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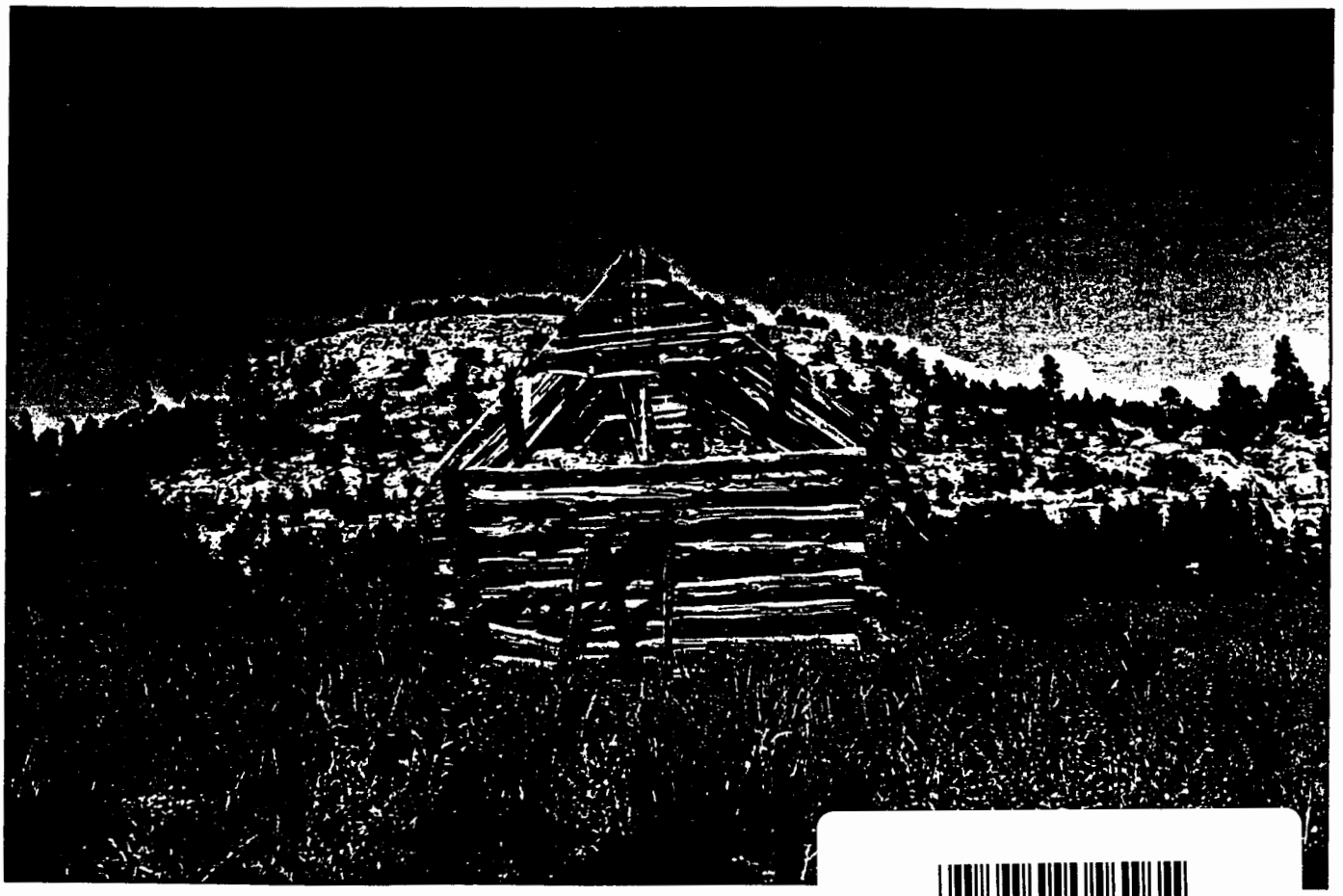
Old-Field Plant Succession on the Pajarito Plateau



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Cover photos: Top, left to right; Garcia homestead (1993), Archuleta homestead (1982), and Montoya y Gomez homestead (1996). Bottom; a close-up shot of Garcia homestead (1982). (Tierney and Foxx)

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Old-Field Plant Succession on the Pajarito Plateau

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Preface

This paper includes information from floristic studies that were made 15 years ago. In an attempt to "round-up" all data from previous plant surveys for the development of a vegetation land cover map, we have decided to compile this information in this report. Succession studies are rare for the area, and the information gathered provides a small amount of data that may be useful in the future. Each of the fields described has had other disturbances since the original study in 1982. Except for two fields, we have not collected quantitative data since 1982. In 1993, in association with other studies, we reestablished transects on two of the fields within Los Alamos National Laboratory boundaries. In this report, we compare the data collected from the two fields in 1982 with that collected in 1993. We have documented changes in the fields through photography of each site, and we have incorporated old photographs taken in 1964 by Homer Pickens. In 1996, we revisited the sites, developed global positioning system (GPS) points, and took additional photographs. Where appropriate we have included these comparative photographs.

Old-Field Plant Succession on the Pajarito Plateau

Teralene Foxx, Gail Tierney, Mary Mullen, Mary Salisbury

Abstract

Eight fallow historic fields of the ponderosa pine and pinon-juniper cover types were surveyed to determine species composition and distribution. The purpose of the study was to understand plant succession on old fields as related to mechanically manipulated sites such as material disposal areas (MDAs). Additionally, we wanted a listing of species on disturbed lands of the Pajarito Plateau to aide in the reclamation planning of MDAs using native species. We also wanted to determine if any species could be used as an indicator of disturbance. The eight historic fields were all within Los Alamos County, New Mexico, and had been abandoned in 1943. Two sites were within the boundaries of Los Alamos National Laboratory and were studied both in 1982 and 1993. The other sites were in the northern part of Los Alamos County, on Forest Service lands, and were studied only in 1982. The study provides a description of each of the field sites, historic information about the homesteads from patent applications, a photographic record of some of the sites, and a listing of species found within each field. Statistical analyses were used to compare the information obtained from each field, data collected in two fields in 1982 and 1993, and data from MDAs in a similar time period with the old field data. We also determined which plant species were the most dominant on each site and compared that data with information for adjacent forested areas. The study showed that there were 78 different plant species found on disturbed sites. Of these 78 species, 23 were found to be dominant on one or more of the MDAs or old fields. However, only 5 species were common on all sites. The species in the genus *Artemisia* (*A. carruthii* and *A. dracunculus*) were found to be dominant on both MDAs and old fields. Both species were a good indicator of disturbance. When we compared the 1982 data with the 1993 data collected on two fields, we found forb species were replaced by grass as succession proceeded. A cluster analysis comparing old fields with MDAs showed that the old fields and MDAs were dissimilar. However, the cluster analysis did show that MDAs were similar to MDAs and old fields similar to old fields. The MDAs appeared to have more species common to earlier successional stages than did the old fields. Historically, the MDA disturbance is more recent than the old-field disturbance by 10 to 20 years. Species such as sweet clover and cheat grass were found on MDAs but only occasionally in old fields. Mid- to late-successional species were commonly found on old fields. Although, the disturbance history of each site is imperfectly known, the study does provide an indication of successional processes within disturbed sites of the Pajarito Plateau. Additionally, it provides a listing of species that will invade disturbed sites, species that may be used in site reclamation.

1.0 Introduction

Disturbance, both man-made (e.g., construction bulldozing) and natural (e.g., fire, flood), leads a successional process by which bare soil becomes vegetated. An understanding of the species composition at the various stages along the successional process is important to understand the reclamation of an area, the prevention of soil loss, and, in some cases, the integrity of a site—that is, was there some undocumented disturbance during the process such as grazing or effluent dumping?

In the 1980s, there was concern about the integrity of waste site covers due to the invasion and development of plant communities within the disturbed areas. Hakonson et al. (1981) showed that rooting depths of plants, the evapotranspiration rates, and the attraction of such sites to burrowing animals were influential factors in waste site integrity. Shallow-rooted plants and those with high evapotranspiration rates were more desirable than deep-rooted plants. Deep-rooted plants could breach covers and potentially bring contaminants to the surface or could be a pathway for water to enter waste. Thus the site cover preparation, the seeding and planting of species, and the maintenance strategies were important for long-term waste site integrity.

To understand the long-term integrity of a site, we needed to know what plants were on the present sites and what would be the long-term establishment of plants on a site (successional processes). In 1980, we surveyed the flora of waste disposal sites (now known as material disposal areas [MDAs]) at Los Alamos National Laboratory (LANL) (Tierney and Foxx 1982). During those studies, we found four species of *Artemisia* (wormwood)—*A. dracunculus* (false tarragon), *A. frigida* (estafiata), *A. ludoviciana* subsp. *albula* (Louisiana wormwood), and *A. carruthii* (Carruth wormwood)— were common components of the flora of disturbed sites.

Three of the MDAs had been placed on fallow fields that had been abandoned in the 1940s. In areas of the field not disturbed by the waste site preparation, there seemed to be a similar pattern of composition with a common component being species of *Artemisia*. Therefore, in 1982, the study was expanded to look at old-field sites both on and off LANL.

Eight fallow historic fields in the ponderosa pine and pinon-juniper cover types were chosen for this study. The eight sites were selected for the following reasons: (1) the original dimensions of the historic agricultural areas could be determined from various maps and ground surveys, (2) some temporal parameters were available from historical documentation, and (3) nearly all sites were either on LANL or United States Forest Service (USFS) lands that were easily accessible. All sites were within Los Alamos County and were part of the federal buy-out or condemnation process for the Manhattan Project; thus, all the fields were abandoned at the same time (1943).

The surveys were intended to document plants characterizing the disturbed areas in and around LANL to help in the prediction of response of plants to disturbance and to provide a list of potential indicators of previous disturbance.

1.1 Literature Review

The Pajarito Plateau has had a long history of use by different groups of peoples. Evidence of prehistoric ruins and gardens shows disturbance by man as early as 10,000 years ago (Steen 1977). The plateau has been logged, grazed, and dry-farmed since the end of the 1800s. More recent disturbances include burned areas, disposal sites, roads, and other structures, which provide an opportunity to study the response of the flora to disturbances over wide time scales.

Patterns of succession have been a topic of research since the late 1800s. It was possible to identify types of disturbances and the time of abandonment through records. Some of the earliest research involved roadside disturbances. Shantz (1917) found that succession in these areas went through an early-weed phase, a late-weed phase, a short-lived grass phase, a perennial phase, an early short-grass phase, and a late short-grass phase. This eventually led to a short-grass sod community, which could also be found in undisturbed communities. Research by other individuals recorded patterns similar to Shantz's by studying fields from the time of abandonment (Savage and Runyon 1937, Judd and Jackson 1939, Judd 1940, and Weaver and Albertson 1956). In 1944, Costello defined a model for successional processes. With an increase in the species composition, he reported (1) the replacement of annuals by perennials, (2) a gradual reduction in the percentage of composition contributed by forbs, (3) the increased abundance of grass, and (4) an increase in density of ground cover. This was generally supported by Lauchbaugh (1955) who described the pattern of succession after abandonment in three phases: (1) forbs and annual grass, (2) subclimax perennial grass, and (3) perennial grass climax. In a further study, Tomanek et al. (1955) found that abandoned fields in central Kansas had a 33% cover value of which two-thirds were long-lived perennials and one-third were short-lived perennials. Additional disturbances to fields have also been researched such as Dyksterhuis' study (1948). He found that fields that experienced little or no livestock grazing and those protected from excessive erosion would recover more quickly than those that had suffered further disturbance.

The study of old fields has contributed more than succession patterns. There has been an effort to identify plant species that indicate previous disturbances. Plants generally known as "colonizers" are usually the first to grow on disturbed sites. Sites can be occupied by native or introduced plants that can out-compete other species when the natural community is upset (Dury and Nisbet 1973). For instance, in the 1940s and 1950s, tumbleweeds (*Salsola kali*) were introduced into the Southwest in a flax shipment. Plants growing on prehistoric ruins are usually different from the surrounding, undisturbed communities and are often ones known to have been of some economic value during prehistoric times in the Southwest (Yarnell 1958). On historic sites, old animal pens, dry-farmed fields, logged areas, and homestead sites all seem to have vegetational compositions different from their surroundings. Additional work by Tierney and Foxx (1982) on low-level radioactive waste disposal sites in the Los Alamos area has found one or more wormwood species to have the highest importance indices, and are also different from surrounding vegetation composition.

2.0 Location Of Study

The old-field study sites are located within Los Alamos County, New Mexico, on the Pajarito Plateau. The Pajarito Plateau is on the east-central edge of the Jemez Mountains (Figure 1). These mountains are formed by a complex pile of volcanic rocks along the northwest margin of the Rio Grande rift in north-central New Mexico. The plateau, which forms an apron of volcanic sedimentary rocks along the eastern flank of the mountains, is aligned approximately north-south and is about 32 to 40 km (20 to 25 mi) in length and 8 to 16 km (5 to 10 mi) wide. The plateau slopes gently eastward from an elevation of about 2286 m (7500 ft) near the mountains toward the Rio Grande, where it terminates at an elevation of about 1889 m (6200 ft) in steep slopes formed by the down-cutting of the Rio Grande, which lies at 1647 m (5400 ft).

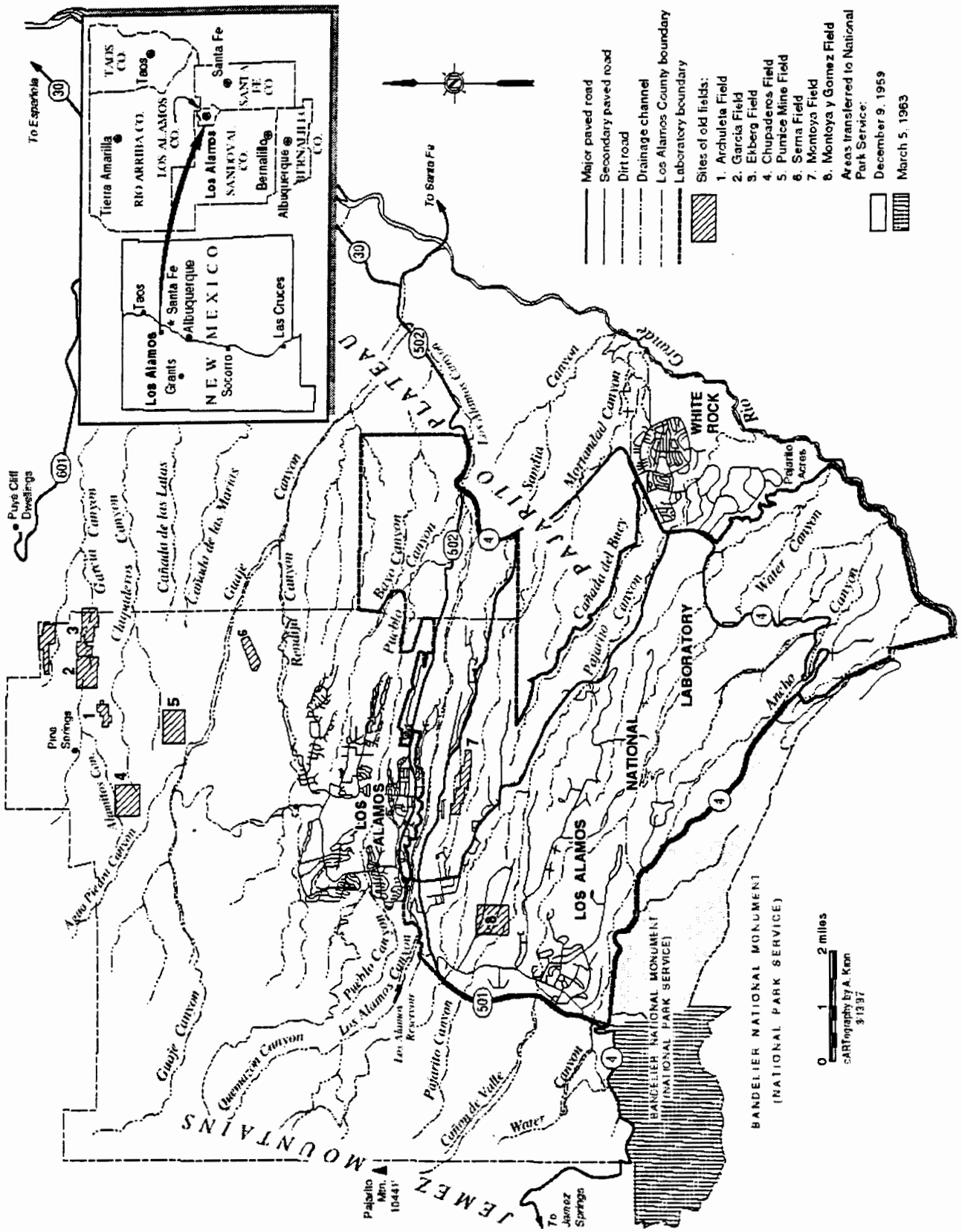


Figure 1. Old-field sites in and around Los Alamos National Laboratory on the Pajarito Plateau within Los Alamos County, New Mexico.

The plateau has been dissected into a number of narrow mesas by southeast-trending intermittent streams. The apronlike plateau at the base of the mountains extends into fingerlike mesas separated by deep canyons. The geological substrate, Bandelier Tuff, was deposited from volcanic eruptions in the Jemez Mountains about 1.1 to 1.4 million years ago (LANL 1988). The tuffs overlap other volcanics, which are underlain by the conglomerate of the Puye Formation (LANL 1988). This conglomerate intermixes with Chino Mesa basalts along the Rio Grande.

The climate of this area is characterized by a semiarid, temperate mountain climate with summer temperatures typically ranging from 10 to 22°C (50 to 80°F) during a 24-hr period (Bowen 1990). Winter temperatures generally range from about -6 to 11°C (the teens to 50°F) during a 24-hr period. The annual precipitation in the vicinity of Los Alamos ranges from 32 to 46 cm (13 to 18 in.) with much of it occurring during summer rain showers in July and August.

3.0 Historical Background of the Pajarito Plateau

The Pajarito Plateau has been in use for at least 10,000 years. Hunter/gatherer groups of Paleo-Indians, identified by their spear points, traversed the plateau probably for wild game, berries, nuts, and other wild fruits (Steen 1977). Around the late 1100s, the Pueblo Indians settled in the area and began agriculture on the mesas and canyon bottoms (Foxx and Tierney 1984). The first extensive farming on the Pajarito Plateau was about 1150 AD by the Pueblo III peoples. Large pueblo settlements were in place in the late 1300s but were abandoned about 1500 AD, possibly due to drought and soil depletion (Steen 1977).

With the arrival of the Spanish, grazing animals such as sheep, goats, cows, and horses were introduced. Sheep were the major domestic livestock until the late 1800s, when cattle became more profitable. Historical information indicates that Pajarito Canyon was used as a source of water for sheep and later, possibly, for cattle from nearby ranches.

From 1742 to 1751 Pedro Sanchez owned the land that became known as the Ramon Vigil Grant (Figure 2). Pedro Sanchez lived in Santa Cruz, and in 1741 he petitioned Governor Gaspar Domingo Mendoza for a grant of vacant land west of the Rio Grande in order to support his family. Nearly 100 years later heirs of Pedro Sanchez sold the grant to Ramon Vigil (August 1851) just at the time the US Government was surveying the area; therefore, the name Ramon Vigil Grant. From 1879 to 1943 the grant changed hands several times, eventually coming under ownership of Winfield Smith of Milwaukee, Wisconsin, and Edward P. Shelton of Cleveland, Ohio. From that time until the early 1940s, the grant was used for lumbering, grazing livestock, and homesteading.

In 1897, H. S. Buckman bought logging and timber rights to the Ramon Vigil Grant, which was just east and south of the Anchor Ranch. A newspaper article of December 1903 speculated that Buckman cut 36,000,000 board feet on the 32,000-acre grant. Areas adjacent to the Grant were also logged when the land was sold to the Ramon Land and Lumber Company in 1906. The logging industry continued clear-cutting areas into the 1940s (Foxx and Tierney 1984).

From approximately 1885 through 1887, the Ramon Vigil Grant was rented to a Texas cattleman, W. C. Bishop, who ran 3000 head of cattle on 32,000 acres (Chambers 1974). From the early 1900s through the 1940s, the land was used as part of the Grant USFS grazing allotments. The Ramon Vigil Grant allotment supported 190 animals (Forest Service Memos archived at the Los Alamos Historical Society).

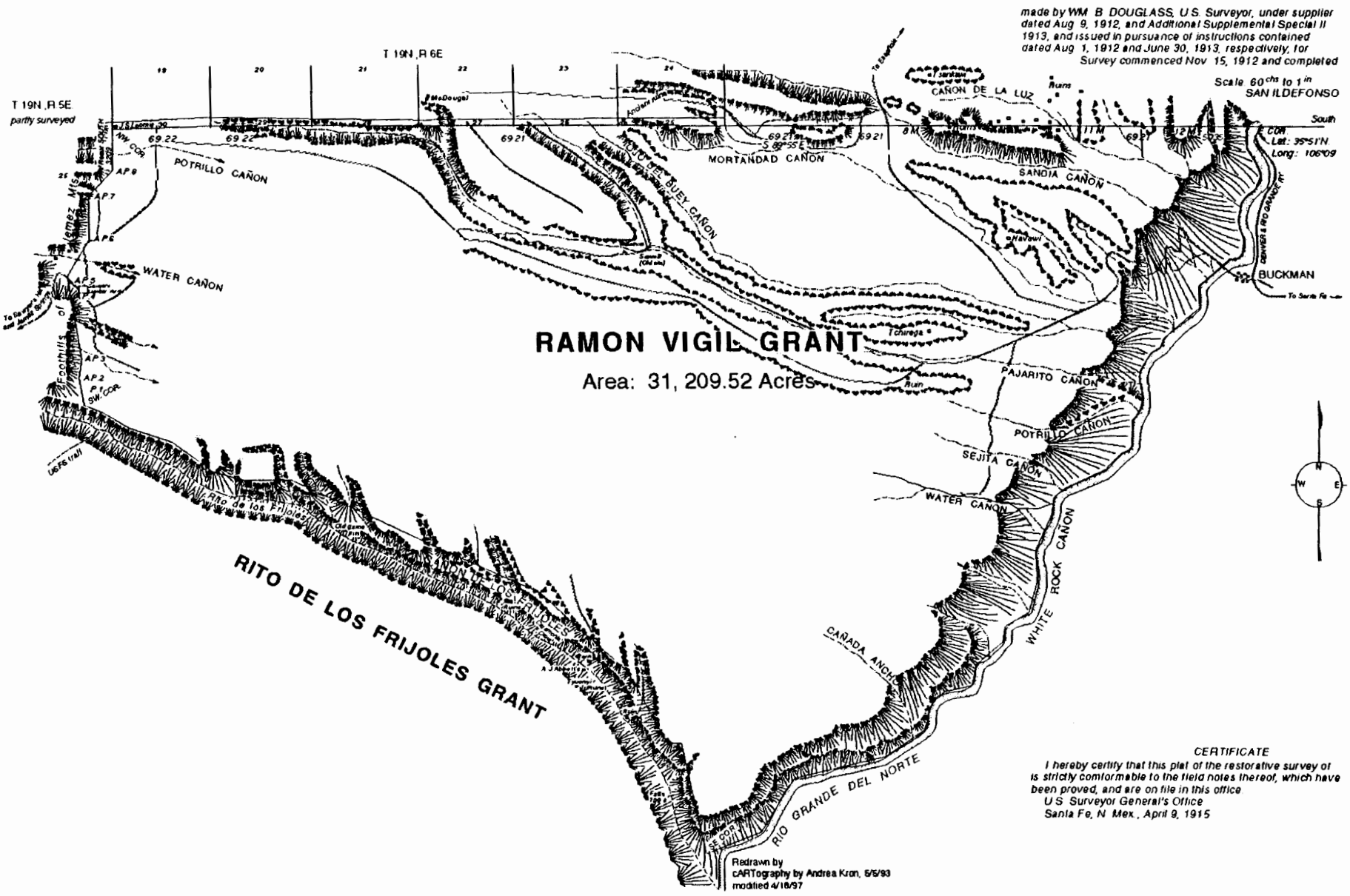


Figure 2. A 1912 map showing the area of the Ramon Vigil Grant on the Pajarito Plateau.

After the Homestead Act of 1862, the plateau west and north of the Ramon Vigil Grant became homesteads for summer grazing areas and subsistence agriculture. The act granted quarter-sections of land to any settler who occupied a site for five years. Sections of mesa top and canyon bottom were cleared for such crops as beans, wheat, corn, alfalfa, and oats. In addition to cash crops, settlers usually had small vegetable gardens and fruit orchards near their cabins (McGehee et al., pers. com.) Settlers also kept small herds of goats, horses, cows, and sheep (Foxx and Tierney 1984). Most families stayed during the warm months and wintered in towns such as Buckman and Santa Fe or in the Española Valley. By 1937, 35 homesteads occupied about 15 km^2 (6 mi^2) of the Pajarito Plateau (Figure 3)(Foxx and Tierney 1984). Eventually the lands known as the Ramon Vigil Grant were purchased by Frank Bond of Espanola. Much of the grant was acquired by the Federal Government in 1943 for the Manhattan Project. Later in the 1960s, portions of the southern boundary of the grant became part of Bandelier National Monument. Los Alamos County was established by state statute in 1948 from Santa Fe and Sandoval Counties, and the communities of Los Alamos and White Rock developed.

In 1943, the Federal Government acquired approximately 54,000 acres of the plateau through condemnation or purchase (Chambers 1974) (Figure 4 and Appendix A). Farms and the Los Alamos Ranch School were abandoned and grazing allotments were discontinued. The acquired area included six of the old homestead sites examined in this study.

After World War II, the Laboratory continued to exist. From the beginning, buildings and facilities were often placed in areas cleared by logging or farming. The result is that fallow fields, homestead sites, and logged areas have had different disturbances occurring over the decades. In more recent years urbanization, including development of road ways, extensive building, and waste burial (to name a few) have disturbed both forested and nonforested sites. Areas that reverted back to the USFS have been used for recreation and some cattle grazing.

Some reclamation of sites has occurred in the past 45 years. After the purchase or condemnation of the homesteads and adjacent agricultural fields, erosion became a severe problem in Garcia Canyon (Pickens 1964). In the early 1960s, a watershed development project was established to alleviate this problem.

4.0 Description of Homestead Sites

Appendix B, Table B-1 shows a listing of all the homesteads of the Los Alamos area compiled from Bureau of Land Management (BLM) records. The listing has certificate numbers, application numbers, date, and acreage. Appendix B, Table B-2 provides information compiled by R. F. Shaw comparing the 1942 owners with the original grantees. Appendix B, Table B-3 shows the grazing allotments and animals on each allotment in 1943. Information in the following section is a summation from these lists and homestead documents obtained from the National Archives. Because of landscape changes, inheritances, and indistinct maps, we have used a variety of sources to determine the names of each site.

Fields 1, 2, and 3 (Archuleta, Garcia, and Ekberg Fields) are located in Garcia Canyon on land that now belongs to the USFS or is in private ownership. Fields 4 and 5 (Chupaderos and Pumice Mine Fields) are located on the Santa Fe National Forest. Field 6 (Serna Field) is within Rendija Canyon and is on land belonging to the Department of Energy (DOE) and is near the Sportsman's Club firing range. Two fields are within the boundaries of LANL; Field 7 (Montoya Field) is on Sigma Mesa and Field 8 (Montoya y Gomez Field) is on Twomile Mesa. Tables 1 and 2 give descriptive and historical information about the fields. Table 1 gives the location of each field; Table 2 indicates the homesteader and the crops grown.

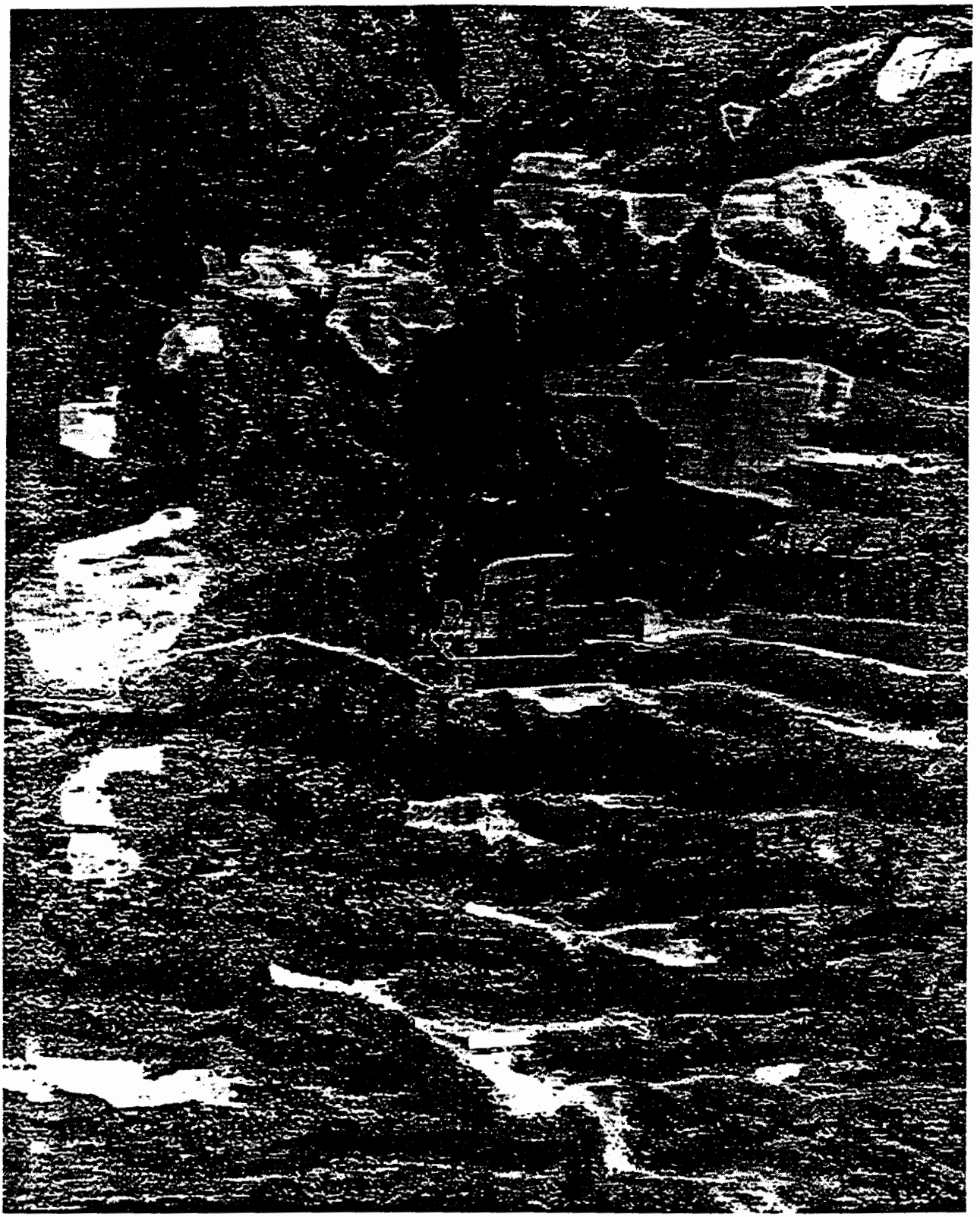
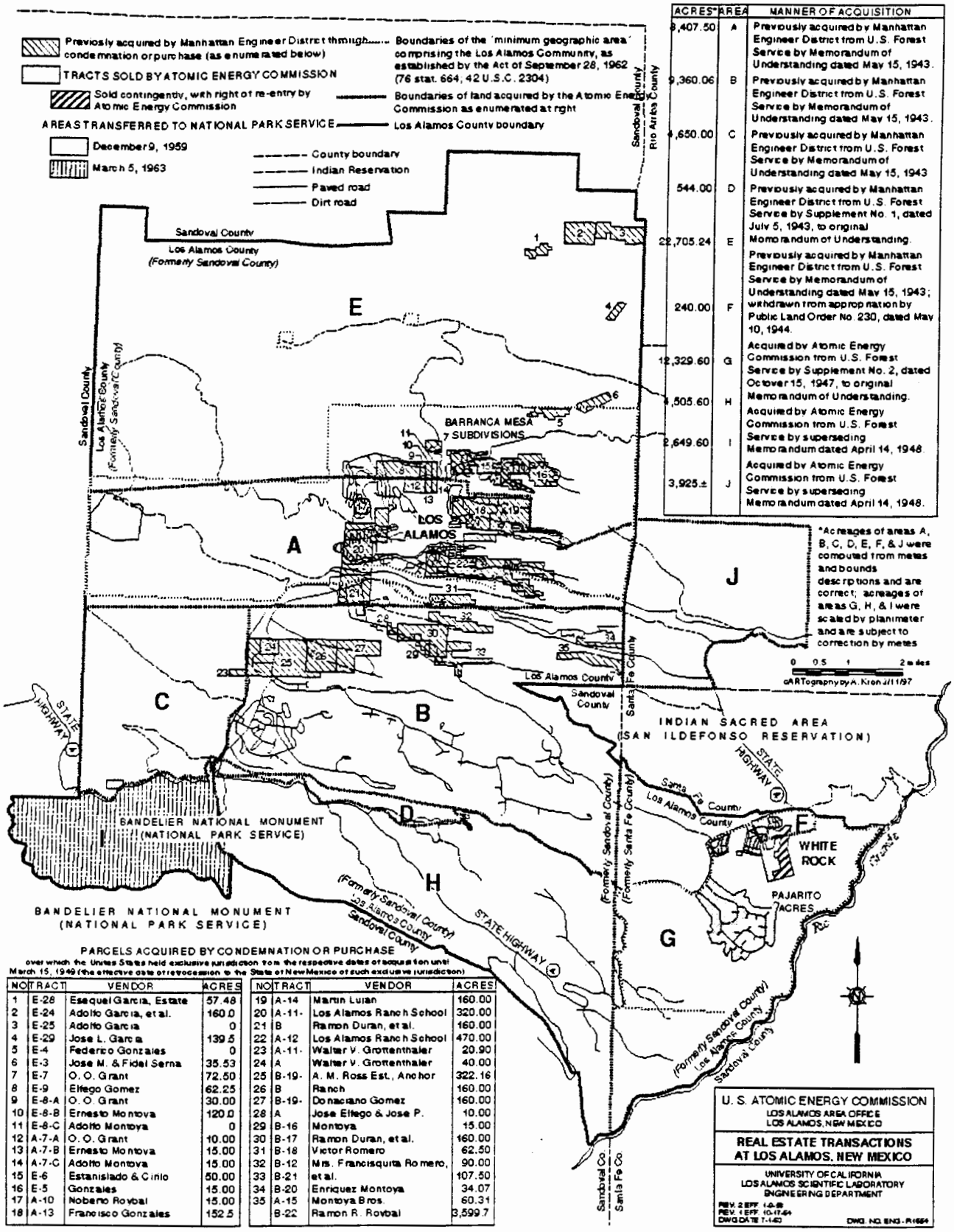


Figure 3. Aerial photograph of Los Alamos townsite taken in 1935 showing the extensive land areas used for dry-land farming (National Archives and Record Service, Washington, DC, Rio Grande Series No. 1477). Scale is 1:4680.



