966-1967. From June 1967 to June 1970 he was on active duty in the US Army. Assigned to military intelligence, he was stationed at Fort Holabird, Maryland; Sandia Base, New Mexico; Fort Hood, Texas and various temporary assignments. While on active duty, Donald attended the University of New Mexico in 1968. In September 1970, Donald entered the University of Texas at Austin and received a Bachelor of Science (with Honors) degree in August 1972. Donald worked as a homebuilder and general contractor in Austin, Texas until 1994 and constructed numerous custom homes and commercial structures. During this time, he also served on several active duty tours with the Army National Guard and US Army Reserve. These assignments took him to the Netherlands, Germany, Belize, Guatemala, Honduras, and Panama. Donald holds the rank of Major, US Army Reserve (Retired). On 1 January 1983, Donald married Jan L. Allen, DVM. They have two children, Jefferson Lee and Elise Mackenzie. Donald's two oldest sons, Erik Mark and Daniel James are from a previous marriage.

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