ACRES*	AREA	MANNER OF ACQUISITION
3,407.50	A	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Memorandum of Understanding dated May 15, 1943.
9,360.06	B	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Memorandum of Understanding dated May 15, 1943.
4,650.00	C	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Memorandum of Understanding dated May 15, 1943
544.00	D	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Supplement No. 1, dated July 5, 1943, to original Memorandum of Understanding.
22,705.24	E	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Memorandum of Understanding dated May 15, 1943; withdrawn from appropriation by Public Land Order No. 230, dated May 10, 1944.
240.00	F	Acquired by Atomic Energy Commission from U.S. Forest Service by Supplement No. 2, dated October 15, 1947, to original Memorandum of Understanding.
12,329.60	G	Acquired by Atomic Energy Commission from U.S. Forest Service by superseding Memorandum dated April 14, 1948.
4,505.60	H	Acquired by Atomic Energy Commission from U.S. Forest Service by superseding Memorandum dated April 14, 1948.
2,649.60	I	
3,925.±	J	

*Acreages of areas A, B, C, D, E, F, & J were computed from metes and bounds descriptions and are correct; acreages of areas G, H, & I were scaled by planimeter and are subject to correction by metes

PARCELS ACQUIRED BY CONDEMNATION OR PURCHASE over which the United States held exclusive jurisdiction from the respective dates of acquisition until March 15, 1949 (the effective date of retrocession to the State of New Mexico of such exclusive jurisdiction)

NO	TRACT	VENDOR	ACRES
1	E-28	Esequel Garcia, Estate	57.48
2	E-24	Adolfo Garcia, et al.	160.0
3	E-25	Adolfo Garcia	0
4	E-29	Jose L. Garcia	139.5
5	E-4	Federico Gonzales	0
6	E-3	Jose M. & Fidel Serna	35.53
7	E-7	O. O. Grant	72.50
8	E-9	Ellego Gomez	62.25
9	E-8-A	O. O. Grant	30.00
10	E-8-B	Ernesto Montoya	120.0
11	E-8-C	Adolfo Montoya	0
12	A-7-A	O. O. Grant	10.00
13	A-7-B	Ernesto Montoya	15.00
14	A-7-C	Adolfo Montoya	15.00
15	E-6	Estanislado & Cinlo	50.00
16	E-5	Gonzales	15.00
17	A-10	Noberto Roybal	15.00
18	A-13	Francisco Gonzales	152.5
19	A-14	Martin Luian	160.00
20	A-11-	Los Alamos Ranch School	320.00
21	B	Ramon Duran, et al.	160.00
22	A-12	Los Alamos Ranch School	470.00
23	A-11-	Walter V. Grottenthaler	20.90
24	A	Walter V. Grottenthaler	40.00
25	B-19-	A. M. Ross Est., Anchor	322.16
26	B	Ranch	160.00
27	B-19-	Donaciano Gomez	160.00
28	A	Jose Ellego & Jose P.	10.00
29	B-16	Montoya	15.00
30	B-17	Ramon Duran, et al.	160.00
31	B-18	Victor Romero	62.50
32	B-12	Mrs. Francisquita Romero,	90.00
33	B-21	et al.	107.50
34	B-20	Enriquez Montoya	34.07
35	A-15	Montoya Bros.	60.31
	B-22	Ramon R. Roybal	3,599.7

Figure 4. Map showing all of the homesteads.

Table 1. Location of fields.

Field Name and Number	Northing	Easting	Township	Range	Section	Elevation	Location
Archuleta Field (1)	3979036.4	384682.9	20N	6E	23	2232 m (7440 ft)	Mesa above Garcia-Alamitos Canyon
Garcia Field (2)	3979674.5	385795.3	20N	6E	23	2130 m (7100 ft)	Garcia Canyon
Ekberg Field (3)	3979746.2	388173.3	20N	7E	19	2099 m (7000 ft)	Garcia Canyon
Chupaderos Field (4)	3977398.9	388962.7	20N	7E	30	2055 m (6850 ft)	Chupaderos Canyon
Pumice Mine Field (5)	3975187.4	389798.9	19N, 20N	7E	5	1980 m (6600 ft)	Above Guaje Canyon
Serna Field (6)	3974723.7	385514.5	19N	6E	2	2070 m (6900 ft)	Rendija Canyon
Montoya Field (7)	3970146.4	382873.7	19N	6E	22	2190 m (7300 ft)	Sigma Mesa
Montoya y Gomez Field (8)	3969535.2	380691.8	19N	6E	20	2190 m (7300 ft)	Twomile Mesa

Table 2. Site name and homesteader as related to crops and livestock.

Field Name (Number)	Homesteader	Year	Acres	Crops	Livestock	Grazing Allotment (# of animals)
Archuleta Field (1)	Ezequiel Garcia	1915	57.5	corn, beans, oats, potatos, wheat	cattle, chickens	18
Garcia Field (2)	Adolfo Garcia	1919	59.5	beans, corn, barley, wheat	cattle, chickens, hogs	27
Ekberg Field (3)	Garcia	1920-30s	?	beans	cattle	
Chupaderos Field (4)				none	large livestock	
Pumice Mine Field (5)				?	large livestock	
Serna Field (6)	Andres Martinez	1912	62.25	beans, corn, wheat, peas, garden seeds	livestock	
Montoya Field (7)	José Albino Montoya	1911	90	beans, corn, oats	chickens, large livestock	
Montoya y Gomez Field (8)	Donaciano Gomez	1899	160		horses	28

4.1 Field 1 (Archuleta/Alamitos Field)

This homestead field was patented under Ezequiel Garcia in 1922. It was referred to as the Archuleta Field in documents by Homer Pickens and is called Alamitos in other literature. Garcia homesteaded approximately 42.5 acres in 1922 and an additional 14.98 acres in 1938. His first homestead entry was filed in 1914, but permanent residence on the land began in 1915. Improvements to the parcel included a one-room log house, a corral made of logs, a chicken house, and a wire fence on the west side of the property. Only 25 acres were listed as suitable for cultivation, and by 1921 all of this was planted in crops. Corn and beans were the major food items grown, with the addition of oats, potatoes, and wheat over the years the land was occupied. The land had no merchantable timber, nor was it suitable for irrigation.

In USFS documents for 1943, the grazing allotments belonged to six individuals surnamed Garcia, two named Gomez, two named Gonzales, one Grant, one Lopez, three named Roybal, and two named Trujillo. A total of 190 animals were allowed (Appendix B).

This field lies at the highest altitude, 2232 m (7440 ft), of all the fields in the Garcia-Chupaderos Canyons area. Two log buildings still stand on the site along with part of an *horno* (oven). Figure 5 shows the condition of the buildings on the site in (a) 1982, (b) 1993, and (c) 1996.

We found that there were some relatively large ponderosa pine trees scattered throughout the field. Also, some large stumps were next to 10- to 12-in.-diameter trees that probably grew after the stumps had been cut. This mesa top location is surrounded by ponderosa pine and gamble oak.

The Archuleta Field suffered from extensive erosion when farming ceased and the land was no longer tilled. As part of the Northern Rio Grande Resource Conservation and Development Project, three homestead fields (a total of 60 acres) were planted with grasses, forbs, and woody plants of food value to deer and wild turkey as well as a soil cover to prevent erosion. The field was treated by disking twice to reduce competing vegetation and seeded and packed. The southwest corner of the field was also mulched with hay (Figures 6 to 9). The area was seeded with mountain mahogany (*Cercocarpus montanus*) to improve browse potential on the site (Figure 10). In a September 1964 memo from L. K. Sandoval, Work Unit Conservationist, Soil Conservation Service (SCS), to E. E. Wingfield, Chief Project Support Branch, Mr. Sandoval writes as follows:

> *"The disking of Archuletta field has been completed in preparation for seeding. The results of this operation indicate a 75% weed kill."*

In an October 1964 memo to Hurlon Ray, SCS, Glenn C. Niner states that the following accomplishments have been completed:

> *"Archuleta Field was treated first . . . . All but a portion of the field was re-disked with the Game Department disk as competing vegetation was not sufficiently reduced with summer disking. Resulting seed bed on much of the field was finely powdered and very loose. Till-and-Pack seeder furnished by Rust Tractors Company did fair job of firming soil except for powdery surface. The field was planted by either the Till-and-Pack or grain drill. The hay mulch was used in the southwest corner of this field."*

This memo goes on to say that in July 1965 the area will be planted with

Indiangrass	(PM-C-54)
Little bluestem	(Pastura)
Big bluestem	(PM-C-119)
Blue grama	(Lovington)
Sideoats	(Vaugh and PM-NM-368)

Browse species may also be used.

In another memo dated August 1964 from S. H. Fuchs to E. E. Wingfield the following is stated:

"The sage prevalent on most of the field (probably Artemisia gnaphalodes) is a rhyzomatous plant and will undoubtedly offer a lot of competition to seedlings that come up. The sage will likely be difficult to kill. We would like for the A. E. C.[1] *to disc 'Archuletta' field as soon as possible.*

Mountain mahogany seed furnished by the AEC will be cleaned and used in the planting.

Additionally the New Mexico Department of Game and Fish will 'provide Mountain mahogany, bitter brush, and 4-winged saltbush.'

The Soil Conservation Service will provide the following species: Indian ricegrass, western wheatgrass, crested wheatgrass, Siberian wheat, pubescent wheat, Russian wildrye, big bluegrass, Stipa-Oryzopsis, green needle grass, basin wildrye, sideoats grama, and 4-winged saltbush."

In a memo to L. K. Sandoval on August 8, 1965, James Folks reported the following information about the soils on Archuleta, Garcia, and Homestead Fields.

"I surveyed the 3 tracts of land in Los Alamos County that the AEC is interested in reseeding.

All tracts consist of one mapping unit, which is unnamed loam, 1 to 9 percent slopes. This soil consists of 6 to 16 inches thick. The subsoil is of moderate, medium subangular blocky structure. The permeability is moderate.

This soil is leached of lime from 10 to 30 inches. It has a tendency to crust on the surface reducing the intake rate and increasing the runoff.

This soil is developing in material from acid igneous rocks, pumice, and other volcanic debris. It appears to be low in organic matter and shows signs of being very susceptible to erosion.

Compaction of fill material for dams, dikes, etc., is hazardous due to high silt content. Pit type tanks in this soil are more suitable.

The slope varies from 1 to 9 percent with 5 percent being the most dominant. Gullies 1 to 3 feet deep are common on lower tracts.

Small areas of pumice, conglomerate, and some rhyolite are included in this mapping unit."

Figure 11 shows the condition of the gullies in (a) 1982 and (b and c) 1993.

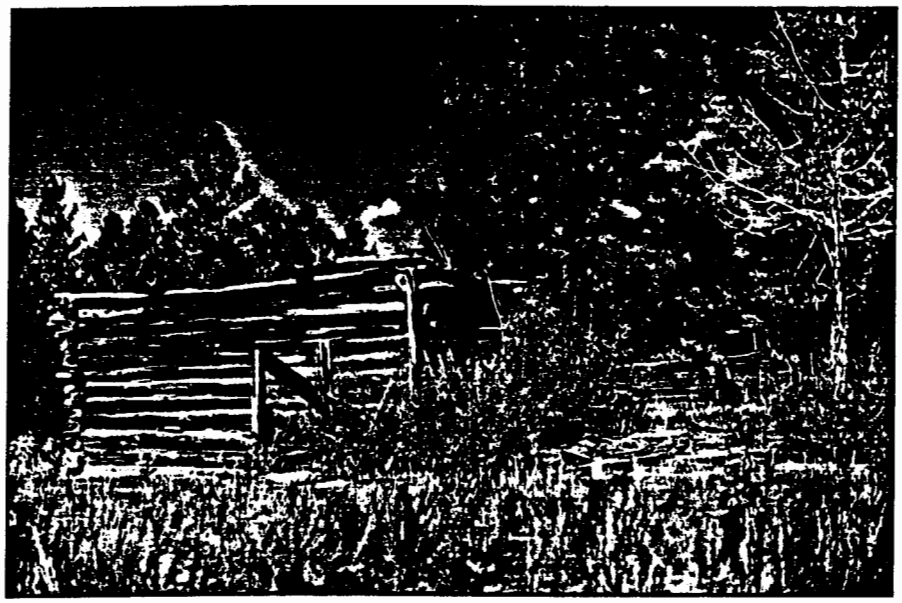
4.2 Field 2 (Garcia Field)

At the time of the buy-out, fields in Garcia Canyon were under the name of Adolfo Garcia. In the May 19, 1924 Homestead entry, he says his land is bounded on the east by the Juan Luis Garcia Homestead. Juan Garcia had homesteaded in 1887.

[1]A.E.C. is the Atomic Energy Commission (AEC)

(a)

(b)



(c)

Figure 5. The condition of the two log houses on Archuleta Field (Field 1) in (a) 1982 and (b) 1993, and the main log house in (c) 1996.

Figure 6. Bags of seed for planting and bales of hay for mulching purposes as part of the experimental work to be done on Archuleta Field (Field 1) in 1964.

Figure 7. Planting forage seed before mulching with hay on Archuleta Field (Field 1) in 1964.

Figure 8. Till-and-pack seed drill firming seed bed after dusting on Archuleta Field (Field 1) in 1964.

Figure 9. Mulching with hay on Archuleta Field (Field 1) in 1964.

Figure 10. Mountain mahogany *(Cercocarpus montanus)* seeds planted on Archuleta Field (Field 1) in 1964.

In a letter to the Secretary of Interior, May 14, 1914, there was a request for open land (55 acres) applied for by Adolfo Garcia in 1910. Garcia and his family began residence on the land in 1914 and filed a homestead application in 1921 for 55 acres. Another application was made in 1932 for an additional 4.5 acres of land. Land patents were issued in 1924 and in 1933. Improvements made to the land included a three-room log house, a stable, one corral for cattle, a wire fence encompassing 35 acres, a chicken coop, and a hog pen. The 1921 application included this description.

"Improvement[s] I have made on the land consist of the fence enclosing 35 and 55 acres and constructed of 3 barb wires, cedar posts and pitch pine posts, posts about 2 yards apart and the fence worth about $300. The log house is approximately 10 logs high or 10 ft and outside dimensions about 10 ft by 20 ft and the house worth about $600; other improvements are a chicken house, pig pen and yard, corral for cattle and a tool house of lumber all worth about $300 more."

Figure 12 shows the condition of the log house in (a) 1982, (b) 1993, and (c) 1996.

Adolfo Garcia grew several crops on the homestead. In 1919, 18 acres of beans, corn, and wheat were cultivated. A crop of barley was added to the fields in 1923. The acreage was increased in 1920 to 18.5 acres and again in 1920 to 19.5 acres. The first year, 1919, he harvested 5000 lb of beans, 3000 lb of corn, and 2500 lb of wheat. In 1920 he harvested 2000 lb of beans, 2500 lb of corn, and 1875 lb of wheat. The harvest was much less in 1922 with only 200 lb of beans, 600 lb of corn, and 500 lb of wheat. In 1923 he harvested 1000 lb of beans, 5000 lb of corn, and 2375 lb of barley. (Homestead Entry, May 19, 1924).

The elevation of this site is about 2130 m (7100 ft). It is generally situated in ponderosa pine cover type. A cabin is located at the west end of the homestead, and fields lie to the northeast. Several stone diversions or water catchment dams are among the trees to the northeast side, and a ditch runs along the upper south side of the fields. These are believed to be prehistoric structures, along with a ruin west of the cabin. After the land was removed from cultivation, erosion apparently became a large problem. Records from Homer Pickins indicate that in 1964 a Wildlife Habitat and Watershed Development Project was undertaken to use fields in Garcia Canyon as an experiment for planting various types of forage seed. A water catchment was put in or enlarged. Figure 13 shows the water catchment through time. The entire field was disked (Figure 14) and seeded with *Menodora scabra* and *Petalostemum purpureum*. Boy scouts planted trees and shrubs (Figure 15). During this three-year project, the entire upper south half of the field was planted with pine seedlings. Erosion now seems to be minimal.

In a memo to file by Homer Pickens, July 25, 1966, Pickens indicates,

> *"On July 21, 1966, two varieties of ground cover were planted in Garcia field near the 1962 sign post.*
>
> 1. *Menodora Scabra or Rough Menodora*
> 2. *Petalostemum Purpureum or Purple Prairie Clover.*
>
> *These are experimental plantings to detemine their value in erosion control and food for wildlife."*

4.3 Field 3 (Ekberg Field)

The Garcia family eventually acquired adjacent homesteads and tracts of land throughout Garcia Canyon to the east. All lands owned by the Garcias were planted in beans. The names we have located for this field include Homestead Field—during Homer Picken's reclamation project—and Ekberg Field. In 1982 when we did the surveys, the lands were owned by the Ekbergs. This field was part of the early acquisition by the AEC along with other fields.

The elevation of this site is about 2099 m (7000 ft), and the site is located east of Garcia Field. It lies on a bench above the stream channel and gently slopes to the east in a ponderosa pine-dominated community.

Heavy erosion also became a problem in this field after the land was sold to the government. Water catchments were apparently developed on these fields also (Figure 16). The land was reclaimed in 1964 under the same program described by Homer Pickens. Heavy equipment was used to fill in gullies and to contour hillsides and reseed grasses. In 1982, the Ekberg Field was a small, privately owned parcel. The original corral stood near the entrance of the field and by 1997 the corral was disintegrating (Figure 17). The field is presently dominated by chamisa and other plants of disturbance (Figure 18).

4.4 Field 4 (Chupaderos Field)

Field 4 lays on a mesa top northwest of the Copar Pumice Mine on Santa Fe National Forest lands. It is at an elevation of approximately 2055 m (6850 ft) and overlooks Chupaderos Canyon. The mesa slopes gently to the west and is dotted with juniper and a few scattered ponderosa pine (Figure 19). A historic field, Chupaderos was not plowed but used as pasture land for livestock. Both sheep and cattle have been grazed in the area before and during the homestead era. The field was removed from active farming in the 1940s. Because it was not plowed, evidence of prehistoric grid gardens or water conservation devices can still be seen in this field, suggesting that it may have been at least partially cleared by Indians prior to the arrival of the Spanish in the 1500s.

(a)

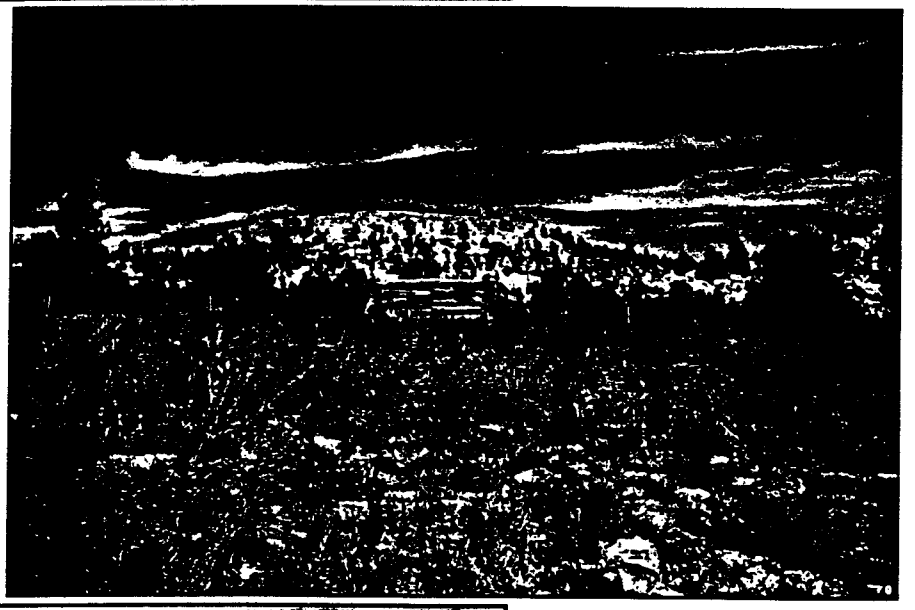
(b)

(c)

Figure 11. The condition of erosion gullies in Archuleta Field (Field 1) in (a) 1982 and (b and c) 1993.

(a)

(b)

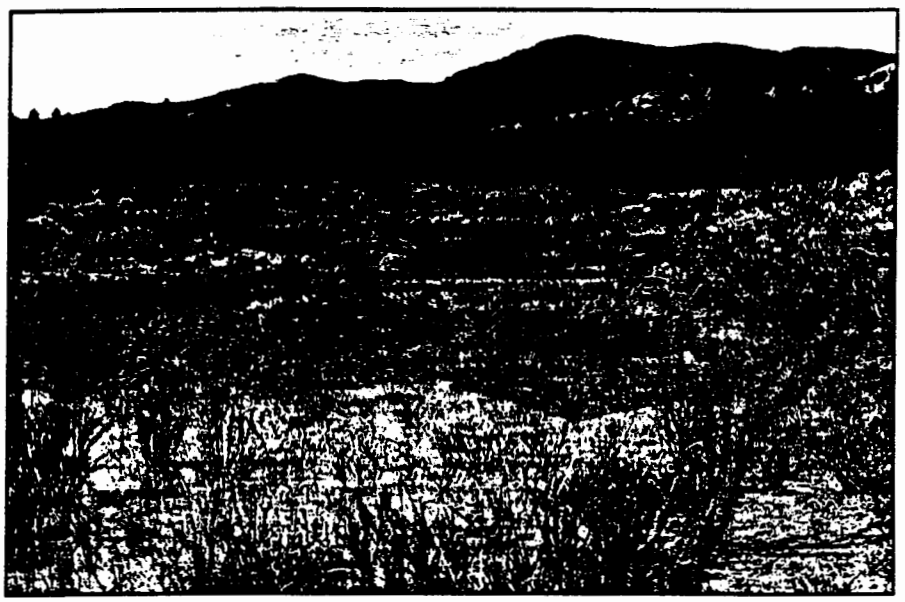


(c)

Figure 12. The condition of the log house in Garcia Field (Field 2) in (a) 1982, (b) 1993, and (c) 1996. The lone juniper in the field in the foreground is the same in (a) and (c).

(a)

(b)

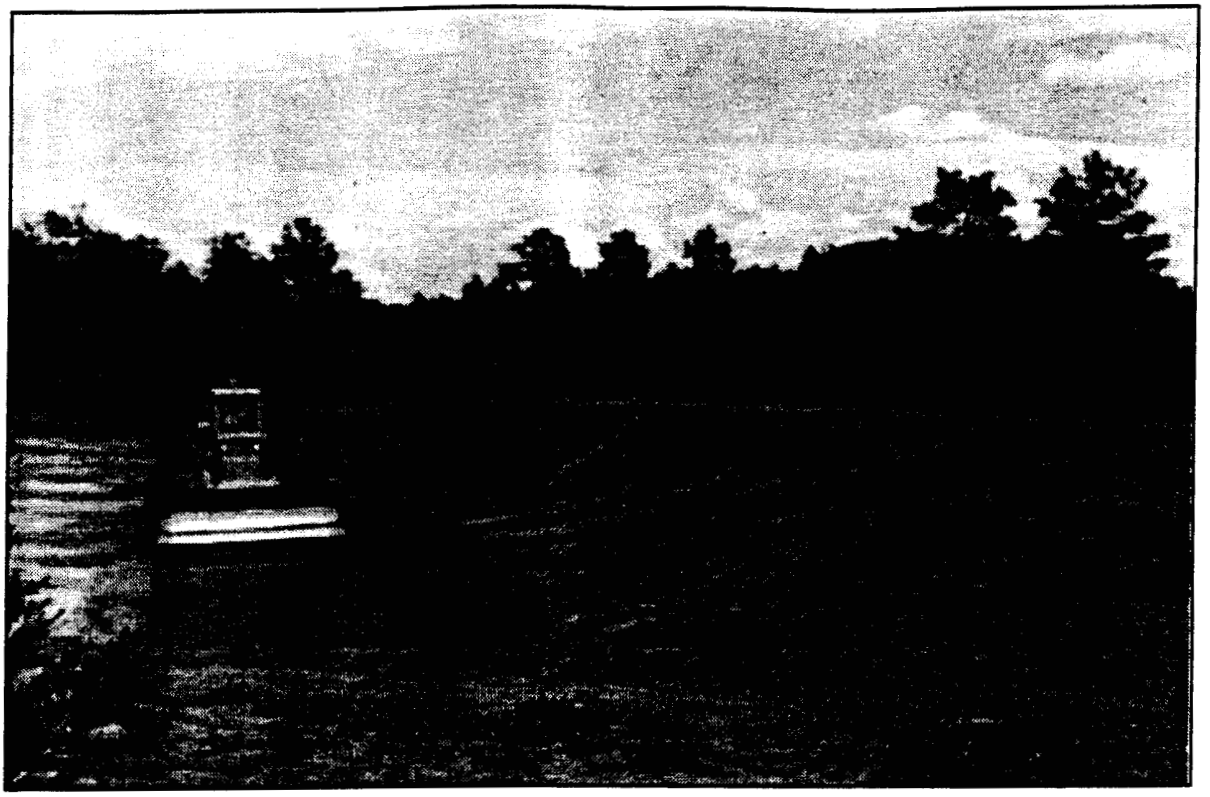


(c)

Figure 13. The water catchment that was put in or enlarged in Garcia Field (Field 2) during the Wildlife Habitat and Water Development Project in (a) 1964; the same catchment in (b) 1982 and (c) 1996.

Figure 14. Garcia Field (Field 2) was planted using a Hanson browse seeder.

Figure 15. Boy Scouts planting trees in Garcia Field (Field 2) in April 1964.



(a)

(b)

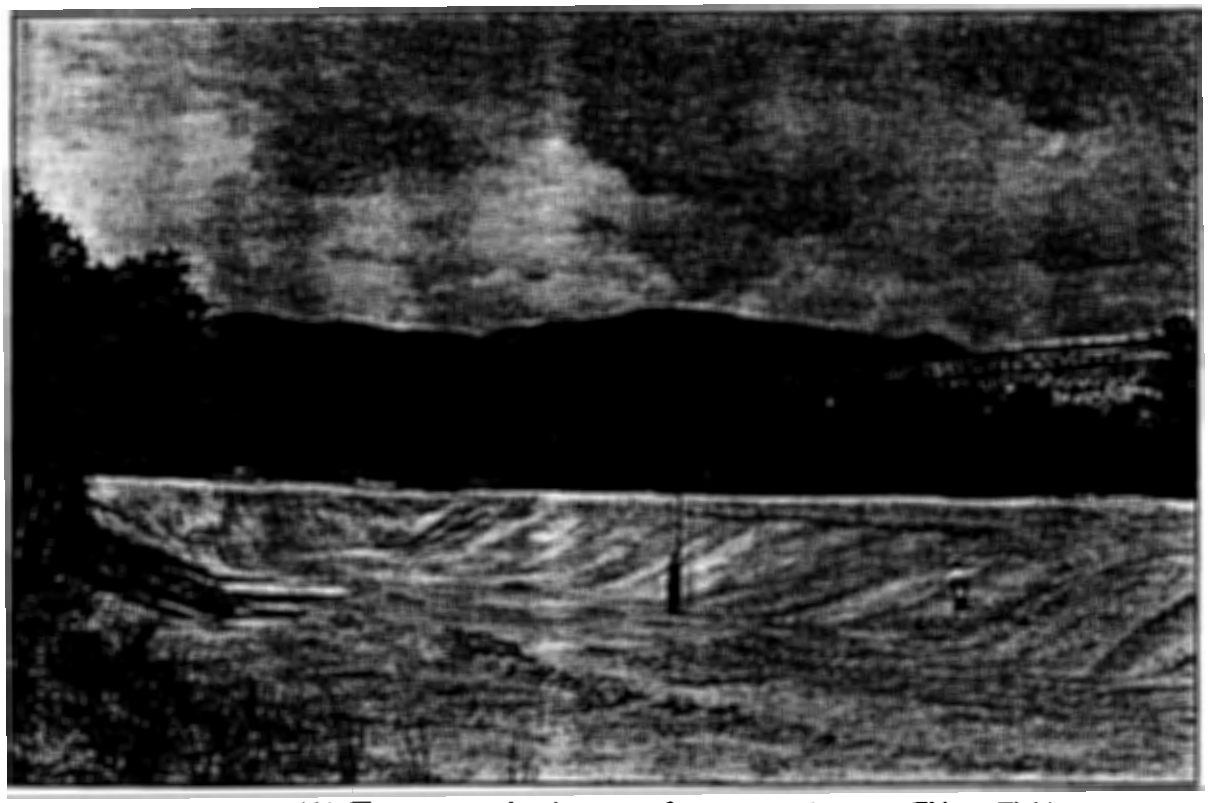
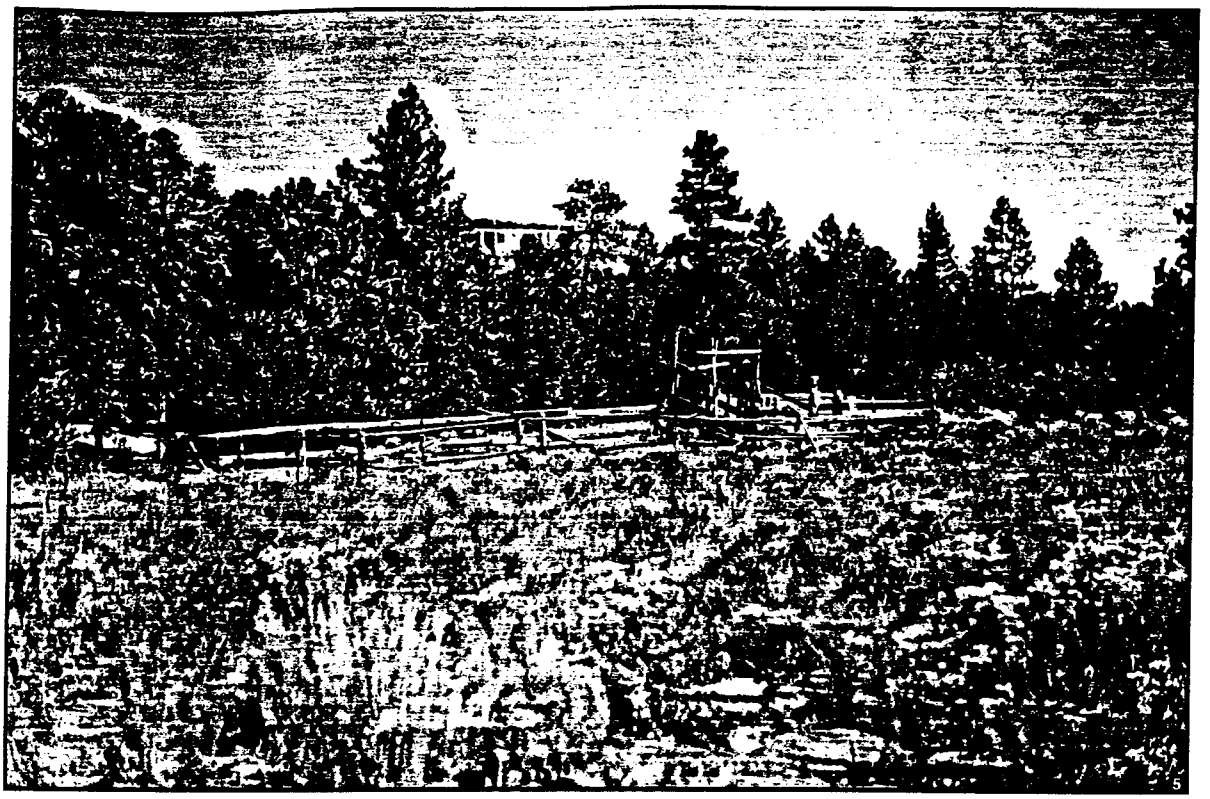


Figure 16 (a and b). The apparent development of a water catchment at Ekberg Field (Field 3) during the 1964 reclamation.



(a)

(b)

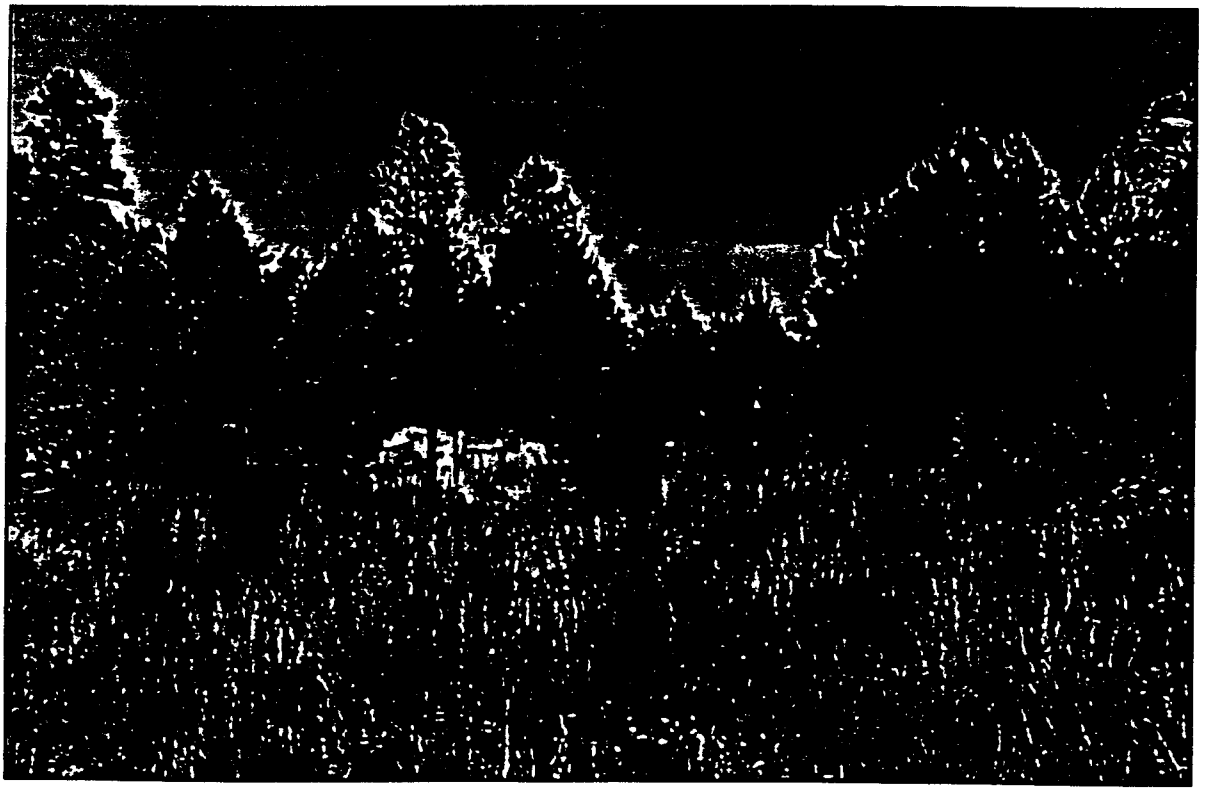
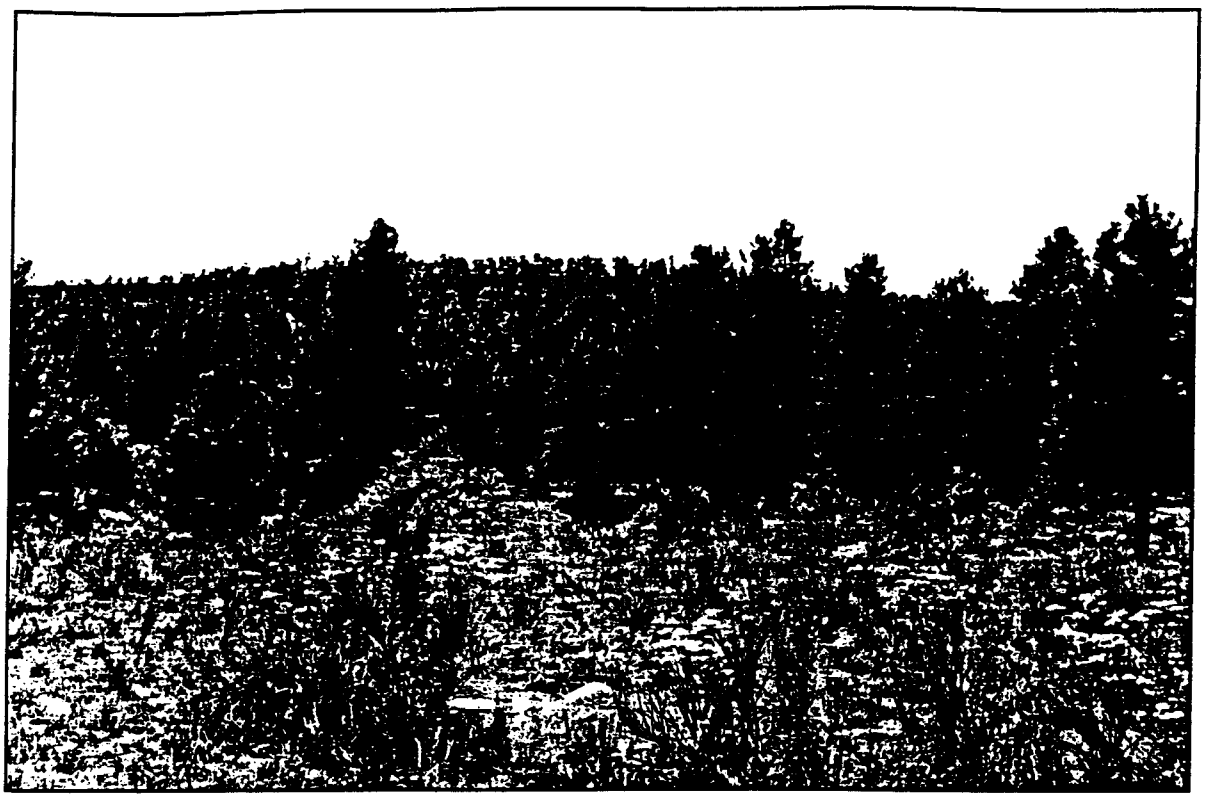


Figure 17. The corral in Ekberg Field (Field 3) in (a) 1982 and (b) 1997.



(a)

(b)

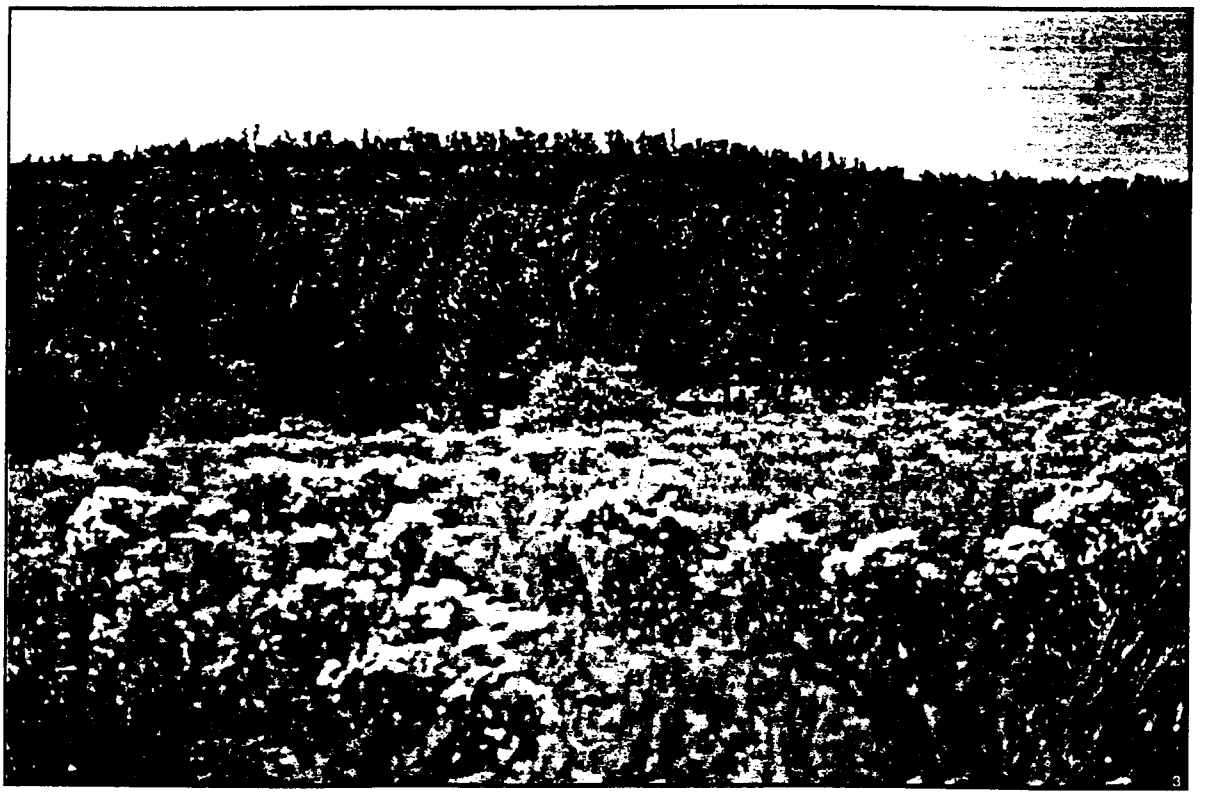


Figure 18 (a and b). Views of portions of Ekberg Field (Field 3) showing dominance by chamisa and other plants of disturbance.

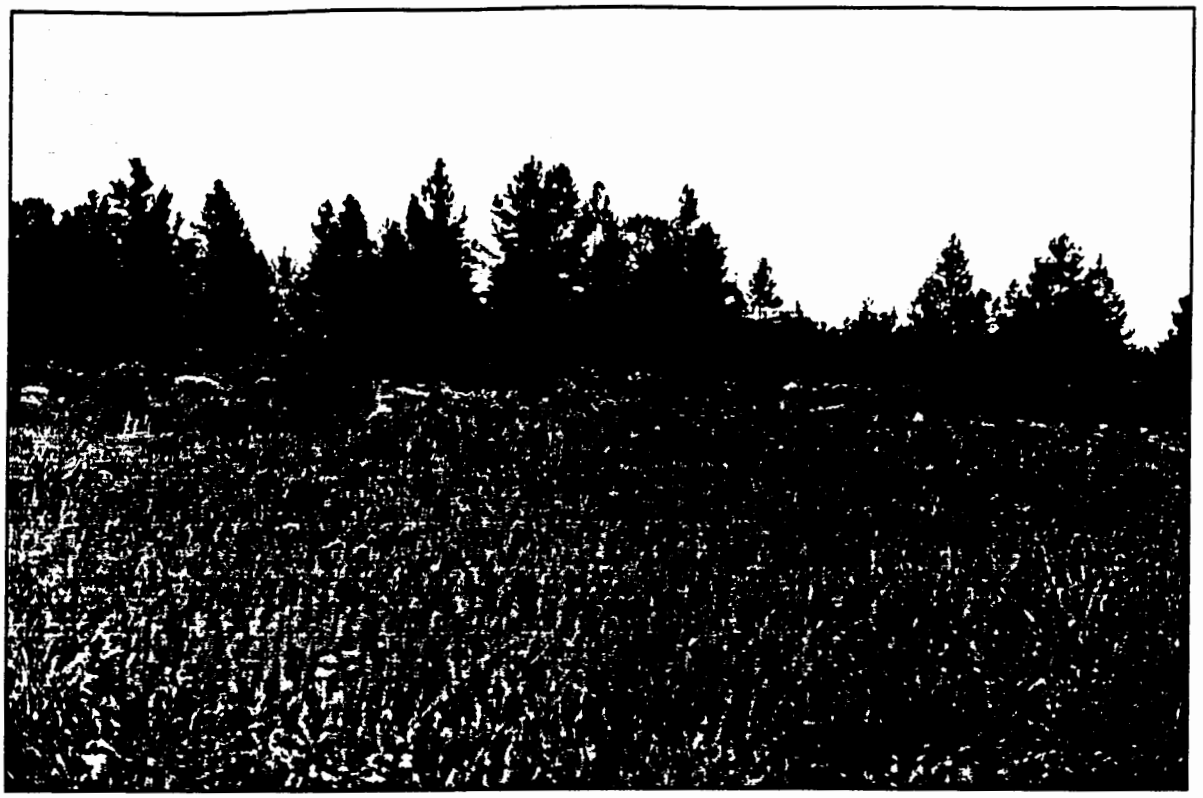


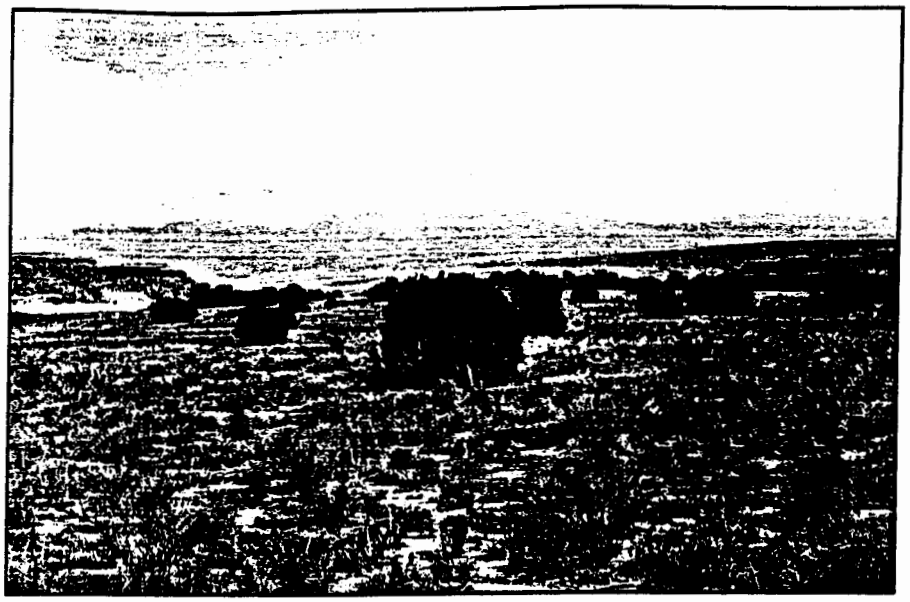
Figure 19. The mesa top around Chapaderos Field (Field 4) in 1982 dotted with juniper and ponderosa pine.

4.5 Field 5 (Pumice Mine Field)

Field 5 is not part of the original land area acquired by the AEC for the Manhattan Project. This field lies just outside the northeastern border of the purchase within the Santa Fe National Forest. The elevation of this mesa top site is approximately 1980 m (6600 ft), and while the dominant vegetation is now pinon and juniper, the mesa top appears to have had pine on it in the past. A few old ponderosa pine stumps were found, indicating historic logging and field clearing. The Pumice Mine Field was also used as grazing land for livestock during the homestead era. Prehistoric garden plots were found in an area just north of the pumice mine as well as a small plot on the northern portion of the field. The field is on the southeast edge of the Copar Pumice Mine. Figure 20 shows views of the field in (a) 1982, (b) 1993, and (c) 1996.

4.6 Field 6 (Serna Field)

Field 6 was under the name of Jose M. and Fidel Serna in the 1940 acquisition maps. Homestead records show two homesteads in the Rendija Canyon area, those of Federico Gonzales and Andres Martinez. From this information and other lists, it appears that the fields designated as the Serna Field were part of the Martinez homestead, which was 62.25 acres. Martinez began residency in March 1912. Every year from then on he planted "beans, corn, wheat, peas, and garden seeds" and "harvested very fair crops every year." At one time there was a two-room house, a shade, a corral, a stable, and a small reservoir (which is still visible); and the land was fenced. The Gonzales had approximately 38 head of cattle in the Guaje allotment for 1943, but there is no mention of Martinez or Serna.



(a)

(b)

(c)

Figure 20. Views of the Pumice Mine Field (Field 5) in (a) 1982, (b) 1993, and (c) 1996.

This field is located in Rendija Canyon, to the southeast of what is now the rifle range for the Sportsman's Club. The field stands at approximately 2070 m (6900 ft) in elevation and follows the gradual canyon bottom drainage to the east. The plant community is predominantly ponderosa pine with some large junipers and oaks in the area (Figure 21). As with other fields, it began to erode when the area became fallow. Ditches were contoured for erosion control probably during the same time period Homer Pickens records erosion control measures going on in other old fields. In addition, arroyos near the road were filled with Christmas trees by local Boy Scouts.

Since 1982, off-road vehicles have further disturbed much of the area, and in some cases, increased erosion.

4.7 Field 7 (Montoya Field)

This field orginally was part of the Ramon Vigil Grant, but in a homestead claim in 1911, José Albino Montoya filed for 90 acres and took up permanent residency. Montoya built several structures on the land including a log-and-frame house, a corral, a hen house, a reservoir, and a wire fence. In 1911, 5 acres of beans, corn, and oats were planted. Only beans were planted in 1912 on 10 acres of land. By 1914, 25 acres were cultivated with only beans planted.

In 1942, the Montoya Field was part of lands acquired for the Manhattan Project. This field lies at approximately 2190 m (7300 ft) in elevation on the top of what is known today as Sigma Mesa and is in the heart of Laboratory property (Figure 22). The field appears to have once been part of the ponderosa pine community. Presently, much of Montoya Field is a juniper- and oak-dominated community. The Laboratory uses the mesa, including the field, as a storage area. Present day disturbances also include roads and buildings on parts of the mesa.

4.8 Field 8 (Montoya y Gomez Field)

There are two fields or homesteads on Twomile Mesa. At the time of the acquisition, one was shown to belong to J. E. and J. R. Montoya (160 acres) and the other to Donaciano Gomez. Octogenarian Marcos Gomez, who was raised on the Gomez homestead, was brought to the mesa area and he identified both the Montoya and the Gomez homestead sites (*Journal North*, Saturday, February 1, 1986). In an interview with Mr. Gomez, he recalled his years of sheep herding in the Valle Grande.

We did not find patent records under J. E. and J. R. Montoya but do have patent records for the Gomez homestead. Lists by R. Shaw (Appendix B, Table B-2) show that the area was homesteaded by Miguel Sanchez. One of the fields on Twomile Mesa was patented to Donaciano Gomez in 1905 for 160 acres. The homestead is on the rim of Pajarito Canyon. Remnants of the homestead remain, and trails to the spring used by the homesteaders are still visible.

Gomez began a permanent residence on the land and filed a homestead application in 1899. The improvements made to the land included a three-room log house, a stable, and a fence around the property. The homestead entry does not specify what crops were grown; it only states 25 acres were cultivated in favorable growing seasons.

The field lies at approximately 2190 m (7300 ft) in elevation on a mesa top to the south of Sigma Mesa. The land slopes gradually to the east with the contour of the mesa top. Ponderosa pine dominates the community here. This field is also in the middle of active Laboratory property and near a disposal site (MDA F) (Figure 23). The homestead site has remained relatively undisturbed, but a meteorological tower, roads, and a waste disposal site, as well as remnants of other old facilities, can be found within the field area. A small log building was visible in 1982 and in 1996 at one side of the field (Figure 24).

5.0 Methodology

5.1 Historical Data

Aerial maps from 1935 were studied to find cleared areas in and around LANL. The fields were then located by USFS surveys and topographic maps. Original maps drawn at a later date and redrawn from existing original survey work were obtained showing the locations of homesteads. Universal transverse mercator coordinates were noted and the fields were then ground-checked. The AEC acquisition dates were also researched for homesteads within the county boundaries of Los Alamos.

Historical information on each field was researched through the State Land Office records. All land entry papers in the National Archives are available through the card indices located at regional offices of the BLM. Copies of the original land patents, homestead entries, and homesteader testimony listed with the Department of the Interior were obtained from the National Archives and Record Service in Washington, DC.

All homestead entry papers are filed under the name of each individual land office, usually in two series: one for those who had completed their requirements, and the other for those who had not. Early file series are RG 49 (BLM: 1863–1908). Subsequent to 30 June 1908, all land entry papers are filed in the National Archives in a single numerical series (Public Land Series) regardless of entry type. These entries give the locations of each homestead in the Pajarito Plateau area dating to before the turn of the century. A complete file includes original application, certificate of publication, proof of two witnesses, proof of the claimant, and final certificate.

Eight historic agricultural areas were chosen for study because of their edaphic similarities to previously studied waste disposal sites (Tierney and Foxx 1982). Several of the waste sites were located on historic fields and a direct comparison would be possible between these and other historic fields. Each area is also located within the ponderosa pine community and most are on mesa tops. The eight sites were selected for the following reasons: (1) the original dimensions of historical agricultural areas could be estimated, (2) some temporal parameters were available from historical documentation, (3) these fields were comparable to low-level radioactive waste disposal sites (Tierney and Foxx 1982), and 4) from previous studies and observations, four species of *Artemisia* could be considered "key species."

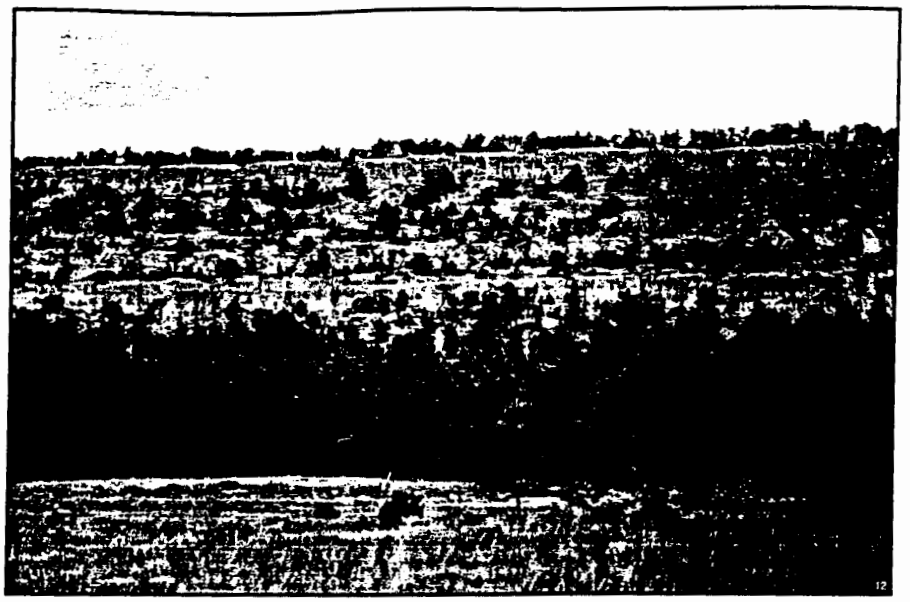
5.2 Vegetation Data

At each site, transects were established to determine species composition, density, and abundance. Collection of vegetation data for old fields was accomplished with the use of Daubenmire plots for understory components and a line intercept method for overstory components. For most fields, four 150-m (500-ft) transects were established. Each transect began at a center point and ran a compass direction of approximately north, east, south, and west. The more recent data repeated for two old-field sites only recorded data from two 150-m (500-ft) transects beginning at a center point and heading approximately north and south or east and west.

Guides used for plant identification were Martin and Hutchins (1980), Foxx and Hoard (1984), and Foxx and Tierney (1985). Any specimens with questionable identifications were taken to the University of New Mexico Herbarium for confirmation.

5.2.1 Understory

The quadrat method was used with a Daubenmire plot of 20 by 50 cm (8 by 20 in.) (Daubenmire 1959) to measure the cryptogamic and herbaceous layer and the percent bare soil, litter, and woody species less than 1 m (3 ft) tall. Visual estimates of foliar cover were used to determine percent cover and species composition. Quadrats were placed



(a)

(b)

(c)

Figure 21. Views of Serna Field (Field 6) in Rendija Canyon showing (a and b) predominantly ponderosa pine with (c) large junipers and oak.

Figure 22. A view of Montoya Field (Field 7) on Sigma Mesa on Laboratory property (1996).

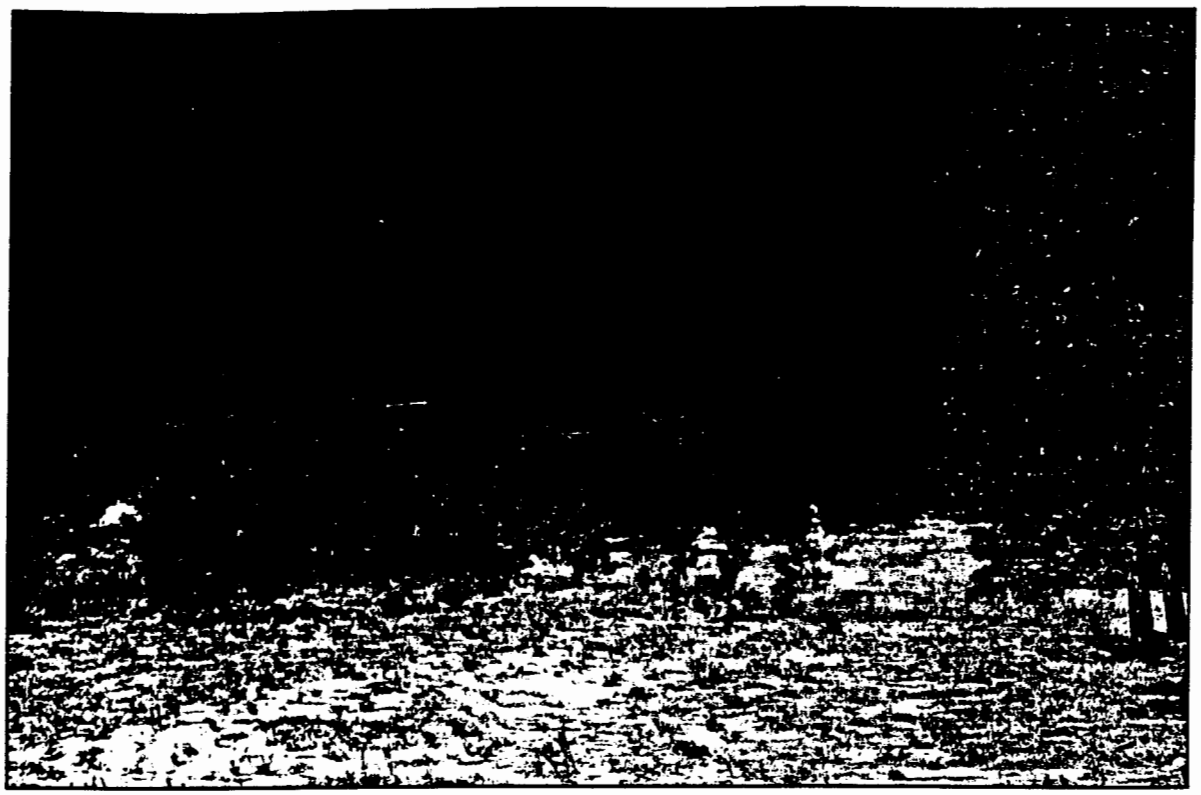
every 3 m (10 ft) along each 150-m (500-ft) transect line. All lines started at a central point and ran a compass direction—one line for each direction: north, east, south, and west. For this report, only understory vegetation was looked at. All vegetational data that was collected was analyzed with the following methods:

Cover = sum cover of a species/ (transect distance/10)
Relative Cover = sum cover of a species/ sum cover of all species
Frequency = # pts. occurrence of a species/ (transect distance/10)
Relative Frequency = frequency of a species/ sum of frequency of all species
Dominance Index = average of relative cover and relative frequency

5.2.2 Overstory

Most of the fields had few trees and shrubs in 1982. Therefore, the overstory vegetation was not analyzed for this project. However, the overstory components were recorded and analyzed for two fields surveyed in 1993. The following is the method in which the 1993 data was gathered.

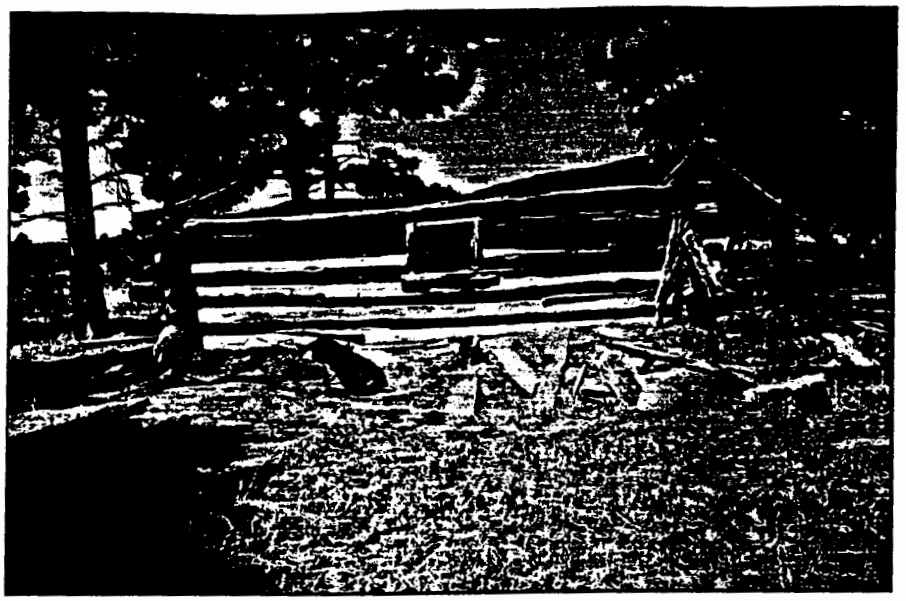
A line intercept method was used to measure the single-stemmed overstory components within most taller woodlands and some riparian zones (i.e., ponderosa pine, mixed conifer). For this method, the transect lines were run with the understory transects. For statistical purposes, the line was divided into 15-m (50-ft) sections, thus creating separate divisions in each 150-m (500-ft) transect. Within each 15-m (50-ft) section, the diameter at breast height (DBH) of all trees and shrubs within 3 m (10 ft) of either side of the transect line and equal to or greater than 1 m (3 ft) in height was recorded. The canopy cover was



(a)

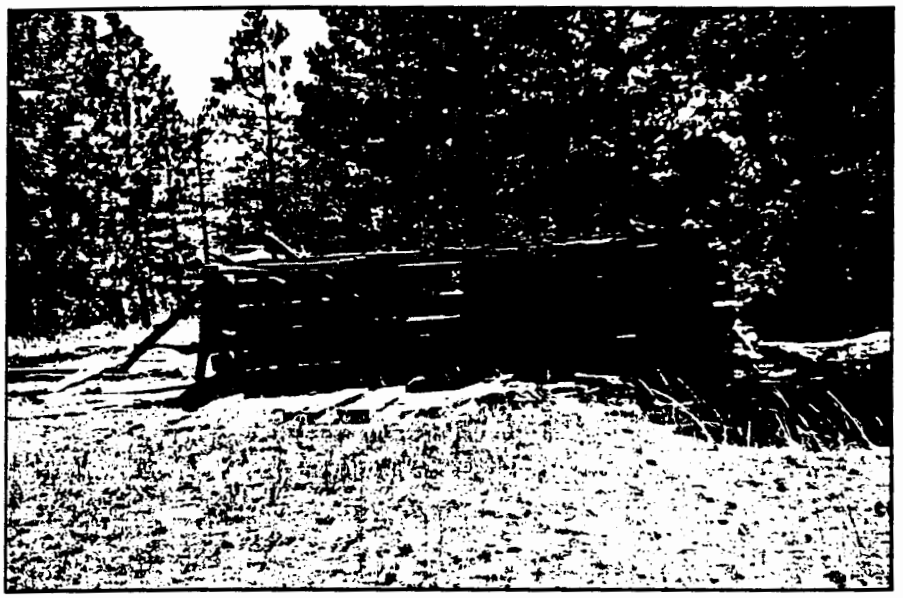
(b)

Figure 23 (a and b). Views of Montoya y Gomez Field (Field 8) on Laboratory property on Twomile Mesa.



(a)

(b)



(c)

Figure 24. A small log building was visible at one side of Montoya y Gomez Field (Field 8) in (a and b) 1982 and (c) in 1996.

measured by the length of the cover of any species intersecting the transect line. This canopy cover was measured from the point at which each particular species first overhung the transect line to the point where that species terminated cover along the line. If cover overlapped, that is, if there was more than one individual of the same species included in that cover, canopy was measured as continuous as long as the canopy cover of that particular species had no breaks in the cover intersecting the line. If the canopy extended into the next 15-m (50-ft) section, the measurement was counted separately in the two sections.

5.2.3 Species Dominance Indices

Each field was characterized as to percent cover and frequency. To determine which species were the most common or dominant on a site we used the dominance, or importance, index calculated from the relative cover and relative frequency. Those species having an index number of 5 or greater were defined as dominant. These indices were used to compare the individual field plant flora between fields and with similar data collected for the waste sites (Tierney and Foxx 1982).

5.3 Soils

Soil samples were taken from the old fields except in the Rendija and Chupaderos Fields. Guidelines from New Mexico State University's Soil, Plant, and Water Testing Laboratory were followed. Before a sample was taken, the field was examined for variations in texture, color, slope, degree of erosion, and drainage to locate areas of uniformity. Samples were taken by hand with soil tubes, soil augers, or spades to plow depth or about 20.3 cm (8.12 in.). Fifteen to twenty samples were taken from uniform areas and mixed together thoroughly in a plastic container. They were then dried and sent to Colorado State University's Soil Testing Laboratory for analysis. Soils were analyzed for pH, bulk density, texture, nutrification, phosphorus and calcium content, water retention ability, cation exchange ability, and phosphorus sorption.

5.4 Statistical Analysis

Graphical, nonparametric, and multivariate methods were used to analyze percent cover, species importance, and succession. Data were displayed using box plots, bar charts, and star plots; similarity between plots was displayed using the results of a cluster analysis. The Wilcoxon Rank Sum test (Gilbert 1987) was used to test for a shift in the distribution of importance values at waste sites versus old fields for 6 species, and to test for a shift in the distribution of total percent cover at waste sites versus old fields.

6.0 Results

6.1 Vegetation Characteristics of Each Field

The phytosociological data were examined for each field. For purposes of comparison, Table C-1 in Appendix C shows an enumeration of all species found on all sites. Appendices D through K have the data collected for each site by transect. Figure 25 indicates the total cover for all eight sites; Figure 26 represents the number of species found on each site by forb, grass, and shrub.

Field 1 (Archuleta Field): The total understory cover for Field 1 was 14.7%. Twenty-one species were identified from transects: 7 grass species with a cover of 1.4%, 12 forb species with a cover of 10.6%, and 2 shrub species with a cover of 2.7%. Western wheatgrass and Russian wheatgrass were the most common grass species found on the site. Wormwood had the highest percent cover of forbs. Small ponderosa pines were also noted scattered throughout the area and had a measured cover of approximately 1%. Species with the highest importance indices were wormwood, snakeweed, pingüe, and leafy golden aster (Table 3). A complete data set for this field is in Appendix D.

Table 3. Comparison of cover and dominance index for Archuleta Field (Field 1).

Species	Cover (%)	Dominance Index
Carruth wormwood	3.08	20
Leafy golden aster	2.54	18
Snakeweed	2.38	14
Western wheatgrass	1.13	12
Pingüe	1.76	10
Chamisa	1.55	8
False tarragon	0.13	2
Sweetclover	0.43	4
White ragweed	0.13	2
Russian wheatgrass	0.08	1
Dropseed	0.08	1
Bottlebrush squirreltail	0.03	0.5
Evening primrose	0.04	0.5
Unknown grass	0.05	0.4
Unknown Composite	0.05	0.3
Scartet beeblossom	0.03	0.2
Bluegrass	0.008	0.1
Bermuda grass	0.05	0.1
American vetch	0.001	0.09
Ponderosa pine	1.1	4

Field 2 (Garcia Field): Garcia Field is within the ponderosa pine cover type. There are small trees and a few shrubs throughout the area. The total understory cover for Garcia Field was 25.6%. Twenty-nine species were identified from the transects: 9 grass species with a cover of 10.9%, 18 forb species with a cover of 14.3%, and 2 shrub species with a cover of 0.4%. Little bluestem and western wheatgrass were common on the site. Carruth wormwood and false tarragon had the highest forb cover. The species with the highest dominance indices included carruth wormwood, western wheatgrass, little bluestem, and false tarragon (Table 4). A complete data set for this field is in Appendix E.

Table 4. Comparison of cover and dominance index for Garcia Field (Field 2).

Species	Cover (%)	Dominance Index
Western wheatgrass	5.1	20.3
Carruth wormwood	3.98	17
Little bluestem	3.8	12
False tarragon	3.11	11
Leafy golden aster	1.42	7
Blue grama	1.01	4
Redtop	0.86	2
Wolftail	1.13	3
Dropseed	0.52	3
Lupine	0.5	3
Indian grass	1.3	3
American vetch	0.12	2
Black grama	0.80	2
Mullein	0.5	1
Chamisa	0.19	0.9
Sweetclover	0.15	0.8
Snakeweed	0.53	2.0
Pingüe	0.11	0.6
Apache plume	0.25	0.6
Spreading fleabane	0.05	0.3
Evening primrose	0.12	0.8
Cheatgrass	0.001	0.2
Shepherd's purse	0.001	0.2
Flax	0.001	0.2
Goldeneye	0.01	0.1
Wild chrysanthemum	0.001	0.1
Desert four o'clock	0.0005	0.1
Fleabane daisy	0.03	0.1

Field 3 (Ekberg Field): Ekberg Field is within the ponderosa pine zone. The total understory cover for the field was 25.8%. Thirty-one species were identified along the transects: 7 grass species with a cover of 12.7%, 22 forb species with a cover of 9%, and 2 shrub species with a cover of 4.1%. Blue grama had the highest grass cover and chamisa the highest forb cover. The species with the highest dominance indices were chamisa, blue grama, leafy golden aster, snakeweed, and false tarragon (Table 5). A complete data set for this field is in Appendix F.

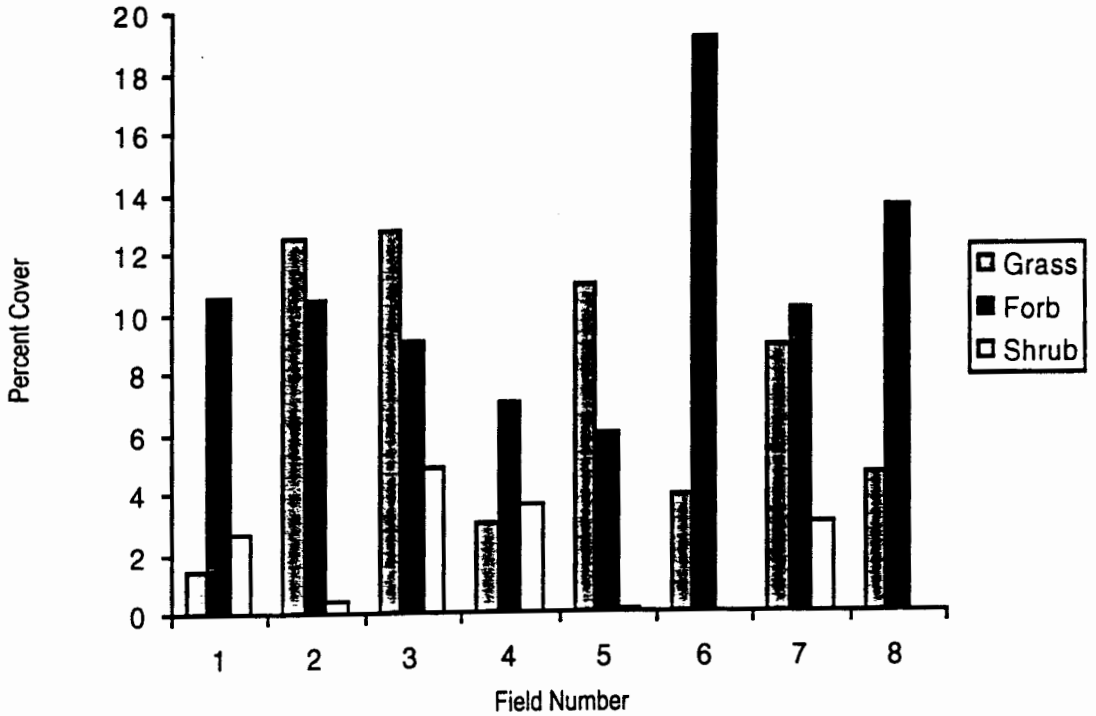


Figure 25. Comparison of percent cover for all fields.

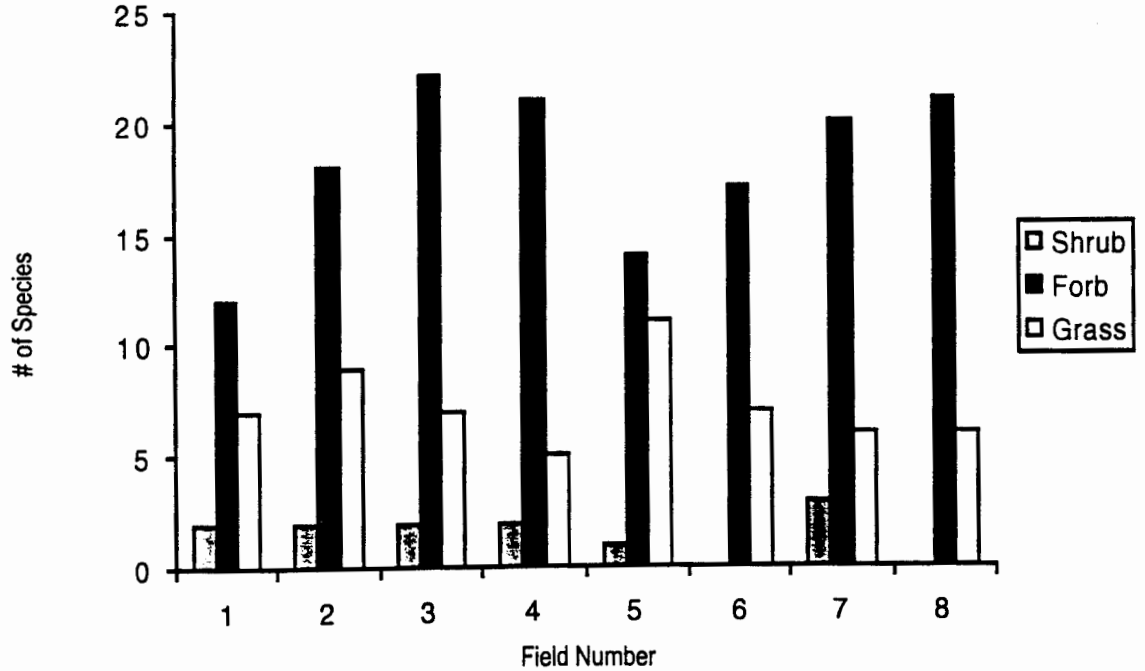


Figure 26. Comparison of number of species by type for all fields.

Table 5. Comparison of cover and dominance index for Ekberg Field (Field 3).

Species	Cover (%)	Dominance Index
Blue grama	7.17	25
Chamisa	3.9	12
Spiny golden weed	2.1	10
Snakeweed	2.61	10
False tarragon	1.99	10
Bottlebrush squirreltail	1.49	8
Bermuda grass	1.66	5
Dropseed	1.65	4
Brome	0.45	2
Evening primose	0.48	2
Milkvetch	0.36	2
Lupine	0.26	2
Little bluestem	0.28	2
Globemallow	0.18	0.9
Longleaf butterweed	0.28	0.9
One-seed juniper	0.28	0.9
American vetch	0.004	0.8
Sweetclover	0.08	0.5
Louisiana wormwood	0.05	0.5
Aster	0.10	0.4
Greenthread	0.05	0.4
White ragweed	0.13	0.3
Carruth wormwood	0.04	0.3
Buckwheat	0.05	0.3
Puccoon	0.026	0.3
Pingüe	0.06	0.3
Prairie clover	0.03	0.2
Woolly Indian wheat	0.03	0.2
Shepherd's purse	0.03	0.1
Mountain muhly	0.001	0.1
Stickseed	0.001	0.1

Field 4 (Chupaderos Field): Chupaderos Field was in the pinon-juniper cover type. The total understory cover for this field was 13.5%. Twenty-eight species were identified along the transect: 5 grass species with a cover of 3%, 21 forb species with a cover of 7%, and 2 shrub species with a cover of 3.5%. Blue grama had the highest cover and wormwood, the highest forb cover. Small ponderosa pines and chamisa were scattered throughout the area. Species with the highest dominance indices were blue grama, carruth wormwood, chamisa, and little bluestem (Table 6). A complete data set for this field is in Appendix G.

Table 6. Comparison of cover and dominance index for Chupaderos Field (Field 4).

Species	Cover (%)	Dominance Index
Blue grama	2.75	51
Carruth wormwood	4.72	17
Chamisa	3.18	12
Little bluestem	0.1	11
Buckwheat	0.25	3
American vetch	0.09	3
Lamb's quarters	0.19	2
False tarragon	0.44	2
Leafy golden aster	0.4	2
Stickseed	0.25	1
Dropseed	0.17	1
Prairie sunflower	0.07	0.9
One-seed juniper	0.38	0.9
Spiny golden weed	0.03	0.6
Blue gilia	0.02	0.5
Ponymint	0.02	0.5
Hidden flower	0.05	0.4
Firewheel	0.03	0.3
Bottlebrush squirreltail	0.01	0.3
Fetid marigold	0.01	0.3
Beardstongue	0.01	0.2
Goatsbeard	0.03	0.2
Mountain muhly	0.01	0.1
Scarlet trumpet	0.01	0.1
Evening primrose	0.01	0.1
Woolly Indian wheat	0.01	0.1
Russian thistle	0.01	0.1
Tansy-mustard	0.01	0.1

Field 5 (Pumice Mine Field): This field was in a pinon-juniper cover type with an understory of blue grama and sand dropseed. A few oak, juniper, and chamisa were scattered throughout the area. The total understory cover for the Pumice Mine Field was 16.5%. Twenty-six species were identified from transects: 9 grass species with a cover of 10.5%, 14 forb species with a cover of 5.9%, and 1 shrub species with a cover of .1%. Sand dropseed and blue grama made up the highest cover of grass. Snakeweed and false tarragon had the highest cover of forb. A few chamisa were scattered throughout the area. Species with the highest dominance indices were sand dropseed, snakeweed, blue grama, false tarragon, and three-awn (Table 7). A complete data set for this field is in Appendix H.

Table 7. Comparison of cover and dominance index for Pumice Mine Field (Field 5).

Species	Cover (%)	Dominance Index
Dropseed	5.22	36
Snakeweed	3.60	20
Blue grama	2.93	11
False tarragon	1.60	9
Poverty three-awn	0.82	6
Bermuda grass	0.55	4
Bottlebrush squirreltail	0.30	3
Spiny goldenweed	0.16	2
Mountain muhly	0.30	2
Russian thistle	0.25	2
Three-awn	0.25	1
Walkingstick cactus	0.13	0.5
Wolftail	0.03	0.5
Chamisa	0.10	0.6
Globemallow	0.02	0.4
Prickly pear cactus	0.03	0.3
Lamb's quarters	0.03	0.2
Estafiata	0.03	0.2
Blue gilia	0.01	0.2
Goatsbeard	0.01	0.2
False buffalo grass	0.01	0.1
Wild chrysanthemum	0.01	0.1
Pincushion cactus	0.001	0.1
Louisiana wormwood	0.001	0.1

Field 6 (Serna Field): Serna Field was within a ponderosa pine cover type with an understory of blue grama. The total understory cover for Serna Field was 22.9%. A few oak and small ponderosa pine were scattered throughout the area. Twenty-four species were found along the transects in Serna Field: 7 grass species with a cover of 3.9% and 15 forb species with a cover of 19%. Blue grama had the highest grass cover; carruth wormwood and false tarragon had the highest forb cover. The species with the highest dominance indices were carruth wormwood, false tarragon, sand dropseed, estafiata, evening primrose, and lupine (Table 8). A complete data set for this field is in Appendix I.

Table 8. Comparison of cover and dominance index for Serna Field (Field 6).

Species	Cover (%)	Dominance Index
Carruth wormwood	8.09	31
False tarragon	6.13	22
Sand dropseed	0.94	8
Estafiata	2.48	7
Evening primrose	0.68	5
Lupine	0.61	5
Blue grama	1.65	4
American vetch	0.21	4
Ponymint	0.15	2
Redtop	0.83	2
Spiny goldenweed	0.25	2
Nodding buckwheat	0.20	1
Cheatgrass	0.23	1
Bermuda grass	0.13	0.7
Bluegrass	0.15	0.5
Leafy golden aster	0.46	0.2
Aster	0.05	0.4
Globemallow	0.001	0.2
Ragweed	0.001	0.2
Lamb's quarters	0.03	0.2
Smartweed	0.01	0.1
Witchgrass	0.001	0.1

Field 7 (Montoya Field): Montoya Field was within the ponderosa pine zone near the ecotone with the pinon-juniper cover type. The total understory cover for Montoya Field was 21.5% in 1982. Twenty-nine species were identified from the transects: 6 grass species with a cover of 8.4%, 20 forb species with a cover of 10.1%, and 3 shrub species with a cover of 3%. Blue grama had the highest grass cover and carruth wormwood the highest forb cover. The species with the highest dominance indices were carruth wormwood, blue grama, pingüe, Gambel oak, and snakeweed (Table 9). A complete data set for this field is in Appendix J.

Table 9. Comparison of cover and dominance index for Montoya Field (Field 7).

Species	Cover (%)	Dominance Index
Carruth wormwood	5.86	31
Blue grama	6.98	30
Pingüe	1.93	10
Gambel oak	2.78	6
Snakeweed	0.88	5
Mountain muhly	0.72	3
False tarragon	0.43	2
Three-awn	0.46	2
Leafy golden aster	0.34	2
Bottlebrush squirreltail	0.15	2
Buckwheat	0.14	2
Scarlet beeblossom	0.09	1
Fendler's rose	0.18	1.0
Flax	0.03	0.6
Beardtongue	0.06	0.5
Fleabane daisy	0.06	0.5
Bluegrass	0.08	0.4
White ragweed	0.04	0.4
Sweetclover	0.05	0.3
Woolly Indian wheat	0.02	0.3
Indian paintbrush	0.03	0.3
Lamb's quarters	0.01	0.2
Redtop	0.03	0.2
Wild chrysanthemun	0.28	0.2
Puccoon	0.03	0.2
Skeletonweed	0.03	0.2
One-seed juniper	0.01	0.1
Owl-clover	0.01	0.1
Greenthread	0.01	0.1

Field 8 (Montoya y Gomez Field): Montoya y Gomez Field was within the ponderosa pine cover type. The total understory cover was 23.6%. Twenty-seven species were identified from the transects: 7 grass species with a cover of 8.6% and 20 forb species with a cover of 15.0 %. No shrub species were recorded in 1982. Blue grama had the highest grass cover and carruth wormwood the highest forb cover. The species with the highest dominance indices were wormwood, blue grama, goldenweed, evening primrose, false tarragon, spreading fleabane, and pingue (Table 10). A complete data set for this field is in Appendix K.

Table 10. Comparison of cover and dominance index for Montoya y Gomez Field (Field 8).

Species	Cover (%)	Dominance Index
Carruth wormwood	7.06	29
Blue grama	2.62	13
Leafy golden aster	1.89	11
Evening primrose	0.84	9
False tarragon	1.83	8
Spreading fleabane	0.76	7
Pingüe	1.65	6
Redtop	1.65	5
Bottlebrush squirreltail	0.13	2
Snakeweed	0.63	2
Dropseed	0.08	1
American vetch	0.01	1
Narrowleaf yucca	0.1	0.7
Flax	0.03	0.6
Mountain muhly	0.03	0.2
Mullein	0.05	0.2
Peppergrass	0.001	0.2
White ragweed	0.001	0.2
Common sunflower	0.03	0.2
Gayfeather	0.01	0.2
Beardstongue	0.001	0.1
Guara	0.001	0.1
Scarlet beeblossom	0.01	0.1
Russian thistle	0.001	0.1
Blazing star	0.01	0.1
Goatsbeard	0.01	0.1

6.2 Analysis Between Fields (1982 Data)

A comparison was made between the eight fields sampled in 1982. Table 11 shows the relationship between fields. There was overlap within fields for the forb cover but no overlap for the grasses.

The forb covers in 1982 in Field 8 (Montoya y Gomez), Field 2 (Garcia), and Field 3 (Ekberg) were similar. Field 7 (Montoya), Field 1 (Archuleta), and Field 3 (Ekberg) were similar as were Field 1 (Archuleta) and Field 3 (Ekberg). Field 6 (Serna Field) in Rendija Canyon showed a difference with a higher forb cover than the other fields. Field 4 (Chupaderos) had a lower forb cover, and Field 5 (Pumice Mine) had the lowest forb cover of all the fields.

Table 11. Comparison of forb cover for the eight fields from a multiple range test.

Field	1	2	3	4	5	6	7	8
1	x		x					
2								
3								
4				x				
5					x			
6						x		
7	x		x				x	
8		x	x					x

(X denotes that the fields were not statistically different).

The grass cover in 1982 in Field 4 (Chupaderas), Field 5 (Pumice), and Field 2 (Garcia) was similar. Field 3 (Ekberg) and Field 7 (Montoya) were similar. Field 6 (Serna), Field 8 (Montoya y Gomez), and Field 1 (Archuleta) were similar. There was no overlap between fields for grass cover.

6.3 Comparison of Species Composition on Two Fields Visited in 1982 and in 1993

Two field areas were revisited and reassessed in 1993. They were Field 7 and Field 8 (Montoya and Montoya y Gomez). Figure 27 indicates the differences in cover percentages between 1982 and 1993.

There was a shift from forbs to grasses seen in the dominant species identified for each field in 1993. Grass cover was higher in 1993 than it was in 1982.

Field 7 (Montoya): After 10 years the understory cover for Montoya Field was 29% as compared to 18% in 1982. Twenty-eight species were identified from the transects in 1982 and 36 species in 1993. In 1982 blue grama had the highest grass cover and wormwood the highest forb cover. The species with the highest importance indices were wormwood, blue grama, pingüe, Gambel oak, and snakeweed. In 1993 the species with the highest importance indices were blue grama, mountain muhly, carruth wormwood, pingüe, sweet clover, scarlet trumpet, and snakeweed. This was a change from only one grass and 5 forbs in the top 5 with two grasses and other forbs in the top 5 (Table 12).

Field 8 (Montoya y Gomez): After 10 years the total percent cover for Montoya y Gomez Field had increased from 23.6% to 44.4%. Blue grama was still the grass with the highest percent cover but the cover had increased from 2.6% to 10.2%. In 1982 carruth wormwood and leafy golden aster had the highest importance indices. These forbs, although still part of the major components of the fields had lower importance indices; and species such as spreading fleabane, which had the lower importance index in 1982, was the forb with the highest importance index in 1993 (Table 13). In 1982 there was only one grass species with an importance index greater than 5; in 1993 there had been a substantial increase in the percent cover of mountain muhly. In 1993, blue grama and mountain muhly were in the top 5 species with importance indices greater than 5.

6.4 Analysis between Years (1982 and 1993)

Data was collected on two field systems in 1993, Field 7 (Montoya) and Field 8 (Montoya y Gomez). Figure 27 shows the differences in the cover in 1982 verses 1993; Figure 28 compares the numbers of species on each field in 1982 and 1993.

Bar charts were used to visually display succession of 4 species that were present at 2 sampling events 11 years apart at 2 old-field sites (Figure 29). Wormwood (ARCA) decreased in importance at each of the 2 sites to

Table 12. 1982 and 1993 comparison of phytosociological data for Montoya Field.

Species	Cover (%) 1982	Dominance Index	Cover (%) 1993	Dominance Index
*Blue grama	6.98	30	5.54	17
Mountain muhly	0.72	3	6.35	12
Carruth wormwood	5.86	31	2.05	11
Pingüe	1.93	10	1.60	10
White sweet clover			1.15	5
Scarlet trumpeter			0.85	5
Snakeweed	0.88	5	1.05	5
Unknown 8			1.35	3
Three awn	0.46	2	0.65	3
Golden aster			0.60	3
Unknown 1			1.25	3
Bluegrass	0.08	0.4	0.95	2
Wheatgrass			0.50	2
Fleabane daisy	0.06	0.5	0.25	2
Sedge			0.30	1
Ragweed			0.2	1
Unknown 2			0.2	0.9
Prairie sunflower			0.50	0.9
Sweetclover	0.05	0.3	0.15	0.9
Gumweed			0.20	0.8
Nightshade			0.20	0.7
Unknown 3			0.35	0.7
Greenthread	0.01	0.1	0.15	0.6
Mullein			0.1	0.6
Bristlegrass			0.25	0.5
Sweetclover			0.15	0.4
Dandelion			0.15	0.4
Unknown 5			0.15	0.4
Rock-jasmine			0.05	0.4
Canadian wild rye			0.05	0.4
Bottlebrush squirreltail	0.15	2	0.05	0.4
Unknown 9			0.05	0.4
Leafy golden aster	0.34	2	0.10	0.4
Flax	0.03	0.6	0.05	0.3
Unknown 7			0.05	0.3
Redtop	0.03	0.2		
Pussytoes			0.10	0.1
False tarragon	0.43	2		
Wild chrysanthemum	0.28	0.2		
Indian paintbrush	0.03	0.3		
Lamb's quarters	0.01	0.2		
Buckwheat	0.14	2		
Scarlet beeblossom	0.09	1.0		
White ragweed	0.04	0.4		
One-seed juniper	0.01	0.1		
Puccoon	0.03	0.2		
Owl-clover	0.01	0.1		
Beardtongue	0.06	0.5		
Woolly Indian wheat	0.02	0.3		
Skeletonweed	0.03	0.2		
Wild Rose	0.18	1.0		

* For scientific names see Appendix M.

Table 13. 1982 and 1993 comparison of phytosociological data for Montoya y Gomez Field.

Species	Cover (%) 1982	Dominance Index	Cover (%) 1993	Dominance Index
*Blue grama	2.62	13	10.19	18
Spreading fleabane	0.76	7	7.90	19
Mountain muhly	0.03	2	9.21	15
Carruth wormwood	7.06	29	4.44	14
Leafy golden aster	1.89	11	4.61	12
False tarragon	1.83	8	1.31	4
Big sagebrush			1.6	3
Pingüe	1.65	6	0.96	3
American vetch	0.01	1	0.97	3
Bottlebrush squirreltail	0.13	2	0.49	2
Deervetch			0.80	1
Cinquefoil			0.25	1.0
Wild chrysanthemum			0.25	0.9
Dropseed	0.8	1	0.2	0.7
Fleabane daisy			0.20	0.6
Mullein	0.05	0.2	0.30	0.5
Sweet clover			0.10	0.4
Pine dropseed			0.10	0.3
Gayfeather	0.01	0.2	0.10	0.3
Shrubby potentilla			0.10	0.3
Horseweed			0.05	0.2
Gumweed			0.05	0.2
Beardstongue	0.001	0.1	0.05	0.2
Greenthread	0.01	0.1	0.05	0.2
Redtop	1.65	5		
Poverty three-awn	0.10	0.5		
Scarlet beeblossom	0.001	0.1		
Snakeweed	0.63	2		
Common sunflower	0.03	0.2		
White ragweed	0.001	0.2		
Peppergrass	0.001	0.2		
Flax	0.03	0.6		
Blazing star	0.01	0.1		
Evening primrose	0.84	9		
Russian thistle	0.001	0.1		
Goat's beard	0.01	0.1		
Narrowleaf yucca	0.13	0.7		

* For scientific names see Appendix M.

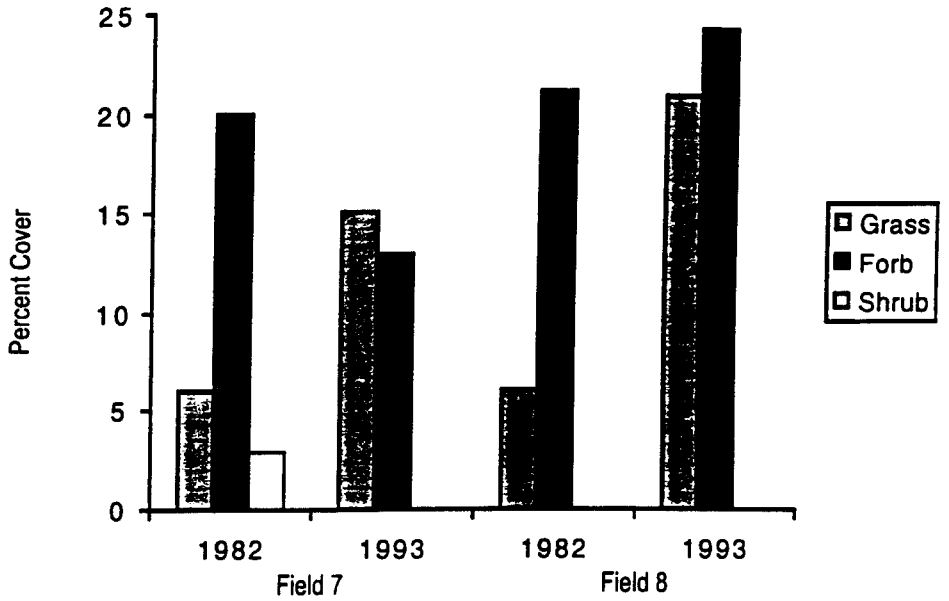


Figure 27. Comparison of total percent cover for Field 7 and Field 8, 1982 and 1993.

while blue grama (BOGR) and mountain muhly (MUMO) increased at each of the sites. Pingüe (HYRI) increased at the Montoya y Gomez site but remained constant at the Montoya site.

7.0 Comparison of Data Collected on Fields with that Collected on Waste Sites

Using information gathered in 1980 by Tierney and Foxx for MDAs, we statistically compared the percent cover and species composition for each MDA and old field.

7.1 Total Percent Cover

Total percent cover at MDAs was compared to total percent cover at old fields. The box plots (Figure 30) display individual total percent cover values for each of the plots. The boxes enclose the middle 50% of the total percent cover values, and the horizontal line is drawn at the median. Old fields tended to have higher total percent cover than the MDAs, but the Wilcoxon Rank Sum test (Gilbert 1987) did not indicate a significant shift in the location of the total percent cover for the 2 groups ($p = 0.35$).

7.2 Old Field/Waste Site Similarities and Differences

A cluster analysis (Statistical Sciences 1995) was done using all 23 species with an importance value of at least 5 on one or more of the study plots. The distance metric used was Euclidean (root sum-of-squares differences) and the clustering method was Compact, the largest distance between a point in 1 cluster and a point in another cluster (Figure 31).

The old fields all clustered together before the MDAs began to join them, and seven of the old fields joined one another before the first 2 MDAs clustered together. This indicates that the clustering algorithm found more similarities among the old fields than among the MDAs, and that the old fields are more similar to one another than to the MDAs.

7.3 Comparison of Succession Species

Star plots were drawn to enable visual representation of the importance values for the 5 waste sites and 8 old fields. Each ray represents one species, with the length of the ray proportional to the magnitude of the importance value. Star plots can elucidate patterns in the data that may lead the researcher

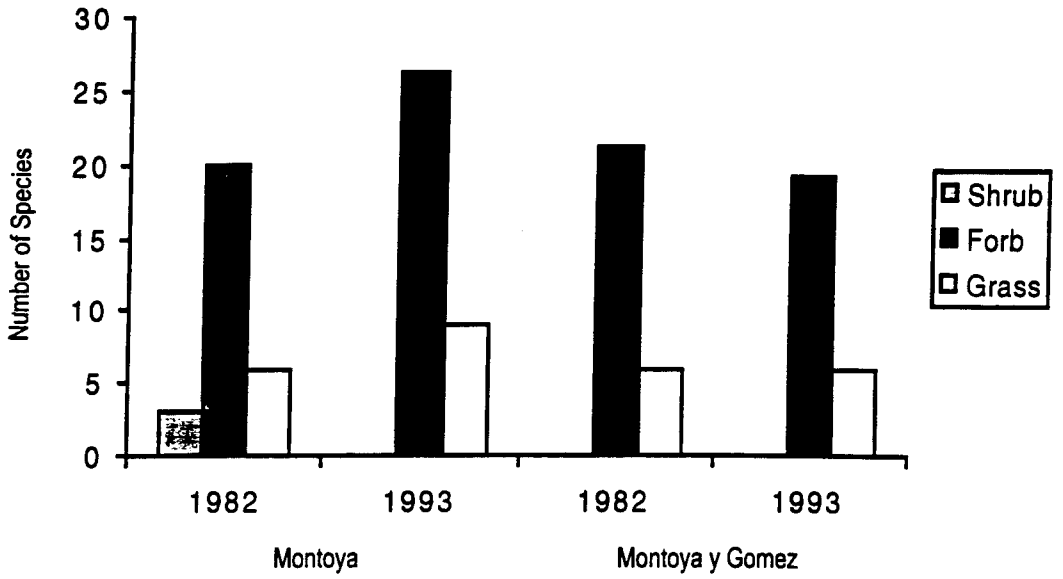
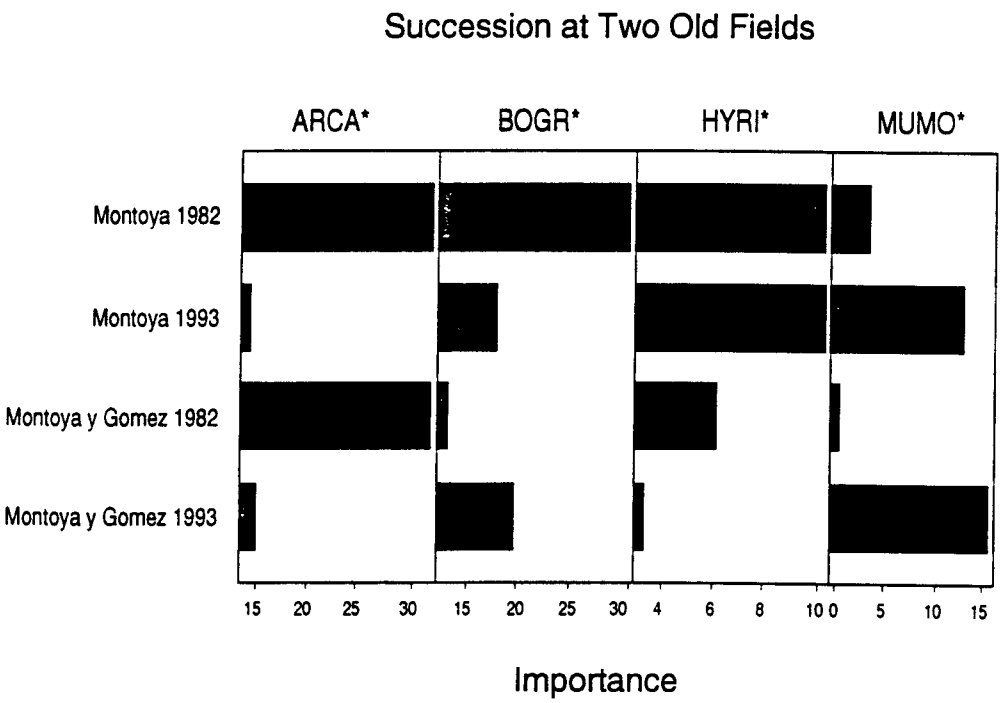


Figure 28. Comparison of numbers of species between 1982 and 1993 for Fields 7 and 8.



*ARCA = *Artemisia carruthi*, BOGR = *Bouteloua gracilis*, HYRI = *Hymenoxys richardsonii*, MUMO = *Muhlenbergia montana*

Figure 29. Bar charts showing succession of four plant species at two old fields in 1982 and 1993.

to conclude similarities between plots or groups of plots. Figure 32 displays plots for all 23 species. There are no discernible similarities between patterns. Species were classified as early-successional, middle-successional, or late-successional species. Figure 33 displays only the early-successional species. The waste sites appear to contain larger numbers of early-successional species with large importance values than the old fields. In contrast, Figure 34 displays only the late-successional species. The old fields tend to contain larger numbers of late-successional species with larger importance values. Figure 35 shows the mid-successional species. Both waste sites and old fields tend to contain several mid-successional species with large importance values. All star plots indicate that the species composition and importance values for species present vary among all the sites.

7.4 Comparison of Importance Values

The importance values for 6 species at MDAs were compared to their importance values at old fields. The box plots (Figure 36) display individual importance values for each of the plots. The boxes enclose the middle 50% of the importance values, and the horizontal line is drawn at the median. The Wilcoxon Rank Sum test was used to test for a shift in the distribution of importance values at waste sites versus old fields. Blue grama (BOGR) ($p=0.07$), little bluestem (ANSC) ($p=0.05$), and wormwood (ARCA) ($p=0.14$) tended to have greater importance values on the old fields than at the waste sites, while sweetclover (MEX) ($p=0.01$) and cheatgrass (BRTE) ($p=0.12$) tended to have smaller importance values on the old fields than at the waste sites. False tarragon (ARDR) ($p=1.0$) importance values overlapped between old fields and waste sites.

7.5 Comparison of the Presence of *Artemisia*

Using a geographic information system (GIS), we did an analysis of 4000 records in the plant data base from the transects and data collected throughout the Laboratory to determine the extent of presence of two species of *Artemisia*—carruth wormwood and false tarragon. In all cases, those records that pertained to these two species with the highest importance index were on known abandoned fields or disturbed areas. Figures 37 and 38 show the locations in both the ponderosa pine and pinon-juniper cover types where these species were recorded.

7.6 Comparison of Disturbed and Cleared Areas with Forested Sites

Disturbance within the ponderosa pine and pinon-juniper cover types generally involves removal of vegetation. Using the information collected in the disturbed sites with similar information collected in adjacent forested areas, we compared the numbers and types of species between these two sites. As can be seen in Figure 39, as the forest overstory increased, the understory cover decreases. Also the numbers of species decrease markedly. In the forested areas generally there were only 3 to 4 understory species (generally grass), and in the open meadows there were as many as 45 species. This study, along with the studies done on MDAs, indicates species that are common to disturbed areas on the Pajarito Plateau. Appendix L gives some of the biological information found in the literature for species with high importance indices on either old fields or waste sites.

8.0 Comparison of Soils Characteristics

Soil characterization was performed for 6 of the 8 sites. The information is presented to provide a baseline for any future studies. All samples were within the normal ranges for the Pajarito Plateau. Results of analyses are in Tables 14 and 15.

9.0 Conclusion and Discussion

This study has provided information about species that occur on two types of disturbed sites (MDAs and old fields) within LANL and

on the Pajarito Plateau. Because of the levels of disturbance and the uncertain disturbance history of each site, the actual stages of succession are not clearly visible; but some inferences can be made from the data collected. Most of the old fields were disturbed and abandoned 10 to 20 years before the disturbance of the MDA sites. The data indicated that the old fields were more similar to each other while the MDA sites were similar to each other.

Although we only had data on two of the 8 fields 10 years after the original study, the later study indicates that succession proceeds from common forb species to grass through time. As succession proceeds, grass cover increases; grasses that had low percent cover in the early stages will take the niche of forb species that were found earlier. The comparison of forested areas with fallow fields indicated a change in species diversity and composition. As the forest canopy closes, there is less species diversity and lower understory cover. In dense forested areas there may be as few as 4 forb species and mostly grasses, whereas meadowed areas will have as many as 45 species depending on the stage of succession.

Many of the plants mentioned in this study are biological weeds. That is, they are evolutionary and ecological products adapted to survival in habitats disturbed by human activity. Without constant human interaction over thousands of years, these weeds would not be present or in sufficient density to be such regular indicators of human activity. Some biological weeds such as snakeweed and big sagebrush increase with overgrazing and remain decades later to testify to the poor grazing practices of the times. Normally, big sagebrush is found in the ecotonal area between pinon-juniper woodland and short-grass prairie, while snakeweed prefers mesas. The late 1800s saw huge herds of domestic animals destroying the grass while the sagebrush invaded in their wake in some areas and snakeweed invaded in somewhat drier regions.

Examination of the data in this study suggests that herbaceous species in the genera *Artemisia* (e.g., false tarragon and carruth wormwood) are an indicator of a stage of succession and may be potentially useful as ground cover for reclamation of MDA sites. False tarragon was found in all fields but not in great numbers compared with other species. All fields except two had wormwood. Wormwood consistently had higher importance index values for forbs in all fields where it was found. On Montoya Field, carruth wormwood and blue grama grass have traded places as dominant species. In 1982, wormwood was slightly more abundant, but by 1993 the values for both species had decreased and blue grama grass had taken the lead over wormwood. Field 8 (Montoya y Gomez Field) experienced a turnover in dominant species where wormwood was present in 1993, but recorded less than 10% of the time. However, the native grass, blue grama, continued as a dominant species between the years. Both Field 7 (Montoya) and Field 8 (Montoya y Gomez) showed a marked increase in numbers of species growing in the fields; not all species continued to exist in these communities.

With the exception of false tarragon, which was probably introduced into this area with sheep herding, *Artemisia* are indigenous and common to the semiarid southwest. Although no exact figures are available to date, they appear to be very long lived perennials. Carruth wormwood and *Artemesia* subsp. *albula* are both caespitose and revegetate to a considerable extent by rooting stems and hence form dense mats. False tarragon is a prolific seed producer although statistical viability of the seed is not known. All three species are shallowly rooted and useful as browse (Tierney and Foxx 1983). From the results of this study, we conclude that *Artemisia* species seem to be good indicators of previous disturbances to land on the Pajarito Plateau.

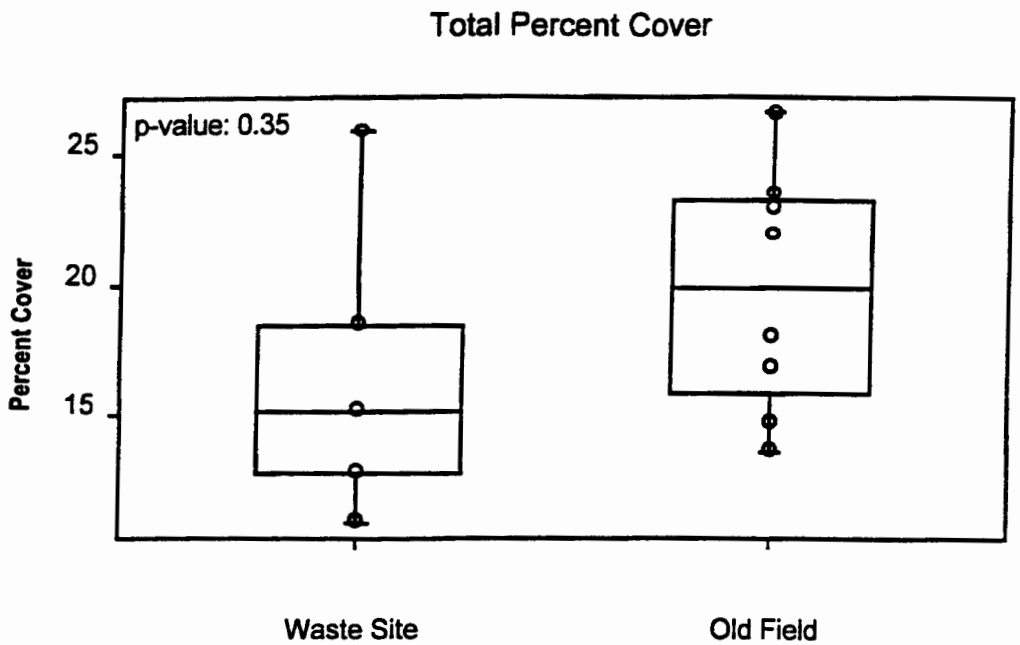


Figure 30. A box plot comparison of total percent cover at waste sites and at old fields.

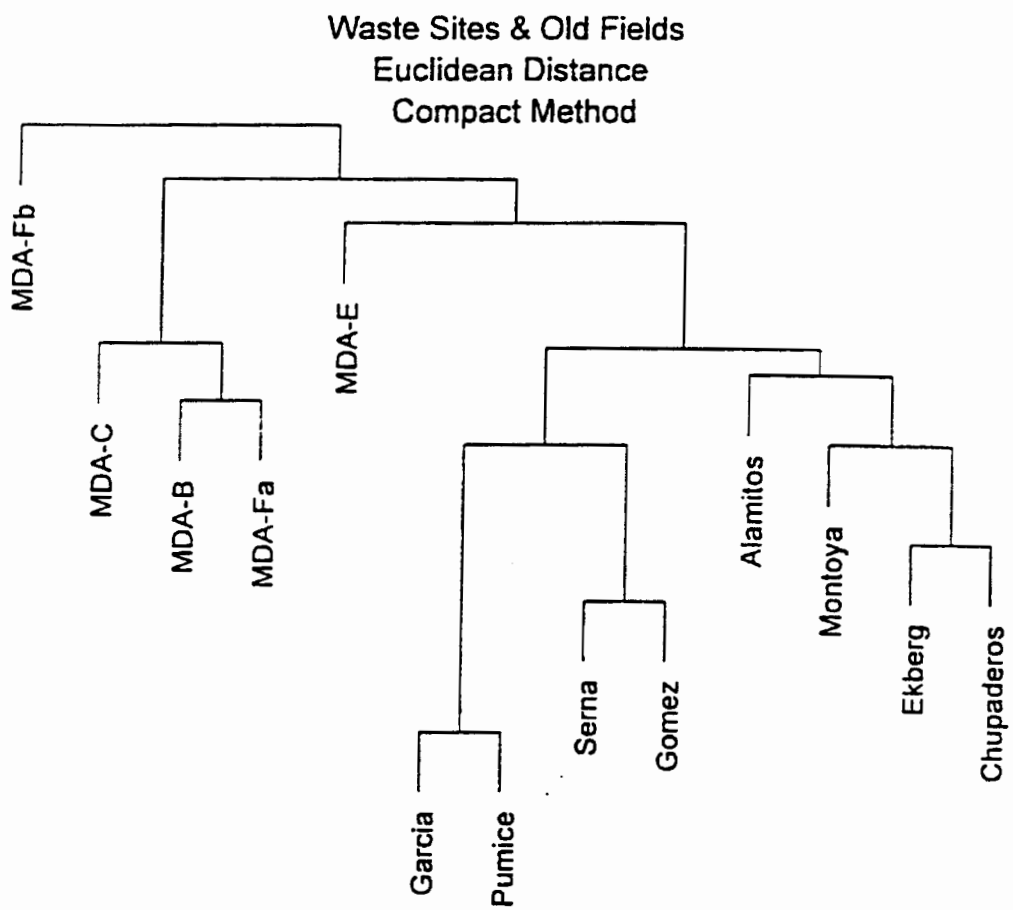


Figure 31. A cluster analysis of all 23 species with an importance value of at least 5 on one or more of the study sites.

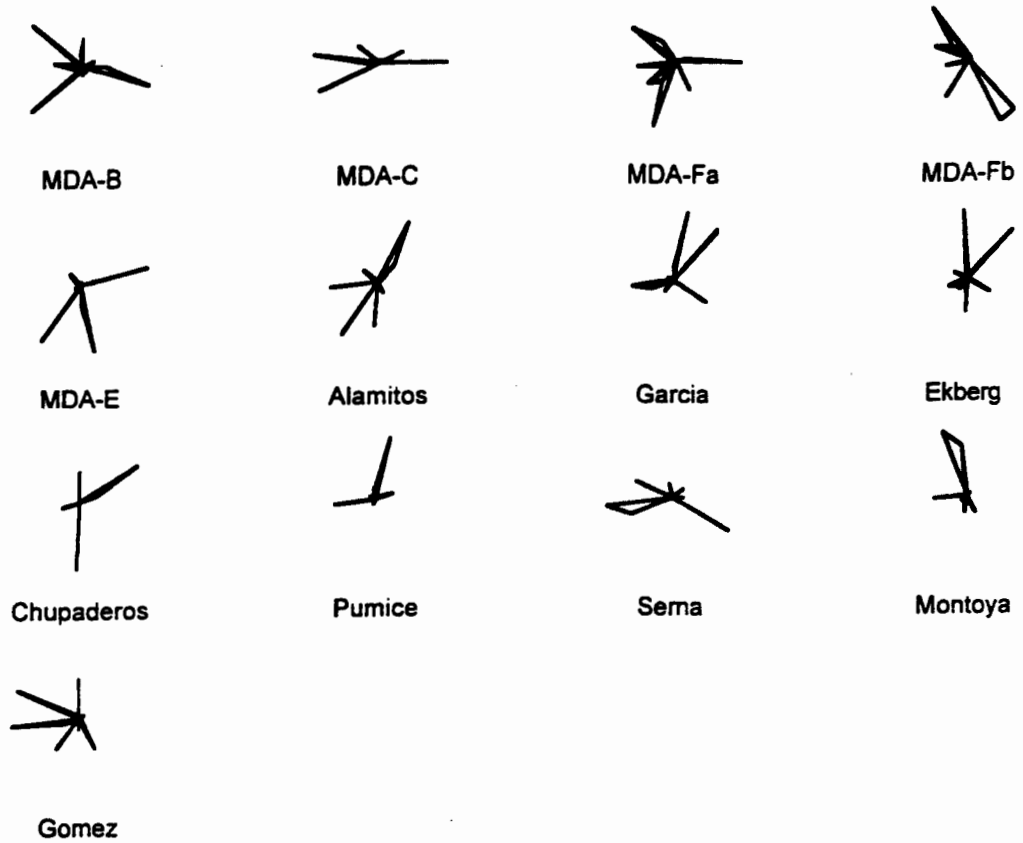


Figure 32. Star plots that represent a visual interpretation of importance values of all vegetation for five waste sites and eight old fields.

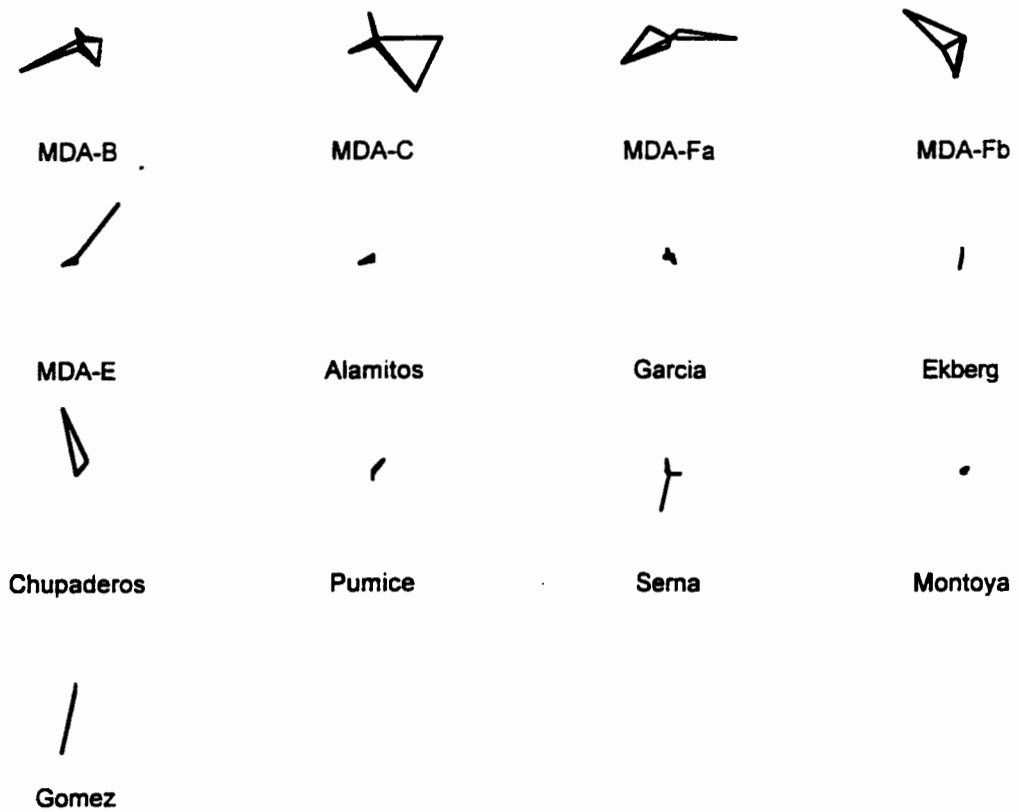


Figure 33. Star plots that represent a visual interpretation of the importance values of the early-successional plant species for five waste sites and eight old fields.

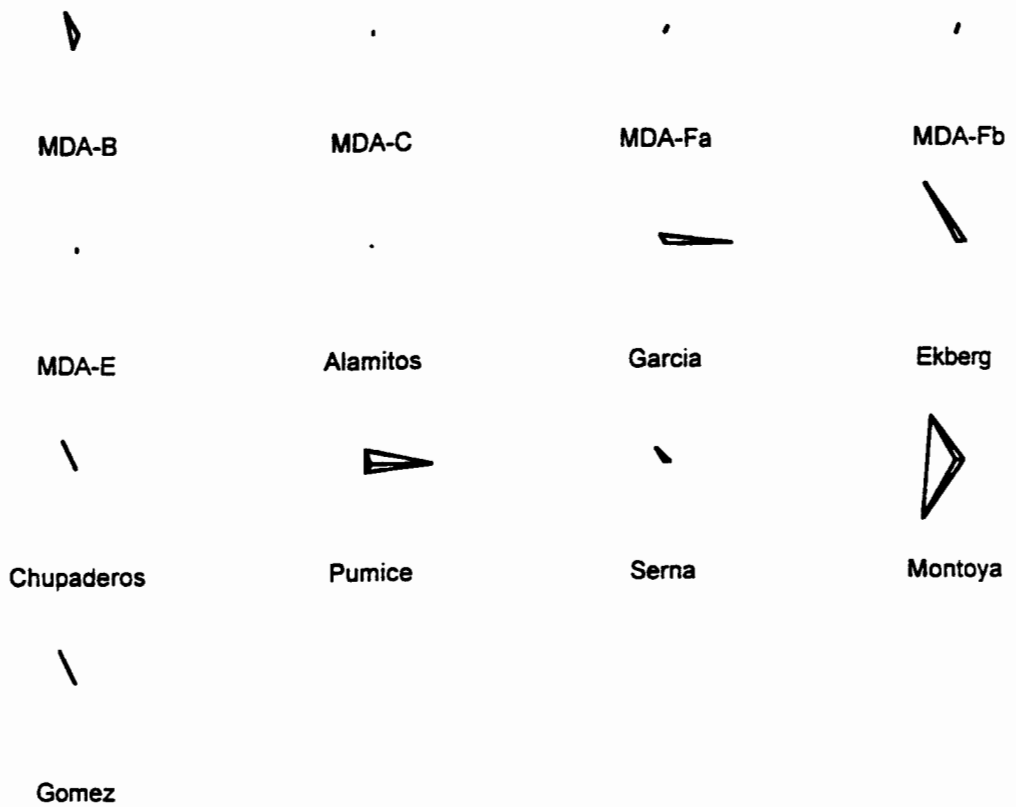


Figure 34. Star plots that represent a visual interpretation of the importance values of late-successional species for five waste sites and eight old fields.

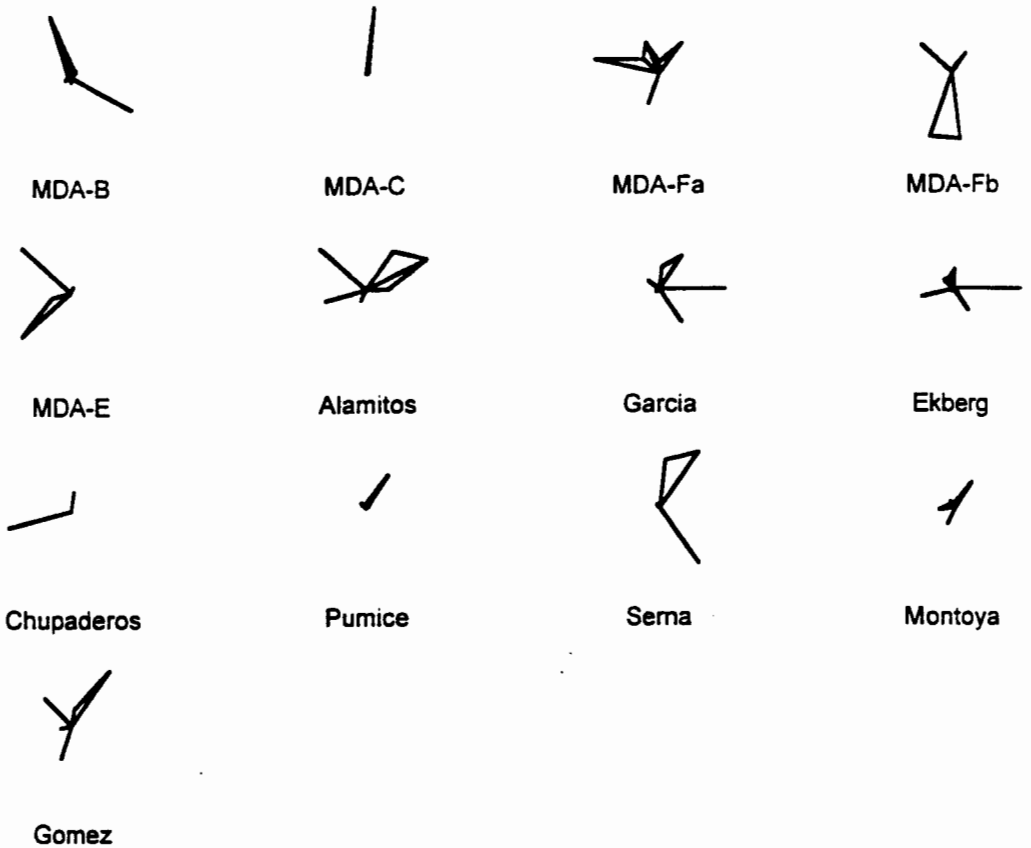


Figure 35. Star plots that represent a visual interpretation of the importance values of the mid-successional species at five waste sites and eight old fields.

Table 14. Soil sample results.

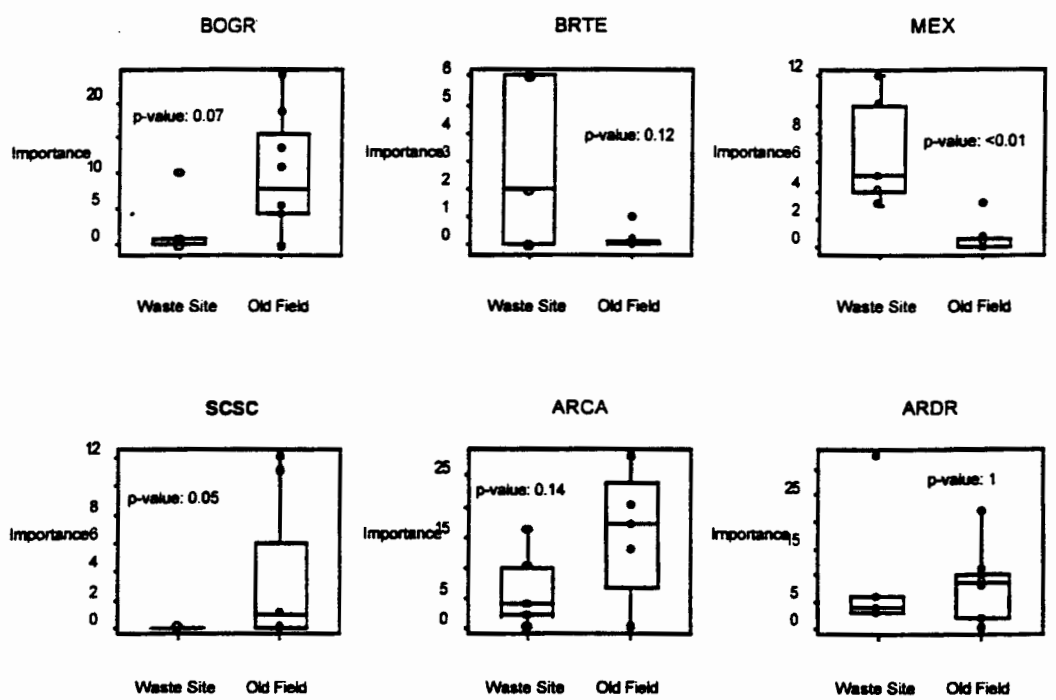
Field	pH	Bulk Density	Organic Matter	Texture*	Cation Exchange Capacity	P Sorption Capacity
Archuleta	7.0	1.63	1.1	L	19.4	7.8
Garcia	6.9	1.78	0.8	SL/L	16.0	4.9
Ekberg	7.2	1.56	1.0	SL/L	16.0	4.8
Pumice Mine	7.1	1.63	0.9	L	19.2	7.5
Montoya	6.5	1.52	1.9	SiL	31.4	9.2
Montoya y Gomez	6.7	1.58	1.2	SiL	21.5	6.7

* L = loam, SL = sand/loam, and SiL = silt/loam

Table 15. Soil sample nutrification.

Field	P*	C	$N0_3$	NH_4	0 Bar % Moisture	1/3 Bar % Moisture	15 Bar % Moisture
Archuleta	6	141	10	8	27.9	32.7	6.7
Garcia	3	97	23	9	22.2	12.3	4.3
Ekberg	13	126	3	9	28.8	14.6	6.2
Pumice Mine	12	142	33	14	28.7	15.9	7.1
Montoya	7	118	50	9	31.8	20.5	7.6
Montoya y Gomez	4	127	40	6	29.2	17.8	6

*P = phosphorus, C = carbon, NO_3 = nitrogen oxide, and NH_4 = ammonium



BOGR = *Bouteloua gracilis*
BRTE = *Bromus tectorum*
MEX = *Melilotus* sp.
SCSC = *Schizachyrium scoparius*
ARCA = *Artemisia carruthi*
ARDR = *Artemisia dracunculus*

Figure 36. Box plots displaying a comparison of the importance values of six plant species at waste sites and old fields.

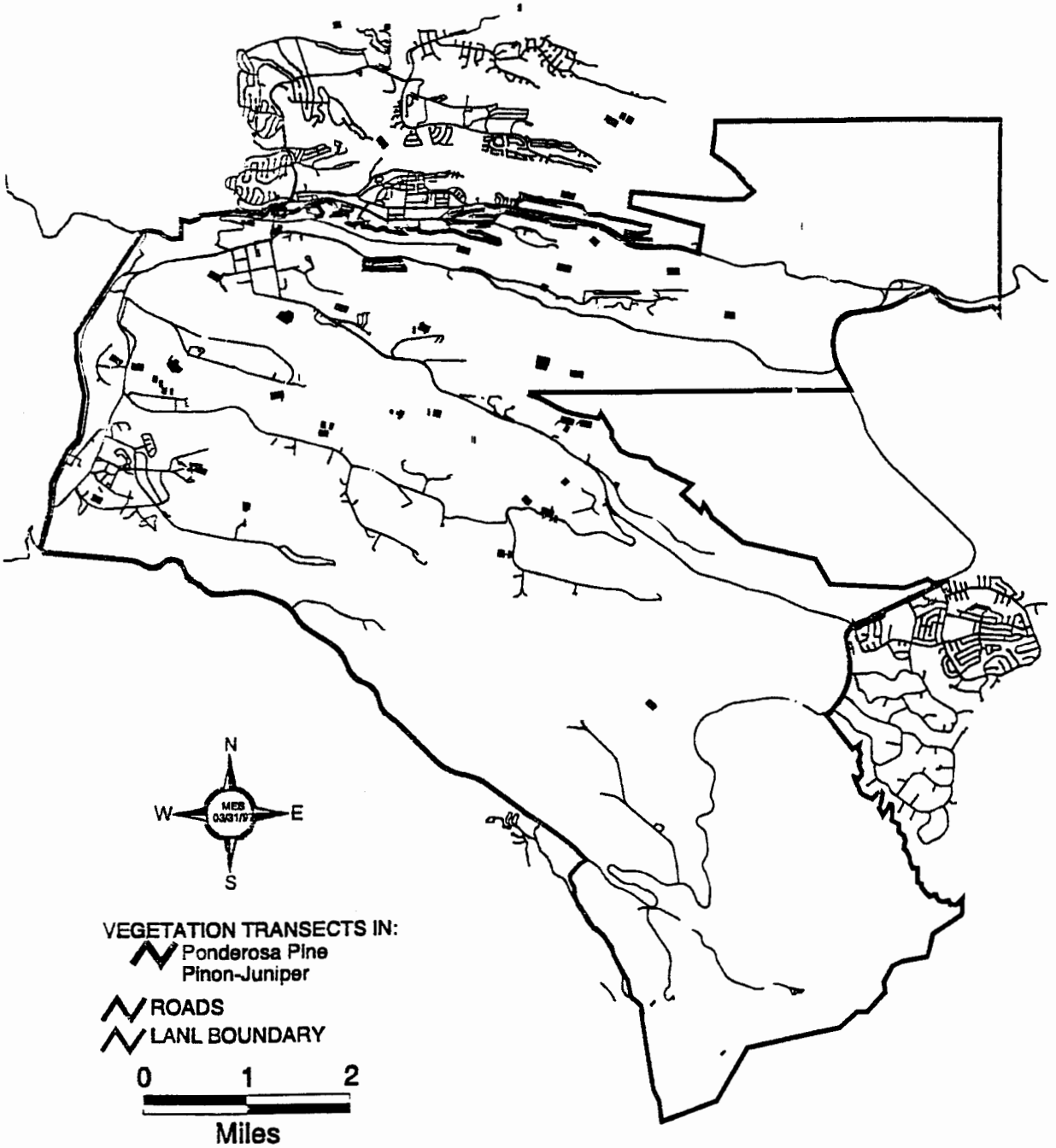


Figure 37. The locations of transects that contained carruth wormwood in both ponderosa pine and pinon-juniper cover types.

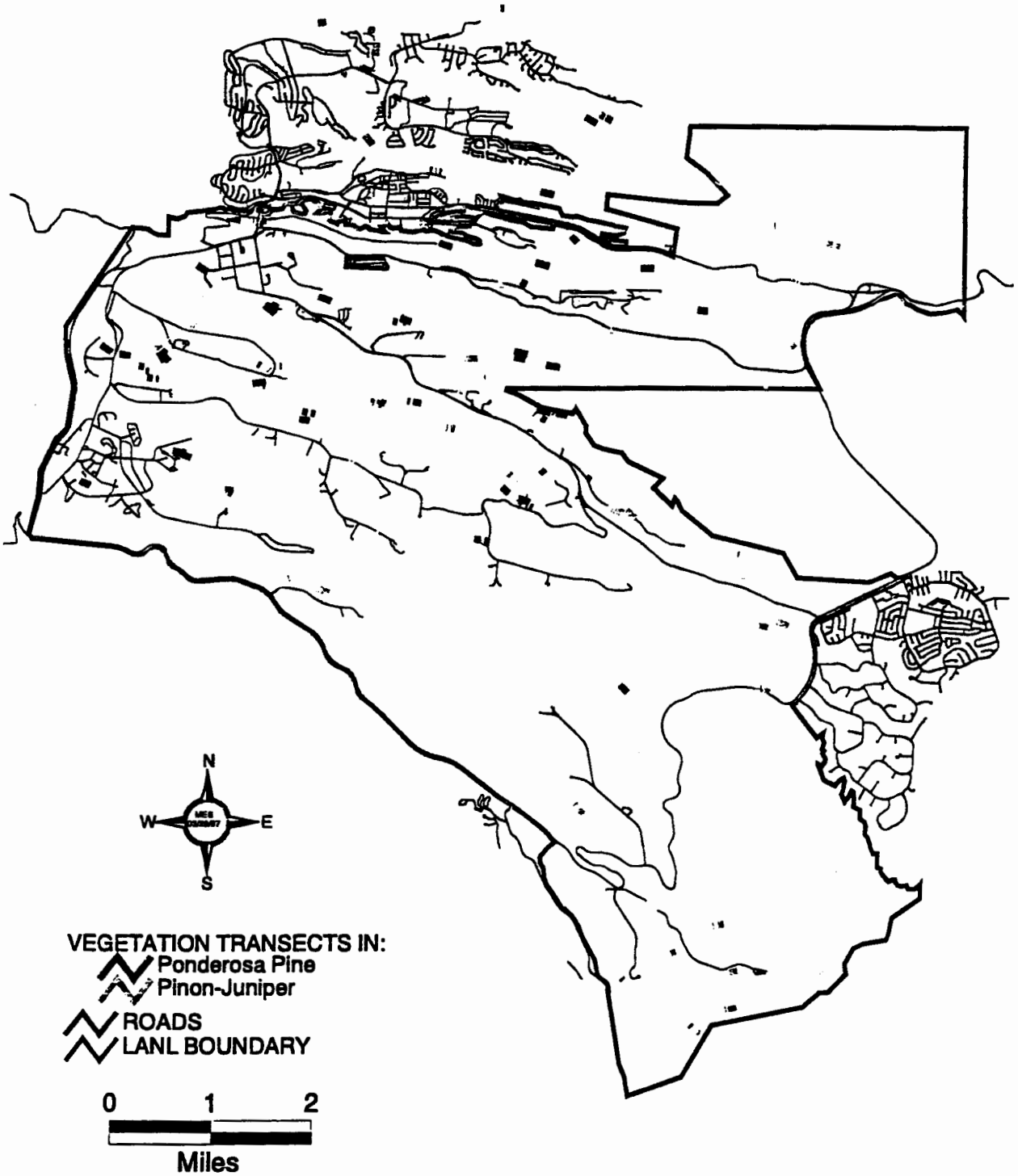
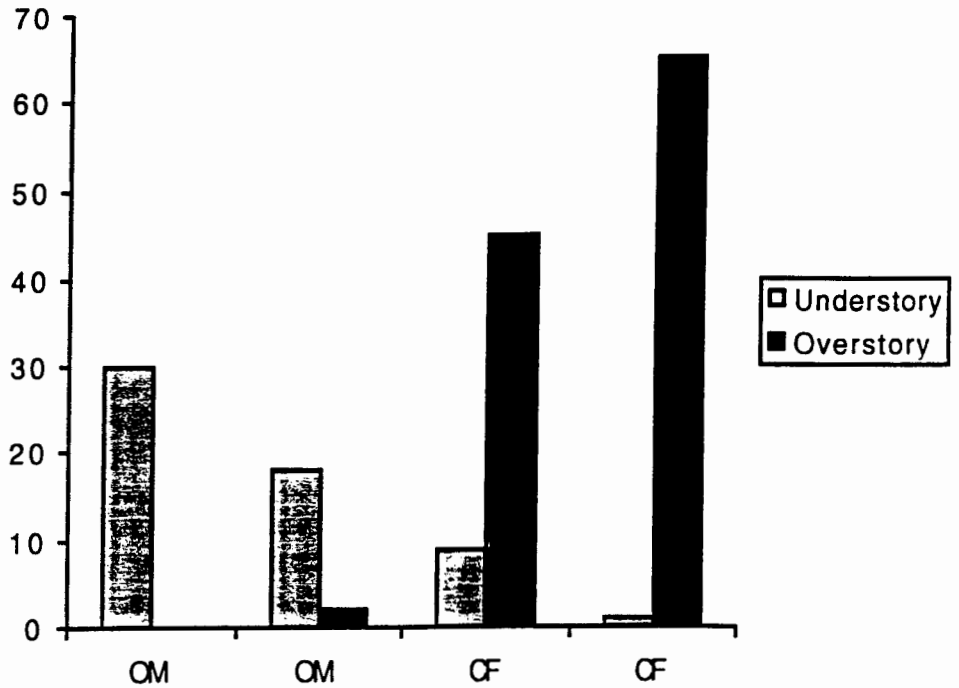


Figure 38. The locations of transects that contained false tarragon in both ponderosa pine and pinon-juniper cover types.



OM = open meadow; CF = closed forest

Figure 39. A comparison of understory cover and overstory cover on portions of Twomile Mesa showing that as the overstory cover increased, the understory cover decreased.

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Appendices

Appendix A. Map of Land Acquisition by Federal Government
Appendix B. Historic Information Relating to Homesteads
Appendix C. Phytosociological Data for All Old Fields
Appendix D. Phytosociological Data for Field 1 (Archuleta Field)
Appendix E. Phytosociological Data for Field 2 (Garcia Field)
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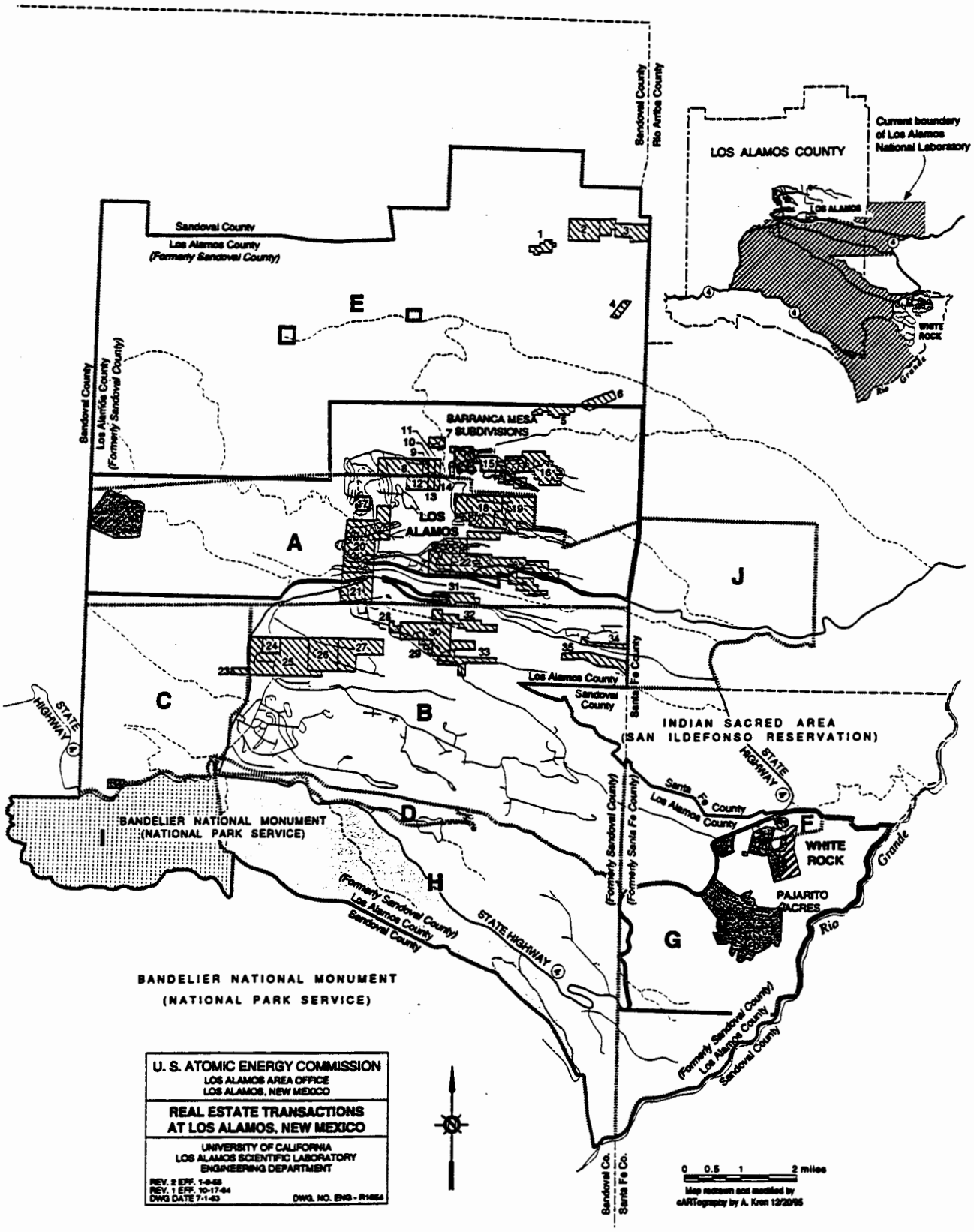
Appendix G. Phytosociological Data for Field 4 (Chupaderos Field)
Appendix H. Phytosociological Data for Field 5 (Pumice Mine Field)
Appendix I. Phytosociological Data for Field 6 (Serna Field)
Appendix J. Phytosociological Data for Field 7 (Montoya Field)
Appendix K. Phytosociological Data for Field 8 (Montoya y Gomez Field)
Appendix L. Biological Data for Dominant Vegetation
Appendix M. List of Common and Scientific Names

Appendix A. Map of Land Acquisition by Federal Government



PARCELS ACQUIRED BY CONDEMNATION OR PURCHASE

over which the United States held exclusive jurisdiction from the respective dates of acquisition until March 15, 1949 (the effective date of retrocession to the State of New Mexico of such exclusive jurisdiction)

NO.	TRACT	VENDOR	ACRES
1	E-28	Esequel Garcia, Estate	57.48
2	E-24	Adolfo Garcia, et al.	160.00
3	E-25	Adolfo Garcia	139.50
4	E-29	Jose L. Garcia	35.53
5	E-4	Federico Gonzales	72.50
6	E-3	Jose M. & Fidel Serna	62.25
7	E-7	O. O. Grant	30.00
8	E-9	Elfego Gomez	120.00
9	E-8-A	O. O. Grant	10.00
10	E-8-B	Ernesto Montoya	15.00
11	E-8-C	Adolfo Montoya	15.00
12	A-7-A	O. O. Grant	50.00
13	A-7-B	Ernesto Montoya	15.00
14	A-7-C	Adolfo Montoya	15.00
15	E-6	Estanislado & Cirilo Gonzales	152.50
16	E-5	Noberto Roybal	125.00
17	A-10	Francisco Gonzales	22.50
18	A-13	Manuel Lujan & Elfego Gomez	150.00
19	A-14	Martin Lujan	160.00
20	A-11-B	Los Alamos Ranch School	320.00
21	A-12	Ramon Duran, et al.	160.00
22	A-11-A	Los Alamos Ranch School	470.00
23	B-19-B	Walter V. Grottenthaler	20.90
24	B-19-A	Walter V. Grottenthaler	40.00
25	B-16	A. M. Ross Est., Anchor Ranch	322.16
26	B-17	Donaciano Gomez	160.00
27	B-18	Jose Elfego & Jose Patricio Montoya	160.00
28	B-12	Ramon Duran, et al.	10.00
29	B-21	Victor Romero	15.00
30	B-20	Mrs. Francisquita Romero, et al.	160.00
31	A-15	Enriquez Montoya	62.50
32	B-22	Montoya Bros.	90.00
33	B-23	Ramon R. Roybal	107.50
34	B-1	Mrs. Sanaida Archuleta	34.07
35	B-2	Fermin L. Vigil	60.31
		TOTAL	3,599.70

ACRES*	AREA	MANNER OF ACQUISITION
8,407.50	A	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Memorandum of Understanding dated May 15, 1943.
9,360.06	B	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Memorandum of Understanding dated May 15, 1943.
4,650.00	C	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Memorandum of Understanding dated May 15, 1943
544.00	D	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Supplement No. 1, dated July 5, 1943, to original Memorandum of Understanding.
22,705.24	E	Previously acquired by Manhattan Engineer District from U.S. Forest Service by Memorandum of Understanding dated May 15, 1943; withdrawn from appropriation by Public Land Order No. 230, dated May 10, 1944.
240.00	F	Acquired by Atomic Energy Commission from U.S. Forest Service by Supplement No. 2, dated October 15, 1947, to original Memorandum of Understanding.
12,329.60	G	Acquired by Atomic Energy Commission from U.S. Forest Service by superseding Memorandum dated April 14, 1948.
4,505.60	H	Acquired by Atomic Energy Commission from U.S. Forest Service by superseding Memorandum dated April 14, 1948.
2,649.60	I	Acquired by Atomic Energy Commission from U.S. Forest Service by superseding Memorandum dated April 14, 1948.
3,925.±	J	Transferred to administrative control of Atomic Energy Commission by Presidential Proclamation No. 3539, dated May 27, 1963.

*Acreages of areas A, B, C, D, E, F, & J were computed from metes and bounds descriptions and are correct; acreages of areas G, H, & I were scaled by planimeter and are subject to correction by metes and bounds computation when available.

Previously acquired by Manhattan Engineer District through condemnation or purchase (as enumerated above)

TRACTS SOLD BY ATOMIC ENERGY COMMISSION

Sold contingently, with right of re-entry by Atomic Energy Commission

AREAS TRANSFERRED TO NATIONAL PARK SERVICE:

December 9, 1959

March 5, 1963

Boundaries of the "minimum geographic area" comprising the Los Alamos Community, as established by the Act of September 28, 1962 (76 stat. 664; 42 U.S.C. 2304)

Boundaries of land acquired by the Atomic Energy Commission as enumerated above

Los Alamos County boundary

County boundary

Indian Reservation

Paved road

Dirt road

Appendix B. Historic Information Relating to Homesteads

Table B-1. Homesteads on the Pajarito Plateau. Patents are copied from the Bureau of Land Management records. Santa Fe, NM.				
Homesteader	Date of Application	Certificate number	Patent Number	Acreage
Benigno Quintana	9/11/1894	2090	-	120
Juan N. Gonzales	9/11/1894	2071	-	120
Pedro Gomez y Gonzales	10/04/1898	-	4093	120
James S. Loomis	05/08/1901	1920	-	163.85
David Romero	07/20/1901	2781	-	160
Severo Gonzales	02/07/1902	1999	-	158.31
William E Moses	07/31/1903	2559	-	40
Efren Gonzales de Duran, widow of Juan Ignacio Duran	06/14/1904	3285	-	160
Miguel Sanchez	09/28/1904	3350	-	160
Donaciano Gomez	04/18/1905	3455	-	160
William C. White	04/18/1905	3459	-	160
David Quintana	08/20/1930	010716	351630	97.50
Harold H. Brook	03/06/1914	0637	389938	130
William M. Hopper	03/06/1914	0688 and 018653	389939	130
Harold H. Brook	03/06/1914	019453	389940	20
Robert G. McDougall	06/15/1914	014750	413859	107.50
Jose Albino Montoya	06/21/1914	014751	479145	90
Estanislado Gonzales	02/18/1916	016045	514423	140
Victor Romero	08/04/1916	018000	541208	15
Eliso M. Vigil	11/10/1916	018196 and 023933	553805	62.50
Federico Gonzales	05/04/1917	018016	582454	57.50
Martin Luian	06/17/1918	020588	636672	160
Francisco Gonzales	09/15/1919	021902	706489	22.50
Roman Martinez	10/21/1919	023461	714008	30
Martha A. Brook	11/28/1919	019452	721732	150
Fermin M. Vigil	07/16/1920	023589	762236	60.31
Andres Martinez	07/16/1920	021789	762235	62.25
Donaciano Gonzales	09/20/1920	028722	773942	12.50
Noberto Roybal	11/04/1920	027177 and 036324	773942	125
Locadio Archuleta	04/01/1921	023882	-	52.70
Federico Gonzales	05/19/1922	042187	862923	15
Ramon Duran	08/15/1922	031525	876162	10
A. J. Connell	01/21/1931	062397	1043435	40
Juan N. Gonzales	09/06/1944	2071	1118944	120
T23 R20N 06E				
Juan Luis Garcia	06/13/1892	1793	-	160
Jose L. Garcia	08/15/1922	025279	876161	35.53
Hipolita de Archuleta	08/31/1922	033345	878099	56.74
Ezequiel Garcia	12/04/1922	022374	889406	42.50
Adolfo Garcia	12/08/1924	041697	949507	55
	08/04/1933	065763	1065411	4.50
Ezequiel Garcia	02/11/1938	066149	1095524	14.98

Table B-2. Owners of the land at the time of the acquisition by the federal government.			
Tract Number	1942 Owners	Entry Date	Original Grantee
B1	Sanaida Archuleta et al.	4/21	Locadio Archuleta
B2	Fermin L. Vigil et al.	7/20	Fermin Vigil
E3	Jose Maria Serna et al.	7/16/20	Andres Martinez
E4	Federico Gonzales et ux.	1917	Federico Gonzales
E5	Noberto Roybal et ux.	11/20	Noberto Roybal
E6	Estanislado Gonzales et al.	12/18/16	Estanislado Gonzales
E7	O. O. Grant et ux.	7/44	Juan Gonzales
A7a	O. O. Grant et ux.	7/44	Juan Gonzales
A7b	Ernesto Montoya et ux.	7/44	Juan Gonzales
A7c	Adolfo Montoya et ux.	7/44	Juan Gonzales
E8a	O. O. Grant et ux.	?	?
E8b	Ernesto Montoya et ux.	?	?
E8c	Adolfo Montoya	?	?
E9	Elfego Gomez	1898	Pedro Gomez y Gonzales
A10	Francisco Gonzales et al.	9/19	Francisco Gonzales
A11a	LA Ranch School	3/6/14	Wm. Hopper & H. H. Brooks
A11b	LA Ranch School	9/11/94 & 4/18/05	Ben. Quintana & Wm. White
A12	Ramon Duran et al.	6/04	Elfren Gonzales de Duran
B12	Ramon Duran et al.	8/22	Ramon Duran
A13	Manuel Lujan	8/20/13	David Quintana
A14	Martin Lujan	6/17/18	Martin Lujan
A15	Enriquez Montoya	11/16	Eliseo Vigil
B16	A. M. Ross estate	5/01 & 2/02	J. Loomis and Severo Gonzales
B17	Donaciano Gomez	4/05	Donaciano Gomez
B18	Jose Elfego Montoya et al.	9/04	Miguel Sanchez
B19a	W. N. Grottenthaler et ux.	7/03	William Moses
B19b	W. N. Grottenthaler et ux.	?	?
B20	Victor Romero et al.	3/01	David Romero
B21	Victor Romero et al.	8/16	Victor Romero
B22	Adolfo Montoya et al.	6/15	Jose Montoya
B23	Ramon R. Roybal et ux.	6/14	Robert McDougall

R. F. Shaw (19 Dec 1984)

Table B-3. U.S. Forest Service allotment tally sheet for one year (1993).

Allotment	Paid Stock	Season	Exempt Stock	Season	Total	Fees
Guaje: Rate- 16¢ per head per month						
Garcia, Adolfo	25	1/1-10/31	2	5/16-10/15	27	40.00
Garcia, Esequiel, Estate	16	1/1-10/31	2	5/16-10/15	18	25.60
Garcia, Feliciano	4	5/16-10/15	-	5/16-10/15	4	3.20
Garcia, Jose L.	15	1/1-10/31	-	5/16-10/15	15	24.00
Garcia, Jose S.	-	-	2	5/16-10/15	2	0.00
Garcia, Salomon	-	-	2	5/16-10/15	2	0.00
Gomez, Elfego	25	1/1-10/31	4	5/16-10/15	29	40.00
Gomez, J. A.	10	1/1-10/31	-	5/16-10/15	10	16.00
Gonzales, Cirilo	25	1/1-10/31	4	5/16-10/15	29	40.00
Gonzales, Estanislado	9	1/1-10/31	-	5/16-10/15	9	14.40
Grant, O. O.	10	1/1-10/31	-	5/16-10/15	10	3.20
Lopez, Justo	9	5/16-10/15	-	5/16-10/15	9	7.20
Roybal, David	6	1/1-10/31	-	5/16-10/15	6	6.40
Roybal, Jose A.	3	5/16-10/15	-	5/16-10/15	3	2.40
Roybal, Noberto	6	1/1-10/31	7	5/16-10/15	13	9.60
Trujillo, Juan	-		2	5/16-10/15	2	0.00
Trujillo, Samuel	-		2	5/16-10/15	2	0.00
Totals	163		27		190	232.00
Pajarito: Rate- 16¢ per head per month						
Anchor Ranch	20	5/16-10/15	-	5/16-10/15	20	16.00
Duran, Jose Ramon	7	5/16-10/15	-	5/16-10/15	7	5.60
Montoya, Jose Elfego	10	5/16-10/15	8	5/16-10/15	18	8.00
Montoya, Jose Patricio	16	5/16-10/15	3	5/16-10/15	19	12.80
Roybal, Ramon R.	56	1/1-5/31	-	5/16-10/15	56	44.80
Trujillo, Marcos	5	5/16-10/15	-	5/16-10/15	5	4.00
Los Alamos Ranch	75	5/16-10/15	-	5/16-10/15	75	0.00
Totals	189		11		200	91.20

Appendix C.

Table C-1. Vegetation Species Presence or Absence List for 1982 Data

Species		Old-Field Sites							
Common Name	Scientific Name	Archuleta (Field 1)	Garcia/ Alamitos (Field 2)	Ekberg (Field 3)	Chupaderos (Field 4)	Pumice Mine (Field 5)	Serna (Field 6)	Montoya (Field 7)	Montoya y Gomez (Field 8)
American vetch	*Vicia americana*	X	X	X	X		X		X
Apache plume	*Fallugia paradoxa*		X						
Aster	*Aster* spp.			X			X		
Beardtongue	*Penstemon* spp.				X			X	X
Bermuda grass	*Cynodon dactylon*	X		X		X	X		
Black grama	*Bouteloua eriopoda*		X	X	X				
Blue grama	*Bouteloua gracilis*		X	X	X	X	X	X	X
Bluegrass	*Poa* spp.	X					X	X	
Bottlebrush squirreltail	*Sitanion hystrix*	X		X	X	X		X	X
Brome grass	*Bromus* spp.			X					
Chamisa	*Chrysothamnus nauseosus*	X	X	X	X	X			
Prickly pear cactus	*Opuntia* spp.					X			
Wild chrysanthemum	*Bahia dissecta*		X			X		X	
Sweet clover	*Melilotus* spp.	X	X	X				X	
Common sunflower	*Helianthus annuus*								X
White ragweed	*Hymenopappus filifolius*	X		X				X	X
Desert four o'clock	*Oxybaphus linearis*		X						
Gayfeather	*Liatris punctata*								X
Cheatgrass	*Bromus tectorum*		X				X		
Dropseed	*Sporobolus* spp.	X	X	X	X	X			X

Species		Old-Field Sites							
Species Common Name	Scientific Name	Archuleta (Field 1)	Garcia/ Alamitos (Field 2)	Ekberg (Field 3)	Chupaderos (Field 4)	Pumice Mine (Field 5)	Serna (Field 6)	Montoya (Field 7)	Montoya y Gomez (Field 8)
Estafiata	*Artemisia frigida*					X	X		
Evening primrose	*Oenothera* spp.	X	X	X	X		X		X
False buffalo grass	*Munroa squarosa*					X			
False tarragon	*Artemisia dracunculus*	X	X	X	X	X	X	X	X
Firewheel	*Gaillardia pulchella*				X				
Flax	*Linum* spp.		X					X	X
Fleabane	*Erigeron* spp.		X					X	
Indian paintbrush	*Castilleja* spp.							X	
Fremont's goosefoot	*Chenopodium fremontii*						X		
Gambel oak	*Quercus gambelii*							X	
Blue gilia	*Ipomopsis longiflora*				X	X			
Globe mallow	*Sphaeralcea coccinea*			X		X	X		
Golden-eye	*Viguiera multiflora*		X						
Lamb's quarters	*Chenopodium* spp.				X	X		X	
Greenthread	*Thelesperma trifidum*			X				X	X
Gaura	*Gaura coccinea*	X						X	X
Spiny goldenweed	*Haplopappus spinulosus*					X	X		
Hidden flower	*Cryptantha jamesii*				X				
Indian grass	*Sorgastrum nutans*		X	X					
Leafy golden aster	*Chrysopsis foliosa*	X	X	X	X		X	X	X
Pepperegrass	*Lepidium* spp.								X
Little bluestem	*Schizachyrium scoparius*		X	X	X				

Table C-1 (cont.)

Species		Old-Field Sites							
Common Name	Scientific Name	Archuleta (Field 1)	Garcia/ Alamitos (Field 2)	Ekberg (Field 3)	Chupaderos (Field 4)	Pumice Mine (Field 5)	Serna (Field 6)	Montoya (Field 7)	Montoya y Gomez (Field 8)
Lupine	*Lupinus caudatus*		X	X			X		
Marigold	*Pectis angustifolia*				X				
Milkvetch	*Astragalus* spp.			X					
Mountain muhly	*Muhlenbergia montana*			X	X	X		X	X
Mullein	*Verbascum thapsus*		X						X
Mustard	*Descurainia* spp.				X				
Narrow-leaf yucca	*Yucca angustissima*								X
Nodding buckwheat	*Eriogonum cernuum*				X		X		
One-seed juniper	*Juniperus monosperma*			X	X			X	
Owl-clover	*Orthocarpus* spp.							X	
Pincushion cactus	*Coryphantha vivipara*					X			
Pingue	*Hymenoxys richardsonii*	X	X	X				X	X
Ponderosa pine	*Pinus ponderosa*	X							
Poreymint	*Monarda pectinata*				X		X		
Poverty three-awn	*Aristida divaricata*					X			X
Prairie clover	*Petalostemum* spp.			X					
Prairie sunflower	*Helianthus petiolaris*				X				
Puccoon	*Lithospermum multiflorum*			X				X	
Ragweed	*Ambrosia* spp.						X		
Redtop	*Agrostis alba*		X				X	X	X
Russian thistle	*Salsola kali*				X	X			X
Russian wheatgrass	*Agropyron desertorum*	X							
Goatsbeard	*Tragopogon dubius*			X	X	X			X
Species		Old-Field Sites							
Species Common Name	Scientific Name	Archuleta (Field 1)	Garcia/ Alamitos (Field 2)	Ekberg (Field 3)	Chupaderos (Field 4)	Pumice Mine (Field 5)	Serna (Field 6)	Montoya (Field 7)	Montoya y Gomez (Field 8)
Sand dropseed	*Sporobolus cryptandrus*						X		
Skeletonweed	*Stephanomeria* spp.							X	
Shepherd's purse	*Capsella bursa-pastoris*		X	X					
Smartweed	*Polygonum* spp.						X		
Snakeweed	*Gutierrezia sarothrae*	X	X	X		X		X	X
Stickleaf	*Mentzelia pumila*								X
Stickseed	*Lappula* spp.			X	X				
Threadleaf butterweed	*Senecio longilobus*			X					
Fleabane	*Erigeron* spp.		X					X	
Trailing fleabane	*Erigeron flagellaris*						X	X	
Vetch	*Vicia* spp.						X		
Walking-stick cholla	*Opuntia imbricata*					X			
Western wheatgrass	*Agropyron smithii*		X	X					
Wheatgrass	*Agropyron* spp.								X
Wild buckwheat	*Eriogonum* spp.			X				X	
Witchgrass	*Panicum capillare*						X		
Woolly Indian wheat	*Plantago purshii*			X	X			X	
Wolftail	*Lycurus phleoides*		X			X			
Carruth wormwood	*Artemisia carruthii*	X	X	X	X		X	X	X
Louisiana wormwood	*Artemisia ludoviciana*			X		X			

Appendix D.

Table D-1. Phytosociological data taken in 1982 for Field 1 (Archuleta Field) by transect.

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
GRAMINEAE						
Andropogon desertorum	E	0	0	0	0	0
Russian wheatgrass	W	0.10	0.60	0.04	1.36	1.98
	S	0.10	0.73	0.06	2.47	1.61
	N	0.12	0.84	0.04	1.42	1.13
	Average	0.08		0.04		1.18
Agropyron smithii	E	1.89	13.31	0.54	22.5	17.90
Western wheatgrass	W	1.70	10.00	0.66	22.45	16.62
	S	0.26	1.82	0.26	10.74	6.28
	N	0.65	4.54	0.38	13.48	9.01
	Average	1.13		0.46		12.45
Cynodon dactylon						
Bermuda grass	E	0	0	0	0	0
	W	0.02	0.12	0.02	0.68	0.40
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	.005		0.01		0.10
Poa sp.	E	0	0	0	0	0
Bluegrass	W	0	0	0	0	0
	S	0.02	0.14	0.02	0.83	0.45
	N	0	0	0	0	0
	Average	.008		0.01		0.11
Sitanion hystrix	E	0.002	0.01	0.02	0.83	0.42
Bottlebrush squirreltail	W	0.12	0.72	0.06	2.04	1.38
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.03		0.02		0.45
Unknown grass	E	0.20	1.41	0.04	1.67	1.54
	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.05		0.01		0.39
Sporobolus spp.	E	0.04	0.28	0.04	1.67	0.97
Dropseed	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.26	1.80	0.10	3.55	2.69
	Average	0.08		0.04		0.92
FORBS						
Artemisia carruthii	E	2.80	19.72	0.44	18.33	19.03
Carruth wormwood	W	3.96	23.21	0.60	20.41	21.81
	S	3.17	22.33	0.60	24..79	23.56
	N	2.38	16.75	0.40	14.18	15.47
	Average	3.08		0.51		19.97
Artemisia dracunculus	E	0.08	0.58	0.10	4.17	2.37
False tarragon	W	0	0	0	0	0
	S	0.12	0.85	0.04	1.65	1.25
	N	0.30	2.11	0.14	4.96	3.54
	Average	0.13		0.07		1.79
Chrysopsis foliosa						
Leafy golden aster						
	E	2.36	16.65	0.50	20.83	18.74
	W	1.86	10.90	0.42	14.29	12.59
	S	2.42	17.09	0.40	16.53	16.81
	N	3.52	24.78	0.56	19.86	22.32
	Average	2.54		0.47		17.62

Table D-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Guara spp.						
Scarlet bee blossom	E	0	0	0	0	0
	W	0	0	0	0	0
	S	0.10	0.71	0.02	0.81	0.77
	N	0	0	0	0	0
	Average	0.03		0.01		0.19
Gutierrezia sarothrae	E	1.51	10.59	0.30	12.50	11.55
Snakeweed	W	5.85	34.27	0.60	20.41	27.34
	S	1.50	10.61	0.32	13.22	11.92
	N	0.682	4.81	0.22	7.79	6.14
	Average	2.38		0.36		14.24
Hymenoxys richardsonii	E	0.34	2.39	0.06	2.50	2.45
Pingüe	W	0.42	2.46	0.08	2.72	2.59
	S	2.04	14.39	0.28	11.57	12.98
	N	4.24	29.81	0.42	14.89	22.35
	Average	1.76		0.21		10.09
Hymenopappus sp.	E	0.16	1.13	0.08	3.33	2.23
White ragweed	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.36	2.55	0.14	4.96	3.75
	Average	0.13		0.06		1.50
Melilotus spp.	E	0.33	2.29	0.12	5.00	3.64
Sweetclover	W	0.40	2.37	0.18	6.12	4.25
	S	0.54	3.82	0.16	6.61	5.22
	N	0.46	3.25	0.14	4.96	4.11
	Average	0.43	2.93	0.15	5.67	4.30
Oenothera sp.	E	0	0	0	0	0
Evening primrose	W	0.16	0.94	0.08	2.72	1.83
	S	0	0	0	0	0
	N	0.002	0.01	0.02	0.71	0.36
	Average	0.04		0.03		0.55
Unknown	E	0.10	0.70	0.02	0.83	0.77
	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.03		0.01		0.19
Vicia americana	E	0	0	0	0	0
American vetch	W	0.002	0.01	0.02	0.68	0.35
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.001		0.01		0.09
Unknown Composite	E	0.10	0.70	0.02	0.83	0.77
	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.10	0.70	.02	0.71	0.71
	Average	0.05		0.01		0.37
SHRUBS/TREES						
Chrysothamnus nauseosus	E	0.60	4.22	0.04	1.67	2.94
Chamisa	W	1.06	6.21	0.16	5.44	5.83
	S	3.90	27.51	0.26	10.74	19.13
	N	0.62	4.36	0.12	4.26	4.31
	Average	1.55		0.15		8.05
Pinus ponderosa	E	3.00	21.09	0.04	1.67	11.38
Ponderosa pine	W	1.40	8.21	0.02	0.68	4.40
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	1.10		0.02		3.95

Appendix E.

Table E-1. Phytosociological data taken in 1982 for Field 2 (Garcia Field) by transect.

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
GRAMINEAE GRAMINOIDES						
Schizachyrium scoparius	E	0	0	0	0	0
Little bluestem	W	1.90	7.92	0.06	2.44	5.18
	S	0	0	0	0	0
	N	13.42	45.45	0.88	38.26	41.86
	Average	**3.83**		**0.24**		**11.76**
Agropyron smithii	E	6.60	28.01	0.60	23.62	25.85
Western wheatgrass	W	9.02	37.60	0.74	30.08	33.84
	S	4.80	18.92	0.56	24.35	21.63
	N	0	0	0	0	0
	Average	**5.10**		**0.48**		**20.33**
Agrostis sp.	E	1.10	4.68	0.14	5.51	5.09
Redtop	W	0	0	0	0	0
	S	0	0	0	0	0
	N	2.32	7.86	0.08	3.48	5.67
	Average	**0.86**		**0.06**		**2.69**
Bouteloua eriopoda	E	0.60	2.55	0.04	1.57	0.26
Black grama	W	1.10	4.58	0.04	1.63	3.10
	S	0	0	0	0	0
	N	1.50	5.08	0.02	0.87	2.97
	Average	**0.80**		**0.03**		**1.58**
Bouteloua gracilis	E	1.10	4.26	0.06	2.36	3.31
Blue grama	W	0.94	3.92	0.16	6.50	5.21
	S	0.20	0.79	0.02	0.87	0.83
	N	1.80	6.10	0.10	4.35	5.22
	Average	**1.01**		**0.09**		**3.64**
Bromus tectorum	E	0.004	0.02	0.04	1.57	0.80
Cheatgrass	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.001**		**0.01**		**0.20**
Lycrus phleoides	E	0	0	0	0	0
Wolftail	W	0	0	0	0	0
	S	1.70	6.70	0.08	3.48	5.09
	N	2.80	9.95	0.14	6.09	7.82
	Average	**1.13**		**0.06**		**3.23**
Sorgastrum nutans	E	4.10	17.43	0.22	8.66	13.05
Indian grass	W	0	0	0	0	0
	N	0	0	0	0	0
	S	0	0	0	0	0
	Average	**1.03**		**0.06**		**3.26**
Sporobolus spp.	E	0.60	2.55	0.06	2.36	2.45
Dropseed	W	1.02	4.26	0.12	4.88	4.57
	S	0.17	0.65	0.14	6.09	3.37
	N	0.30	1.02	0.08	3.48	2.25
	Average	**0.52**		**0.10**		**3.16**
FORBS						
Artemisia carruthii	E	2.15	9.12	0.46	18.11	13.62
Carruth wormwood	W	4.14	17.26	0.50	20.32	18.79
	S	7.32	28.83	0.64	27.83	28.33
	N	2.32	7.86	0.18	7.83	7.85
	Average	**3.98**		**0.45**		**17.15**
Artemisia dracunculus	E	2.30	9.79	0.16	6.29	8.04
False tarragon	W	2.92	12.17	0.26	10.57	11.37
	S	6.60	25.99	0.46	20.00	23.00
	N	0.60	0.03	0.06	2.61	2.32
	Average	**3.11**		**0.24**		**11.18**

Table E-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Bahia dissecta	E	0	0	0	0	0
Wild chrysanthemum	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.002	0.007	0.02	0.87	0.44
	Average	0.001		0.01		0.11
Capsella bursa-pastoris	E	0.004	0.02	0.04	1.57	0.80
Shepherd's purse	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.001		0.01		0.20
Chrysopsis foliosa	E	2.20	9.35	0.16	6.29	7.83
Leafy golden aster	W	0.54	2.26	0.14	5.69	3.97
	S	0.94	3.70	0.16	7.00	5.32
	N	2.00	6.78	0.26	11.30	9.04
	Average	1.42		0.18		6.54
Erigeron flagellaris	E	0.50	2.13	0.08	3.45	4.64
Spreading fleabane	W	0	0	0	0	0
	S	0.50	1.97	0.02	1.87	1.42
	N	0.20	0.68	0.02	0.87	0.77
	Average	0.30		0.03		1.71
Guterrezia sarothrae	E	0	0	0	0	0
Snakeweed	W	0.52	2.18	0.08	3.25	1.71
	S	0	0	0	0	0
	N	1.58	5.35	0.22	9.57	7.46
	Average	0.53		0.08		2.29
Hymenoxys richardsonii	E	0.10	0.43	0.02	0.79	0.61
Pingüe	W	0.30	1.26	0.04	1.63	1.44
	S	0	0	0	0	0
	N	0.02	0.07	0.02	0.87	0.47
	Average	0.11		0.02		0.63
Melilotus spp.	E	0.30	1.28	0.06	2.36	1.82
Sweetclover	W	0.30	1.25	0.04	1.63	1.44
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.15		0.03		0.82
Oxbaphus linearis	E	0	0	0	0	0
Desert four o'clock	W	0.002	0.008	0.02	0.81	0.42
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.0005		0.01		0.11
Linum sp.	E	0	0	0	0	0
Flax	W	0.002	0.008	0.02	0.81	0.41
	S	0.002	0.008	0.02	0.87	0.44
	N	0	0	0	0	0
	Average	0.001		0.01		0.21
Lupinus caudatus	E	0.60	2.56	0.14	5.51	4.03
Lupine	W	0.54	2.25	0.10	4.06	3.16
	S	0.82	3.23	0.10	4.35	3.79
	N	0.20	0.68	0.04	1.74	1.21
	Average	0.54		0.10		3.05
Oenothera sp.	E	0.004	0.02	0.04	1.57	0.80
Evening primrose	W	0.40	1.67	0.04	1.63	1.65
	S	0	0	0	0	0
	N	0.12	1.41	0.04	1.74	1.07
	Average	0.131		0.03		0.88
Vicia americana	E	0.13	0.55	0.14	5.51	3.03
American vetch	W	0.02	0.08	0.02	0.81	0.45
	S	0.02	1.08	0.02	0.87	0.47
	N	0.32	1.08	0.14	6.09	3.59
	Average	0.12		0.08		1.89

Table E-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Verbascum thapsus	E	0	0	0	0	0
Mullein	W	0	0	0	0	0
	S	1.80	7.09	0.04	1.74	4.41
	N	0	0	0	0	0
	Average	**0.45**		**0.01**		**1.10**
Viguiera spp.	E	0	0	0	0	0
Goldeneye	W	0	0	0	0	0
	S	0.02	0.08	0.02	0.87	0.47
	N	0	0	0	0	0
	Average	**0.01**		**0.01**		**0.12**
Erigeron flagellaris	E	0	0	0	0	0
Spreading fleabane	W	0.20	0.83	0.04	1.63	1.23
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.05**		**0.01**		**0.31**
Erigeron spp.	E	0	0	0	0	0
Fleabane daisy	W	0.10	0.42	0.02	0.81	0.61
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.03**		**0.01**		**0.15**
SHRUB/TREES						
Chrysothamnus nauseosus	E	0.22	0.94	0.06	2.36	1.65
Chamisa	W	0.02	0.08	0.02	0.81	0.45
	S	0.50	1.97	0.02	0.87	1.42
	N	0	0	0	0	0
	Average	**0.19**		**0.03**		**0.88**
Fallugia paradoxa	E	1.00	4.25	0.02	0.79	2.52
Apache plume	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.25**		**0.01**		**0.63**

Appendix F.

Table F-1. Phytosociological data taken in 1982 for Field 3 (Ekberg Field) by transect.

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
GRAMINEAE GRAMINOIDES						
Schizachyrium scoparius	E	1.0	4.73	0.04	1.89	3.31
Little bluestem	W	0.10	0.32	0.04	1.71	1.01
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.28		0.02		1.08
Bouteloua gracilis	E	6.40	3.26	0.42	19.81	25.03
Blue grama	W	8.52	26.38	0.68	29.06	27.72
	S	8.80	35.27	0.56	25.93	30.06
	N	4.94	18.05	0.4	15.15	16.6
	Average	7.17		0.52		24.85
Bromus spp.	E	0	0	0	0	0
Brome	W	0	0	0	0	0
	S	0	0	0	0	0
	N	1.80	6.57	0.30	11.36	8.96
	Average	0.45		0.08		2.24
Cynodon dactylon	E	0.10	0.48	0.04	1.89	1.18
Bermuda grass	W	6.54	20.25	0.32	13.68	16.96
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	1.66		0.09		4.54
Muhlenbergia montana	E	0	0	0	0	0
Mountain muhly	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.002	0.007	0.02	0.80	0.40
	Average	0.001		0.01		0.10
Sitanion hystrix	E	1.70	8.05	0.22	10.38	9.20
Bottlebrush squirreltail	W	1.85	5.74	0.44	18.08	12.27
	S	2.40	9.62	0.26	12.04	10.83
	N	0	0	0	0	0
	Average	1.49		0.23		8.07
Sporobolus spp.	E	0.30	1.43	0.08	3.77	2.60
Dropseed	W	6.00	18.57	0.06	2.56	10.57
	S	0.20	0.81	0.04	1.85	1.33
	N	0.10	0.38	0.06	0.27	1.33
	Average	1.65		0.06		3.96
FORBS						
Artemisia carruthii	E	0	0	0	0	0
Wormwood	W	0	0	0	0	0
	S	0.14	0.57	0.08	3.70	1.14
	N	0	0	0	0	0
	Average	0.04		0.02		0.29

Table F-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Artemisia dracunculus	E	0.20	0.96	0.06	2.83	1.90
False tarragon	W	2.62	14.30	0.34	14.53	14.42
	S	0.04	1.62	0.10	4.63	3.12
	N	5.08	18.55	0.52	19.70	19.12
	Average	**1.99**		**0.26**		**9.64**
Artemisia ludoviciana	E					
Louisiana wormwood	W					
	S	0.20	0.81	0.06	2.78	1.80
	N					
	Average	**0.05**		**0.02**		**0.45**
Aster spp.	E	0	0	0	0	0
Aster	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.40	1.46	0.04	1.52	1.49
	Average	**0.10**		**0.01**		**0.37**
Astragalus spp.	E	0.30	1.44	0.08	3.77	1.61
Milkvetch	W	0.02	0.06	0.02	0.85	0.46
	S	1.10	4.41	0.14	6.48	5.45
	N	0	0	0	0	0
	Average	**0.36**		**0.06**		**1.88**
Capsella bursa-pastoris	E	0	0	0	0	0
Shepherd's purse	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.10	0.37	0.02	0.76	0.56
	Average	**0.03**		**0.01**		**0.14**
Chrysopsis foliosa	E	3.30	15.72	0.44	20.75	18.24
Leafy golden aster	W	2.82	8.74	0.26	11.11	9.92
	S	1.50	6.00	0.10	4.63	5.32
	N	0.89	3.58	0.24	9.09	6.33
	Average	**2.13**		**0.26**		**9.95**
Eriogonum spp.	E	0	0	0	0	0
Buckwheat	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.20	0.73	0.04	1.52	1.12
	Average	**0.05**		**0.01**		**0.28**
Gutierrezia sarothrae	E	4.80	22.70	0.28	13.21	18.00
Snakeweed	W	0.02	0.06	0.02	0.85	0.46
	S	3.60	14.42	0.28	12.96	13.96
	N	2.00	7.30	0.16	6.06	6.69
	Average	**2.61**		**0.19**		**9.78**
Hymenoxys richardsonii	E	0.10	0.47	0.02	0.94	0.71
Pingüe	W	0	0	0	0	0
	S	0.10	0.40	0.02	0.93	0.66
	N	0.02	0.07	0.02	0.76	0.42
	Average	**0.06**		**0.02**		**0.25**

Table F-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Hymenopappus sp.	E	0	0	0	0	0
White ragweed	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.50	1.80	0.02	0.76	1.29
	Average	**0.13**		**0.01**		**0.32**
Lappula spp.	E	0	0	0	0	0
Stickseed	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.002	0.007	0.02	0.76	0.38
	Average	**0.001**		**0.01**		**0.10**
Lithospermum multiflorum	E	0	0	0	0	0
Puccoon	W	0	0	0	0	0
	S	0.10	0.40	0.20	0.93	0.66
	N	0.002	0.007	0.002	0.76	0.38
	Average	**0.026**		**0.051**		**0.26**
Lupinus caudatus	E	0.50	2.38	0.12	5.66	4.02
Lupine	W	0.10	0.31	0.02	0.85	0.58
	S	0.10	0.40	0.02	0.93	0.66
	N	0.32	1.17	0.06	2.27	1.72
	Average	**0.26**		**0.06**		**1.74**
Melilotus spp.	E	0.10	0.47	0.02	0.94	0.71
Sweetclover	W	0.20	0.62	0.02	0.85	0.74
	S	0	0	0	0	0
	N	0.02	0.07	0.02	0.76	0.42
	Average	**0.08**		**0.02**		**0.47**
Oenothera sp.	E	0.20	1.00	0.06	2.83	1.89
Evening primrose	W	1.20	3.71	0.08	3.42	3.57
	S	0.10	0.40	0.02	0.93	0.66
	N	0.40	1.46	0.06	2.27	1.87
	Average	**0.48**		**0.06**		**2.00**
Petalostemum spp.	E	0	0	0	0	0
Prarie clover	W	0	0	0	0	0
	S	0.10	0.40	0.02	0.93	0.66
	N	0	0	0	0	0
	Average	**0.03**		**0.01**		**0.17**
Plantago purshii	E	0	0	0	0	0
Woolly Indian wheat	W	0	0	0	0	0
	S	0.10	0.40	0.02	0.93	0.66
	N	0	0	0	0	0
	Average	**0.03**		**0.01**		**0.17**
Senecio longilobus	E	0	0	0	0	0
Longleaf butterweed	W	0	0	0	0	0
	S	1.10	4.41	0.06	2.78	3.60
	N	0	0	0	0	0
	Average	**0.28**		**0.02**		**0.90**
Sphaeralcea spp.	E	0	0	0	0	0
Globemallow	W	0	0	0	0	0
	S	0.20	0.80	10.04	1.85	1.33
	N	0.50	1.83	0.08	3.03	2.43
	Average	**0.18**		**2.53**		**0.94**

Table F-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Thelesperma spp.	E	0.20	0.95	0.04	1.89	1.42
Greenthread	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.05**		**0.01**		**0.35**
Vicia americana	E	0.002	0.009	0.02	0.94	0.48
American vetch	W	0	0	0	0	0
	S	0.002	0.008	0.02	0.93	0.47
	N	0.01	0.04	0.12	4.55	2.29
	Average	**0.004**		**0.04**		**0.81**
SHRUB/TREES						
Chrysothamnus nauseosus	E	1.90	9.00	0.18	8.49	8.74
Chamisa	W	0.30	0.93	0.04	1.71	1.32
	S	4.10	16.42	0.26	12.04	14.23
	N	9.30	33.96	0.38	14.39	24.18
	Average	**3.90**		**0.22**		**12.12**
Juniperus monosperma	E	0	0	0	0	0
One-seed juniper	W	0	0	0	0	0
	S	0.60	2.40	0.02	1.85	2.13
	N	0.50	1.83	0.02	0.76	1.29
	Average	**0.28**		**0.01**		**0.86**

Appendix G.

Table G-1. Phytosociological data taken in 1982 for Field 4 (Chupaderos Field) by transect.

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
GRAMINEAE GRAMINOIDES						
Schizachyrium scoparius	E	0	0	0	0	0
Little bluestem	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.1	0.4	0.02	0.9	0.7
	Average	0.1		0.02		0.7
Bouteloua gracilis	E	21	70.6	0.84	35.9	53.2
Blue grama	W	19.5	66.9	0.9	40.4	53.6
	S	10/9	65.5	0.76	38.0	51.3
	N	11.0	46.8	0.94	41.6	44.2
	Average	2.75		0.86		50.58
Muhlenbergia montana	E	0	0	0	0	0
Mountain muhly	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.02	0.09	0.02	0.9	0.5
	Average	0.01		0.01		0.13
Sitanion hystrix	E	0.02	0.07	0.02	0.9	0.5
Bottlebrush squirreltail	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.02	0.09	0.02	0.9	0.5
	Average	0.01		0.01		0.25
Sporobolus spp.	E	0.06	0.2	0.06	2.6	1.4
Dropseed	W	0.56	1.9	0.08	3.5	2.7
	S	0.04	0.1	0.04	2.0	1.1
	N	0	0	0	0	0
	Average	0.17		0.05		1.3
FORBS						
Artemisia carruthii	E	1.0	3.4	0.2	6.8	5.1
Carruth wormwood	W	5.6	19.1	0.4	19.3	19.2
	S	5.4	17.6	0.46	23.0	20.3
	N	6.9	29.2	0.38	16.8	23.0
	Average	4.72		0.36		16.9
Artemisia dracunculus	E	0.82	2.8	0.12	5.1	3.9
False tarragon	W	0.42	1.4	0.06	2.6	2.0
	S	0.1	0.3	0.02	1.0	0.7
	N	0.42	1.8	0.04	1.8	1.8
	Average	0.44		0.06		2.1
Chenopodium spp.	E	0.1	0.5	0.14	6.0	3.2
Lamb's quarters	W	0.06	0.2	0.06	2.6	1.4
	S	0.46	1.5	0.1	5	3.2
	N	0.14	0.6	0.06	2.7	1.6
	Average	0.19		0.09		2.35
Chrysopsis foliosa	E	0	0	0	0	0
Leafy golden aster	W	0	0	0	0	0
	S	0	0	0	0	0
	N	1.6	5.6	0.18	8.0	7.3
	Average	0.4		0.05		1.83
Crypantha jamesii	E	0	0	0	0	0
Hiddenflower	W	0	0	0	0	0
	S	0.2	0.7	0.04	2.0	1.3
	N	0	0	0	0	0
	Average	0.05		0.01		0.33
Descurainia spp.	E	0.02	0.07	0.02	0.9	0.5
Tansey-mustard	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.01		0.01		0.13

Table G-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Eriogonum cernuum	E	0.1	0.5	0.14	6.0	3.2
Buckwheat	W	.42	1.4	0.08	3.5	2.5
	S	0.42	1.4	0.18	9	5.2
	N	0.04	0.2	0.04	1.8	1.0
	Average	0.25		0.12		3.13
Gaillardia pulchella	E	0	0	0	0	0
Firewheel	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.12	0.5	0.04	1.8	1.1
	Average	0.03		0.01		0.28
Ipomopsis spp.	E	0.02	0.07	0.02	0.9	0.5
Gilia	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.01		0.01		0.13
Gilia longiflora	E	0				
Blue gilia	W	0.02	0.07	0.02	0.9	0.5
	S	0	0	0	0	0
	N	0.06	0.2	0.06	2.6	1.4
	Average	0.02		0.02		0.48
Helianthus petiolaris	E	0.2	0.8	0.08	3.4	2.1
Prairie clover	W	0.06	0.2	0.06	2.6	1.4
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.07		0.04		0.88
Haplopappus spinulosus	E	0.1	0.3	0.1	4.3	2.3
Spiny golden aster	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.03		0.03		0.58
Lappula spp.	E	0.5	1.6	0.1	4.3	2.9
Stickseed	W	0	0	0	0	0
	S	0.5	1.7	0.08	4.0	2.8
	N	0	0	0	0	0
	Average	0.25		0.05		1.42
Monarda pectinata	E	0.06	0.2	0.06	2.6	1.4
Ponymint	W	0.02	0.07	0.02	0.9	0.5
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.02		0.02		0.48
Oenothera sp.	E	0	0	0	0	0
Evening primrose	W	0.02	0.07	0.02	0.9	0.5
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.01		0.01		0.13
Pectis angustifolia	E	0.02	0.07	0.02	0.9	0.5
Fetid marigold	W	0	0	0	0	0
	S	0.02	0.07	0.02	1.0	0.5
	N	0	0	0	0	0
	Average	0.01		0.01		0.25
Penstemon spp.	E	0	0	0	0	0
Beardtongue	W	0.04	0.1	0.04	1.8	0.9
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.01		0.01		0.23
Plantago purshii	E	0.02	0.07	0.02	0.9	0.5
Woolly Indian wheat	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.01		0.01		0.13

Table G-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Salsola kali	E	0	0	0	0	0
Russian thistle	W	0.02	0.07	0.02	0.9	0.5
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.01		0.01		0.13
Tragopogon dubius	E	0	0	0	0	0
Goatsbeard	W	0	0	0	0	0
	S	0.1	0.3	0.02	1.0	0.7
	N	0	0	0	0	0
	Average	0.03		0.01		0.18
Vicia americana	E	0.06	0.2	0.06	2.6	1.4
American vetch	W	0116	0.5	0.16	7.0	3.8
	S	0.06	0.2	0.06	3.0	1.6
	N	0.3	1.3	0.14	6.2	3.7
	Average	0.09		0.11		2.63
SHRUB/TREES						
Chrysothamnus nauseosus	E	5.6	18.8	0.4	17.1	17.9
Chamisa	W	2.3	7.8	0.28	12.3	10.0
	S	2.1	6.7	0.18	9.0	7.9
	N	2.7	11.3	0.3	13.3	12.3
	Average	3.18		0.29		12.02
Juniperus monosperma	E	0	0	0	0	0
One-seed juniper	W	0	0	0	0	0
	S	1.5	4.9	0.04	2.0	3.4
	N	0	0	0	0	0
	Average	0.38		0.01		0.85

Appendix H.

Table H-1. Phytosociological data taken in 1982 for Field 5 (Pumice Mine Field) by transect.

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
GRAMINEAE GRAMINOIDES						
Aristida spp.	E	0	0	0	0	0
Three-awn	W	1.0	5.9	0.02	1.0	3.5
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.25		0.01		0.88
Aristida divaricarpa	E	0.8	3.9	0.22	11	7.4
Poverty three-awn	W	0.4	2.4	0.08	4.0	3.2
	S	1.2	6.9	0.06	3.1	5.0
	N	0.88	3.9	0.22	11	7.4
	Average	0.8		0.1		5.8
Bouteloua gracilis	E	3.5	20.4	0.2	11.0	15.7
Blue grama	W	0.5	3.0	0.02	1.0	2.0
	S	2.5	14.3	0.16	8.3	11.3
	N	5.2	22.9	0.16	8	15.5
	Average	2.93		0.14		11.13
Cynodon dactylon	E	1.3	7.6	0.08	4.4	6.0
Bermuda grass	W	0.3	1.8	0.02	1.0	1.4
	S	0.12	0.7	0.04	2.1	1.4
	N	0.5	2.0	0.08	4	3.0
	Average	0.56		0.06		2.95
Lycrus phleoides	E	0.1	0.6	0.02	1.1	0.8
Wolftail	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.02	0.09	0.02	1	0.5
	Average	0.03		0.01		0.33
Muhlenbergia montana	E	1.2	7.1	0.12	6.6	6.8
Mountain muhly	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.3		0.03		1.7
Munroa squarosa	E	0	0	0	0	0
False buffalo grass	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.02	0.09	0.02	1	0.5
	Average	0.01		0.01		0.13
Sitanion hystrix	E	0.3	1.6	0.14	7.7	4.7
Bottlebrush squirreltail	W	0.6	3.5	0.04	2.0	2.8
	S	0.3	1.5	0.12	6.3	3.9
	N	0	0	0	0	0
	Average	0.3		0.08		2.85
Sporobolus spp.	E	2.2	12.6	0.48	26.4	19.5
Dropseed	W	8.2	48.8	0.86	43.4	46.1
	S	7.8	44.4	0.76	39.6	42.0
	N	3.9	39.5	0.7	35	37.2
	Average	5.52		0.7		36.2
FORBS						
Artemisia dracunculus	E	0.2	1.3	0.04	2.2	1.7
False tarragon	W	1.3	7.8	0.2	10.1	9.0
	S	1.9	10.8	0.26	12.5	12.2
	N	3.0	12.2	0.26	13	13.1
	Average	1.6		0.19		9.0

Table H-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Artemisia frigida	E	0	0	0	0	0
Estafiata	W	0.1	0.6	0.02	1.0	0.8
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.03		0.01		0.2
Artemisia ludoviciana	E	0	0	0	0	0
Louisiana wormwood	W	0	0	0	0	0
	S	0.002	0.01	0.02	1.04	0.5
	N	0	0	0	0	0
	Average	0.001		0.01		0.13
Bahia dissecta	E	0	0	0	0	0
Wild chrysanthemum	W	0.02	0.1	0.02	1.0	0.6
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.01		0.01		0.15
Chenopodium spp.	E	0.1	0.6	0.02	1.1	0.8
Lamb's quarters	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.03		0.01		0.2
Gilia longiflora	E	0	0	0	0	0
Blue gilia	W	0	0	0	0	0
	S	0.02	0.1	0.02	1.04	0.6
	N	0	0	0	0	0
	Average	0.01		0.01		0.15
Gutierrezia sarothrae	E	5.0	29.2	0.36	19.8	24.5
Snakeweed	W	3.5	20.6	0.5	25.3	22.9
	S	2.4	12.6	0.32	16.7	15.1
	N	3.5	15.3	0.34	17	16.1
	Average	3.6		0.38		19.65
Haplopappus spinulosus	E	0.12	0.7	0.04	2.2	1.4
Spiny goldenweed	W	0.3	2.0	0.12	6.1	4.0
	S	0.1	0.7	0.06	3.1	1.9
	N	0.12	0.5	0.04	2	1.3
	Average	0.16		0.07		2.15
Coryphantha vivipara	E	0.002	0.01	0.02	1.1	0.6
Pincushion cactus	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.001		0.01		0.15
Opuntia spp.	E	0.02	0.1	0.02	1.1	0.6
Prickly pear cactus	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.1	0.4	0.02	1	0.7
	Average	0.03		0.01		0.33
Opuntia imbricata	E	0	0	0	0	0
Walking-stick cholla	W	0	0	0	0	0
	S	0.5	2.9	0.02	1.0	2.0
	N	0	0	0	0	0
	Average	0.13		0.01		0.5

Table H-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Salsola kali	E	1.0	6.0	0.14	7.7	6.9
Russian thistle	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.25		0.04		1.73
Spheralcea sp.	E	0	0	0	0	0
Globemallow	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.06	0.3	0.06	3	1.6
	Average	0.02		0.02		0.4
Tragopogon dubius	E	0	0	0	0	0
Goatsbeard	W	0	0	0	0	0
	S	0.02	0.1	0.02	1.0	0.6
	N	0	0	0	0	0
	Average	0.01		0.01		0.15
SHRUBS/TREES						
Chrysothamnus nauseosus	N	0.4	1.8	0.06	3	2.4
Chamisa	E	0	0	0	0	0
	W	0	0	0	0	0
	S	0.1	0.6	0.02	1.04	0.8
	N	0	0	0	0	0
	Average	0.1		0.02		0.6

Appendix I.

Table I-1. Phytosociological data taken in 1982 for Field 6 (Serna Field) by transect.

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
GRAMINEAE GRAMINOIDES						
Agrostis sp.	E	0	0	0	0	0
Redtop	W	0	0	0	0	0
	S	0	0	0	0	0
	N	3.30	11.32	0.14	5.88	8.60
	Average	**0.83**		**0.04**		**2.15**
Bouteloua gracilis	E	5.50	20.27	0.22	7.29	13.78
Blue grama	W	1.10	5.95	0.06	2.48	4.22
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**1.65**		**0.07**		**4.25**
Bromus tectorum	E	0.10	0.38	0.06	1.99	1.18
Cheatgrass	W	0.80	4.32	0.02	0.83	2.57
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.23**		**0.02**		**0.94**
Cynodon dactylon	E	0	0	0	0	0
Bermuda grass	W	0.20	1.08	0.02	0.83	0.95
	S	0.30	1.77	0.04	1.66	1.72
	N	0	0	0	0	0
	Average	**0.13**		**0.02**		**0.67**
Panicum capillare	E	0	0	0	0	0
Witchgrass	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.002	0.007	0.02	0.84	0.42
	Average	**0.001**		**0.01**		**0.11**
Poa spp.	E	0.30	1.11	0.04	1.32	1.22
Bluegrass	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.30	1.02	0.02	0.84	0.93
	Average	**0.15**		**0.02**		**0.54**
Sporobolus cryptandrus	E	2.91	10.72	0.62	20.53	15.63
Sand dropseed	W	0.19	1.05	0.24	9.92	5.48
	S	0.18	1.08	0.14	5.83	3.46
	N	0.47	1.62	0.26	10.92	6.27
	Average	**0.94**		**0.32**		**7.71**
FORBS						
Ambrosia spp.	E	0.002	0.007	0.04	1.32	0.67
Ragweed	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.001**		**0.01**		**0.17**
Aster spp.	E	0	0	0	0	0
Aster	W	0	0	0	0	0
	S	0.20	1.17	0.02	0.83	1.01
	N	0.002	0.007	0.02	0.84	0.42
	Average	**0.05**		**0.01**		**0.36**
Artemisia carruthii	E	5.48	21.52	0.58	19.21	20.36
Carruth wormwood	W	8.22	44.39	0.56	23.14	33.77
	S	8.24	48.52	0.62	25.83	37.18
	N	10.40	35.67	0.70	29.41	32.54
	Average	**8.09**		**0.62**		**30.96**
Artemisia dracunculus	E	2.50	9.22	0.32	10.59	9.91
False tarragon	W	2.80	15.14	0.48	19.83	17.49
	S	4.82	28.38	0.60	25.00	26.69
	N	14.40	42.51	0.58	24.37	33.44
	Average	**6.13**		**0.50**		**21.88**

Table I-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Artemisia frigida	E	7.40	27.26	0.32	10.59	18.93
Estafiata	W	2.00	10.80	0.12	4.96	7.88
	S	0	0	0	0	0
	N	0.50	1.72	0.06	2.52	2.12
	Average	2.48		0.13		7.23
Chenopodium fendleri	E	0	0	0	0	0
Lamb's quarters	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.10	0.34	0.02	0.84	0.59
	Average	0.03		0.01		0.15
Chrysopsis foliosa	E	0.70	2.57	0.12	3.97	3.28
Goldenweed	W	0.82	4.43	0.12	4.96	4.69
	S	0.10	0.58	0.02	0.83	0.71
	N	0.22	0.75	0.04	1.68	1.22
	Average	0.46		0.08		2.48
Eriogonum cernuum	E	0	0	0	0	0
Nodding buckwheat	W	0	0	0	0	0
	S	0.60	3.53	0.02	0.83	2.18
	N	0.20	0.69	0.08	3.36	2.03
	Average	0.20		0.03		1.05
Haplopappus spinulosus	E	0.92	3.39	0.22	7.28	5.31
Spiny goldenweed	W	0.10	0.54	0.02	0.83	0.68
	S	0.004	0.02	0.04	1.66	0.85
	N	0	0	0	0	0
	Average	0.256		0.07		1.71
Lupinus caudatus	E	0.70	2.60	0.20	6.62	4.61
Lupine	W	0.80	4.33	0.26	10.74	7.54
	S	0.84	4.95	0.16	6.66	5.81
	N	0.10	0.34	0.02	0.84	0.59
	Average	0.61		0.16		4.64
Monarda pectinata	E	0.03	0.10	0.12	3.97	2.03
Ponymint	W	0.12	0.66	0.06	2.48	1.56
	S	0.20	1.19	0.06	2.50	1.84
	N	0.23	0.78	0.16	6.72	3.75
	Average	0.15		0.10		2.30
Oenothera sp.	E	0	0	0	0	0
Evening primrose	W	1.30	7.03	0.30	12.39	9.71
	S	0.86	5.11	0.26	10.83	7.97
	N	0.54	1.85	0.08	3.36	2.60
	Average	0.68		0.16		5.07
Spheralcea sp.	E	0	0	0	0	0
Globemallow	W	0	0	0	0	0
	S	0.004	0.02	0.04	1.66	0.85
	N	0	0	0	0	0
	Average	0.001		0.01		0.21
Vicia americana	E	0.23	0.84	0.16	5.29	3.07
American vetch	W	0.23	1.24	0.16	6.61	3.92
	S	0.31	1.84	0.26	10.83	6.34
	N	0.05	0.16	0.12	5.04	2.60
	Average	0.21		0.18		3.98
Unknown	E	0	0	0	0	0
	W	0.02	0.11	0.02	0.83	0.47
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	0.01		0.01		0.12

Appendix J.

Table J-1 Phytosociological data taken in 1982 for Field 7 (Montova Field) by transect.

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
GRAMINEAE GRAMINOIDES						
Agrostis spp.	E	0	0	0	0	0
Redtop	W	0	0	0	0	0
	S	0.10	0.51	0.02	0.71	0.61
	N	0	0	0	0	0
	Average	**0.03**		**0.01**		**0.15**
Aristida spp.	E	0.22	0.70	0.06	2.26	1.48
Three-awn	W	0.10	0.52	0.02	0.91	0.71
	S	1.50	7.66	0.10	3.57	5.62
	N	0	0	0	0	0
	Average	**0.46**		**0.05**		**1.95**
Bouteloua gracilis	E	10.96	34.93	0.74	27.82	31.37
Blue grama	W	5.70	29.66	0.62	28.18	28.91
	S	4.52	23.09	0.42	15.00	19.04
	N	6.74	43.10	0.86	35.96	39.03
	Average	**6.98**		**0.66**		**29.59**
Muhlenbergia montana	E	0	0	0	0	0
Mountain muhly	W	1.60	8.33	0.06	2.73	5.53
	S	0.86	4.39	0.16	5.71	5.05
	N	0.40	2.56	0.04	1.63	2.10
	Average	**0.72**		**0.07**		**3.17**
Poa spp.	E	0	0	0	0	0
Bluegrass	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.30	1.92	0.04	1.63	1.77
	Average	**0.08**		**0.01**		**0.44**
Sitanion hystrix	E	0.24	0.77	0.08	3.01	1.89
Bottlebrush squirreltail	W	0.12	0.62	0.04	1.82	1.22
	S	0.22	1.12	0.14	5.00	3.06
	N	0	0	0	0	0
	Average	**0.15**		**0.07**		**1.54**
FORBS						
Artemisia carruthii	E	7.34	23.40	0.98	36.84	30.12
Carruth wormwood	W	7.92	41.20	0.80	36.36	38.79
	S	4.16	21.25	0.62	22.14	21.70
	N	4.02	25.70	0.92	37.40	31.55
	Average	**5.86**		**0.83**		**30.54**
Artemisia dracunculus	E	0.64	2.04	0.08	3.01	2.52
False tarragon	W	0.64	3.33	0.10	4.55	3.94
	S	0.44	2.25	0.08	2.86	2.55
	N	0	0	0	0	0
	Average	**0.43**		**0.07**		**2.25**

Table J-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Bahia dissecta	E	0	0	0	0	0
Wild chrysanthemum	W	0	0	0	0	0
	S	1.10	0.51	0.02	0.71	0.61
	N	0	0	0	0	0
	Average	**0.28**		**0.01**		**0.15**
Castilleja integra	E	0.02	0.06	0.02	0.75	0.41
Indian paintbrush	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.10	0.64	0.02	0.81	0.73
	Average	**0.03**		**0.01**		**0.29**
Chenopodium spp.	E	0.04	0.13	0.04	1.50	0.82
Lamb's quarters	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.01**		**0.01**		**0.21**
Chrysopsis foliosa	E	0	0	0	0	0
Leafy golden aster	W	0.24	1.25	0.06	27.73	1.99
	S	1.12	5.72	0.16	5.71	5.72
	N	0	0	0	0	0
	Average	**0.34**		**0.06**		**1.93**
Erigeron spp.	E	0.14	0.45	0.16	2.26	1.35
Fleabane daisy	W	0	0	0	0	0
	S	0.10	0.41	0.02	0.77	0.59
	N	0	0	0	0	0
	Average	**0.06**		**0.05**		**0.49**
Eriogonum spp.	E	0.10	0.32	0.02	0.75	0.54
Buckwheat	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.44	2.81	0.20	8.13	5.47
	Average	**0.14**		**0.06**		**1.50**
Guara spp.	E	0.08	0.26	0.08	3.01	1.63
Scarlet bee blossom	W	0	0	0	0	0
	S	0.24	1.23	0.08	2.86	2.04
	N	0.02	0.13	0.02	0.81	0.47
	Average	**0.09**		**0.05**		**1.04**
Gutierrezia sarothrae	E	1.00	3.19	0.14	5.26	4.23
Snakeweed	W	1.02	5.31	0.12	5.46	5.38
	S	1.18	6.03	0.18	6.43	6.23
	N	0.30	1.92	0.06	2.44	2.18
	Average	**0.88**		**0.13**		**4.51**
Hymenoxys richardsonii	E	0.14	0.44	0.06	2.26	1.35
Pingüe	W	1.80	9.37	0.30	13.64	11.50
	S	3.48	17.77	0.42	15.00	16.39
	N	2.30	14.71	.026	15.57	12.64
	Average	**1.93**		**0.20**		**10.47**
Hymenopappus spp.	E	0.12	0.38	0.04	1.50	0.94
White ragweed	W	0	0	0	0	0
	S	0.04	0.20	0.04	1.43	0.82
	N	0	0	0	0	0
	Average	**0.04**		**0.02**		**0.44**

Table J-1 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Melilotus spp.	E	0	0	0	0	0
Sweet clover	W	0	0	0	0	0
	S	0.20	1.02	0.04	1.43	1.23
	N	0	0	0	0	0
	Average	**0.05**		**0.01**		**0.31**
Linum spp.	E	0.02	0.06	0.02	0.75	0.41
Flax	W	0.02	0.10	0.02	0.91	0.51
	S	0.08	0.41	0.08	2.86	1.63
	N	0	0	0	0	0
	Average	**0.03**		**0.03**		**0.64**
Lithospermum multiflorum	E	0	0	0	0	0
Puccoon	W	0	0	0	0	0
	S	0.10	0.51	0.02	0.71	0.61
	N	0	0	0	0	0
	Average	**0.03**		**0.01**		**0.15**
Orthocarpus spp.	E	0.02	0.06	0.02	0.75	0.41
Owl-clover	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.01**		**0.01**		**0.10**
Penstemon spp.	E	0.02	0.06	0.02	0.75	0.41
Beardtongue	W	0.02	0.10	0.02	0.91	0.51
	S	0.20	1.02	0.04	1.43	1.23
	N	0	0	0	0	0
	Average	**0.06**		**0.02**		**0.54**
Plantago purshii	E	0.06	0.19	0.06	2.26	1.22
Woolly Indian wheat	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.02**		**0.02**		**0.31**
Thelesperma trifidum	E	0	0	0	0	0
Greenthread	W	0	0	0	0	0
	S	0.02	0.10	0.02	0.71	0.41
	N	0	0	0	0	0
	Average	**0.01**		**0.01**		**0.10**
Stephanomeria spp.	E	0	0	0	0	0
Skeletonweed	W	0	0	0	0	0
	S	0.10	0.51	0.02	0.71	0.61
	N	0	0	0	0	0
	Average	**0.03**		**0.01**		**0.15**
SHRUBS/TREES						
Juniperus monosperma	E	0	0	0	0	0
One-seed juniper	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.02	0.03	0.02	0.81	0.47
	Average	**0.01**		**0.01**		**0.12**
SHRUBS/TREES						
Quercus gambelii	E	10.00	31.87	0.10	3.76	17.81
Gambel oak	W	0	0	0	0	0
	S	0.10	0.51	0.02	0.71	0.61
	N	1.00	6.39	0.02	1.33	5.50
	Average	**2.78**		**0.04**		**5.98**
Rosa woodsii	E	0	0	0	0	0
Wild rose	W	0	0	0	0	0
	S	0.72	6.68	0.10	3.57	5.62
	N	0	0	0	0	0
	Average	**0.18**		**0.03**		**1.41**

Table J-2. Phytosociological data taken in 1993 for Field 7 (Montoya Field) by transect.

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
GRAMINEAE GRAMINOIDES						
Agropyron spp.	E	1.0	2.54	0.1	4.46	3.5
Wheatgrass	W	0	0	0	0	0
	Average	0.5		0.05		1.75
Androsace septentrionalis	E	0	0	0	0	0
Rock jasmine	W	0.10	0.54	0.02	1.10	0.82
	Average	0.05		0.01		0.41
Aristida longiseta	E	0	0	0	0	0
Three-awn	W	1.3	0.99	0.08	4.4	5.69
	Average	0.65		0.04		2.85
Bouteloua gracilis	E	5.8	14.72	0.22	9.82	12.27
Blue grama	W	5.1	27.4	0.3	16.48	21.94
	Average	5.45		0.26		17.11
Muhlenbergia montana	E	12.4	31.47	0.28	12.5	22.98
Mountain muhly	W	0.30	1.61	0.14	2.2	1.9
	Average	6.35		0.21		11.94
Poa fendleri	E	1.9	4.82	0.10	4.46	4.64
Bluegrass	W	0	0	0	0	0
	Average	0.95		0.05		2.32
Setaria sp.	E	0.5	1.27	0.02	0.89	1.08
Bristlegrass	W	0	0	0	0	0
	Average	0.25		0.01		0.54
Sitanion hystrix	E	0	0	0	0	0
Bottlebrush squirreltail	W	0.10	0.54	0.02	1.1	0.82
	Average	0.05		0.01		0.41
Elymus canadensis	E	0	0	0	0	0
Canadian wildrye	W	0.10	0.54	0.02	1.1	0.82
	Average	0.05		0.01		0.41
FORBS						
Antennaria parvifolia	E	0	0	0	0	0
Pussytoes	W	0.20	1.07	0.02	1.1	0
	Average	0.10		0.01		0
Artemisia carruthii	E	2.9	7.36	0.4	17.86	12.61
Carruth wormwood	W	1.2	6.47	0.22	12.09	9.28
	Average	2.05		0.31		10.95
Chrysopsis foliosa	E	0.20	0.51	0.02	0.89	0.70
Leafy golden aster	W	0	0	0	0	0
	Average	0.10		0.01		0.35
Chrysopsis villosa	E	1.0	2.54	0.12	5.36	3.95
Golden aster	W	0.20	1.07	0.04	2.2	1.64
	Average	0.60		0.08		2.8
Erigeron divergens	E	0.30	0.76	0.02	0.89	0.83
Fleabane daisy	W	0.20	1.07	0.06	3.3	2.19
	Average	0.25		0.04		1.51
Grindelia aphanactis	E	0	0	0	0	0
Gumweed	W	0.40	2.15	0.02	1.1	1.62
	Average	0.20		0.01		0.81
Gutierrezia sarothrae	E	0.5	1.27	0.02	0.89	1.08
Snakeweed	W	1.6	8.6	0.14	7.69	8.14
	Average	1.05		0.08		4.61
Franseria spp.	E	0.40	1.02	0.06	2.68	1.85
Ragweed	W	0	0.01	0.02	1.10	0.55
	Average	0.20		0.04		1.20
Helianthus petiolaris	E	1.0	2.54	0.02	0.89	1.72
Prairie sunflower	W	0	0	0	0	0
	Average	0.50		0.01		0.86

Table J-2 (cont.)

SPECIES	TRANSECT	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Hymenoxys richardsonii	E	0	0	0	0	0
Pingüe	W	3.2	17.21	0.40	21.98	19.59
	Average	1.6		0.20		9.8
Ipomopsis aggregata	E	0.1	0.25	0.02	0.89	0.57
Scarlet trumpet	W	1.60	8.61	0.18	9.89	9.25
	Average	0.85		0.10		4.91
Melilotus albus	E	1.0	2.54	0.10	4.46	3.50
White sweet clover	W	1.3	6.99	0.12	6.59	6.79
	Average	1.15		0.11		5.15
Melilotus officinalis	E	0.3	0.76	0.02	0.89	0.83
Yellow sweet clover	W	0	0	0	0	0
	Average	0.15		0.01		0.42
Melilotus spp.	E	0.3	0.77	0.06	2.68	1.72
Sweet clover	W	0	0	0	0	0
	Average	0.15		0.03		0.86
Linum neomexicanum	E	0.1	0.25	0.02	0.89	0.57
New Mexico flax	W	0	0	0	0	0
	Average	0.05		0.01		0.29
Solanum spp.	E	0.4	1.02	0.04	1.8	1.4
Nightshade	W	0	0	0	0	0
	Average	0.2		0.02		0.7
Thelesperma trifidum	E	0.30	0.76	0.04	1.79	1.27
Greenthread	W	0	0	0	0	0
	Average	0.15		0.02		0.63
Taraxicum officinale	E	0.3	0.76	0.02	0.89	0.83
Common dandelion	W	0	0	0	0	0
	Average	0.15	0.38	0.01	0.45	0.42
Verbascum thapsus	E	0.2	0.51	0.04	1.79	1.15
Mullein	W	0	0	0	0	0
	Average	0.1		0.02		0.58
Unknown 1	E	2.5	6.34	0.10	4.46	5.40
	W.	0	0	0	0	0
	Average	1.25		0.05		2.7
Unknown 2	E	0.40	1.02	0.06	2.68	1.85
	W	0	0	0	0	0
	Average	0.20		0.03		0.92
Unknown 3	E	0.70	1.78	0.02	0.89	1.33
	W	0	0	0	0	0
	Average	0.35		0.01		0.67
Unknown 5	E	0.30	0.76	0.02	0.89	0.83
	W	0	0	0	0	0
	Average	0.15		0.01		0.42
Unknown 7	E	0.10	0.25	0.02	0.89	0.57
	W	0	0	0	0	0
	Average	0.05		0.01		0.29
Unknown 8	E	2.7	6.85	0.14	6.25	6.55
	W	0	0	0	0	0
	Average	1.35		0.07		3.28
Unknown 9	E	0	0	0	0	0.82
	W	0.10	0.54	0.02	1.10	0
	Average	0.05		0.01		0.41

Appendix K.

Table K-1. Phytosociological data taken in 1982 for Field 8 (Montova y Gomez Field).

SPECIES	FIELD	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
GRAMINEAE GRAMINOIDES						
Agrostis spp.	E	0	0	0	0	0
Redtop	W	0	0	0	0	0
	S	6.60	26.89	0.20	7.69	17.29
	N	0	0	0	0	0
	Average	**1.65**		**0.05**		**4.32**
Andropogon spp.	E	0	0	0	0	0
Wheatgrass	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.30	2.11	0.02	1.06	1.58
	Average	**0.08**		**0.01**		**0.40**
Aristida barbatus	E	0	0	0	0	0
Poverty three-awn	W	0.40	1.92	0.06	1.84	1.88
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.10**	**0.48**	**0.02**	**0.46**	**0.47**
Bouteloua gracilis	E	3.80	17.75	0.18	8.25	13.00
Blue grama	W	1.22	5.85	0.10	3.06	4.46
	S	0.20	0.81	0.02	0.77	0.79
	N	5.26	31.09	0.52	27.66	32.37
	Average	**2.62**		**0.21**		**12.66**
Muhlenbergia montana	E	0	0	0	0	0
Mountain muhly	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.10	0.71	0.02	1.06	0.88
	Average	**0.03**		**0.01**		**0.22**
Sitanion hystrix	E	0.04	0.16	0.04	1.83	1.01
Bottlebrush squirreltail	W	0.33	1.58	0.26	7.97	4.78
	S	0.12	0.51	0.08	2.31	1.40
	N	0.02	0.14	0.02	1.06	0.60
	Average	**0.13**		**0.10**		**1.95**
Sporobolus spp.	E	0.02	0.09	0.02	0.92	0.51
Dropseed	W	0.18	0.88	0.14	4.29	2.59
	S	0.12	0.51	0.18	3.08	1.79
	N	0	0	0	0	0
	Average	**0.08**		**0.09**		**1.22**
FORBS						
Artemisia carruthii	E	10.16	47.42	0.84	38.53	43.98
Carruth wormwood	W	7.52	36.06	0.66	20.24	28.16
	S	9.12	37.15	0.70	29.92	32.04
	N	1.46	10.31	0.24	12.77	11.54
	Average	**7.06**		**0.61**		**28.93**
Artemisia dracunculus	E	3.62	16.89	0.32	14.68	15.79
False tarragon	W	1.44	6.91	0.16	4.91	5.91
	S	2.26	9.22	0.26	10.00	9.61
	N	0	0	0	0	0
	Average	**1.83**		**0.19**		**7.83**
Chrysopsis foliosa	E	0.24	1.13	0.10	4.59	2.86
Leafy golden aster	W	4.07	19.50	0.58	17.79	18.64
	S	1.09	4.22	0.38	14.62	9.52
	N	2.14	15.11	0.22	11.70	13.40
	Average	**1.89**		**0.32**		**11.11**
Erigeron flagellaris	E	0.45	2.08	0.18	8.26	5.17
Spreading fleabane	W	1.08	5.19	0.22	6.75	5.97
	S	0.69	2.81	0.24	9.23	6.02
	N	0.83	5.84	0.30	15.96	10.90
	Average	**0.76**		**0.24**		**7.02**
Guara spp.	E	0.002	0.01	0.02	0.92	0.46
Scarlet bee blossom	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.001**		**0.01**		**0.12**

Table K-1 (cont.)

SPECIES	FIELD	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Guterrezia sarothrae	E	1.20	5.60	0.02	0.92	0.46
Snakeweed	W	0	0	0	0	0
	S	0	0	0	0	0
	N	1.32	9.31	0.10	5.32	7.31
	Average	**0.63**		**0.03**		**1.94**
Helianthus annus	E	0	0	0	0	0
Common sunflower	W	0	0	0	0	0
	S	0.10	0.41	0.02	0.77	0.59
	N	0	0	0	0	0
	Average	**0.03**		**0.01**		**0.15**
Hymenopappus spp.	E	0	0	0	0	0
White ragweed	W	0.004	0.02	0.04	1.23	0.62
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.001**		**0.01**		**0.16**
Hymenoxys richardsonii	E	0.64	2.98	0.10	4.59	3.79
Pingüe	W	2.54	12.18	0.16	4.91	8.54
	S	1.90	7.74	0.14	5.39	6.56
	N	1.50	10.57	0.06	3.19	6.88
	Average	**1.65**		**0.12**		**6.44**
Lepidium spp.	E	0	0	0	0	0
Peppergrass	W	0.004	0.02	0.04	1.23	0.62
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.001**		**0.01**		**0.16**
Liatris punctata	E	0	0	0	0	0
Gayfeather	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.02	0.14	0.02	1.06	0.60
	Average	**0.01**		**0.01**		**0.15**
Linum spp.	E	0.002	0.01	0.02	0.92	0.46
Flax	W	0.004	0.02	0.04	1.23	0.62
	S	0.10	0.41	0.02	0.77	0.59
	N	0.002	0.01	0.02	1.06	0.54
	Average	**0.03**		**0.03**		**0.55**
Mentzelia pumila	E	0	0	0	0	0
Stickleaf	W	0.02	0.01	0.02	0.61	0.36
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.01**		**0.01**		**0.09**
Oenothera spp.	E	0.75	3.50	0.32	14.68	9.09
Evening primrose	W	1.58	7.57	0.56	17.18	12.37
	S	0.61	2.49	0.32	12.31	7.40
	N	0.40	2.85	0.20	10.64	6.74
	Average	**0.84**		**0.35**		**8.90**
Penstemon spp.	E	0	0	0	0	0
Beardtongue	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.002	0.01	0.02	1.06	0.54
	Average	**0.001**		**0.01**		**0.14**
Salsola kali	E	0	0	0	0	0
Russian thistle	W	0	0	0	0	0
	S	0.002	0.01	0.02	0.77	0.39
	N	0	0	0	0	0
	Average	**0.001**		**0.01**		**0.10**
Thelesperma trifidum	E	0	0	0	0	0
Greenthread	W	0	0	0	0	0
	S	0.02	0.08	0.02	0.77	0.43
	N	0	0	0	0	0
	Average	**0.01**		**0.01**		**0.11**

Table K-1 (cont.)

SPECIES	FIELD	COVER (%)	RELATIVE COVER	FREQUENCY	RELATIVE FREQUENCY	DOMINANCE INDEX
FORBS						
Tragopogon dubius	E	0	0	0	0	0
Goatsbeard	W	0.02	0.01	0.02	0.61	0.36
	S	0	0	0	0	0
	N	0	0	0	0	0
	Average	**0.01**		**0.01**		**0.09**
Verbascum thapsus	E	0	0	0	0	0
Mullein	W	0	0	0	0	0
	S	0.20	0.82	0.02	0.77	0.79
	N	0	0	0	0	0
	Average	**0.05**		**0.01**		**0.20**
Vicia americana	E	0	0	0	0	0
American vetch	W	0.04	0.17	0.18	5.52	2.85
	S	0.006	0.02	0.06	2.31	1.17
	N	0.002	0.01	0.02	1.06	0.54
	Average	**0.01**		**0.07**		**1.14**
Yucca angustissima.	E	0	0	0	0	0
Narrowleaf yucca	W	0	0	0	0	0
	S	0	0	0	0	0
	N	0.52	3.67	0.04	2.13	2.90
	Average	**0.13**		**0.01**		**0.73**

Table K-2. Phytosociological data taken in 1993 for Field 8 (Montova y Gomez Field).

SPECIES	FIELD	COVER (%)	RELATIVE	FREQUENCY	RELATIVE	IMPORTANCE
GRAMINEAE						
Bouteloua gracilis	E	13.40	34.41	0.56	16.97	25.69
Blue grama	W	6.98	13.98	0.22	7.38	10.68
	Average	**10.19**		**0.39**		**18.19**
Blephaneuron tricholepis	E	0.20	0.51	0.02	0.61	0.56
Pine dropseed	W	0	0	0	0	0
	Average	**0.10**		**0.01**		**0.28**
Muhlenbergia montana	E	1.92	4.93	0.18	5.45	5.19
Mountain muhly	W	16.50	33.05	0.54	18.12	25.590
	Average	**9.21**		**0.36**		**15.39**
Schizachyrium scoparius	E	0	0	0	0	0
Little bluestem	W	1.20	2.40	0.06	2.01	2.21
	Average	**0.60**		**0.03**		**1.11**
Sitanion hystrix	E	0.98	2.52	0.14	4.24	3.38
Bottlebrush squirreltail	W	0	0	0	0	0
	Average	**0.49**		**0.07**		**1.69**
Sporobolus cryptandrus	E	0.30	0.77	0.04	1.21	0.99
Sand dropseed	W	0.10	0.20	0.02	0.67	0.44
	Average	**0.20**		**0.03**		**0.72**
FORBS						
Artemisia carruthii	E	6.14	15.77	0.62	18.79	17.28
Carruth wormwood	W	2.74	5.49	0.42	14.09	9.79
	Average	**4.44**		**0.52**		**13.54**
Artemisia dracunculus	E	1.52	3.90	0.16	4.85	4.38
False tarragon	W	1.10	2.20	0.12	4.03	3.12
	Average	**1.31**		**0.14**		**3.75**
Artemisia tridentata	E	2.20	5.65	0.22	6.67	6.16
Big sagebrush	W	0.10	0.20	0.02	0.67	0.44
	Average	**1.60**		**0.12**		**3.30**
Bahia dissecta	E	0.30	0.77	0.04	1.21	0.99
Wild chrysanthemum	W	0.20	0.40	0.04	1.34	0.87
	Average	**0.25**		**0.04**		**0.93**

Table K-2 (cont.)

SPECIES	FIELD	COVER (%)	RELATIVE	FREQUENCY	RELATIVE	IMPORTANCE
FORB						
Chrysopsis foliosa	E	4.02	10.32	0.42	12.73	11.53
Leafy golden aster	W	5.20	10.42	0.40	13.42	11.92
	Average	**4.61**		**0.41**		**11.73**
Conyza canadensis	E					
Horseweed	W	0.10	0.20	0.02	0.67	0.44
	Average	**0.05**		**0.01**		**0.22**
Erigeron divergens	E	0.40	1.03	0.04	1.21	1.12
Fleabane daisy	W	0	0	0	0	0
	Average	**0.20**		**0.02**		**0.56**
Erigeron flagellaris	E	5.30	13.61	0.54	16.36	14.99
Spreading fleabane	W	10.50	21.03	0.62	20.81	20.92
	Average	**7.90**		**0.58**		**17.96**
Grindelia aphanactis	E	0	0	0	0	0
Gumweed	W	0.10	0.20	0.02	0.67	0.44
	Average	**0.05**		**0.01**		**0.22**
Hymenoxys richardsonii	E	1.42	3.65	0.14	4.24	3.94
Pingue	W	0.50	1.00	0.10	3.36	2.18
	Average	**0.96**		**0.12**		**3.06**
Liatris punctatus	E	0	0	0	0	0
Gayfeather	W	0.20	0.40	0.02	0.67	0.54
	Average	**0.10**		**0.01**		**0.27**
Lotus wrightii	E	0	0	0	0	0
Deervetch	W	1.60	3.21	0.08	2.68	2.94
	Average	**0.80**		**0.04**		**1.47**
Melilotus spp.	E	0	0	0	0	0
Sweet clover	W	0.20	0.40	0.04	1.34	0.87
	Average	**0.10**		**0.02**		**0.44**
Penstemon spp.	E	0	0	0	0	0
Beardtongue	W	0.10	0.20	0.02	0.67	0.44
	Average	**0.05**		**0.01**		**0.22**
Potentilla spp.	E	0	0	0	0	0
Cinquefoil	W	0.50	1.0	0.06	2.01	1.51
	Average	**0.25**		**0.03**		**0.76**
Potentilla fruticosa	E	0	0	0	0	0
Shrubby potentilla	W	0.20	0.40	0.02	0.67	0.54
	Average	**0.10**		**0.01**		**0.27**
Thelesperma trifidum	E	0.10	0.26	0.02	0.61	0.43
Greenthread	W	0	0	0	0	0
	Average	**0.05**		**0.01**		**0.22**
Vicia americana	E	0.74	1.90	0.16	4.85	3.37
American vetch	W	1.20	2.40	0.12	4.03	3.22
	Average	**0.97**		**0.14**		**3.30**
Verbascum thapsus	E	0	0	0	0	0
Mullein	W	0.60	1.20	0.02	0.67	0.94
	Average	**0.30**		**0.01**		**0.47**

Appendix L.

Table L-1. Biological information about certain species.

Information	Species							
	AGSM[a]	AGDE	SCSC	ARCA	ARDR	ARLU	BOGR	BRTE
Origin	native	introduced	native	native	native	native	native	introduced
Habit	grass	grass	grass	forb	forb	forb	grass	grass
Life cycle	perennial	perennial	perennial	perennial	perennial	perennial	perennial	annual
Reproduction	veg/seed	seed	veg/seed	seed	veg/seed	veg/seed	-	seed
Carbon dioxide	C3[b]	C3	C4	C3	-	C3	C4	C3
Habitat	dry/moist	dry/moist	dry		dry	dry	dry	dry
Mycorrhizal	endomy.						endomy.	endomy.
Nodule forming	no	-	no	-	-	reported	no	no
Nitrogen fixing	no	-	no	-	-	yes	no	no
Edible					yes	yes		
Weediness	nonweedy	colonizing	nonweedy	nonweedy	nonweedy	nonweedy	nonweedy	economic
Potential biomass	medium	high	medium high		medium	medium	low medium	low
Establishment	medium	low medium	medium high		low	low medium	medium high	low
Seed availability								
Rooting depths								

a. AGSM = *Agropyron smithii* (western wheatgrass), AGDE = *Agropyron desertorum* (Russian wheatgrass), SCSC = *Schizachyrium scoparius* (little bluestem), ARCA = *Artemisia carruthii* (Carruth wormwood), ARDR = *Artemisia dracunculs* (false tarragon), ARLU = *Artemisia ludoviciana* (Louisiana wormwood), BOGR = *Bouteloua gracilis* (blue grama), BRTE = *Bromus tectorum* (cheatgrass), and CHFO = *Chrysopsis foliosa* (leafy golden aster).

b. C3 = The plant uses a pathway where the first step in CO^2 fixation involves the formation of three-carbon compounds, the stomata are opened, and CO^2 fixation is in the daylight. C4 = The plant uses a pathway where the first step in CO^2 fixation involves the formation of four-carbon compounds, the stomata are opened, and CO^2 fixation is in the daylight.

Information	Species								
	ERDI[a]	ERFL	GUSA	HASP	HYRI	LIPU	LUCA	MEX	MUMO
Origin	native	native	native	native	native	native	native	introduced	native
Habit	forb	forb	shrub	forb	forb	forb	forb	forb	grass
Life cycle	biennial	perennial/ biennial	perennial	perennial	perennial	perennial	perennial	annual	perennial
Reproduction	seed	veg./seed	seed	seed	seed	veg./seed	seed	seed	seed
Carbon dioxide	C3[b]		C3	C3		C3		C3	
Habitat	dry	dry	dry	dry	dry	dry	dry	dry/moist	dry/moist
Mycorrhizal			endomy.						
Nodule forming							possible	recorded	
Nitrogen fixing							maybe	yes	
Edible									
Weediness	nonweedy	nonweedy	economic	nonweedy	nonweedy	nonweedy	nonweedy	colonizing	nonweedy
Potential biomass			medium low	low		low	medium	high	medium
Establishment			low	low		medium	medium low	low medium	low medium
Seed availability									
Rooting depths									

a. ERDI = *Erigeron divergens* (fleabane daisy), ERFL = *Erigeron flagellaris* (trailing fleabane), GUSA = *Gutierrezia sarothrae* (snakeweed), HASP = *Haplopappus spinulosus* (spiny goldenweed), HYRI = *Hymenoxis richardsonii* (pingüe), LIPU = *Liatris punctata* (dotted gayfeather), LUCA = *Lupinus caudatus* (lupine), MEX = *Melilotus* spp. (sweet clover), and MUMO = *Muhlenbergia montana* (mountain muhly).

b. C3 = The plant uses a pathway where the first step in CO^2 fixation involves the formation of three-carbon compounds, the stomata are opened, and CO^2 fixation is in the daylight.

Table L-1 (cont.)

Information	Species								
	OECO[a]	SPCR	VETH	YUAN					
Origin	native	native	introduced	native					
Habit	forb	grass	forb	shrub					
Life cycle	perennial	perennial	biennial	perennial					
Reproduction	seed		seed	seed					
Carbon dioxide	C3[b]	C4	C3						
Habitat	dry	dry	dry/moist	dry					
Mycorrhizal									
Nodule forming									
Nitrogen fixing									
Edible									
Weediness	nonweedy	nonweedy	colonizing	nonweedy					
Potential biomass	low	medium	medium	high					
Establishment	low medium	medium low	low medium	medium					
Seed availability									
Rooting depths									

a. OECO = *Oenothera coronopifolia* (evening primrose), SPCR = *Sporobulus cryptandrus* (sand dropseed), VETH = *Verbascum thapsus* (mullein), and YUAN = *Yucca angustissima* (narrowleaf yucca).
b. C3 = The plant uses a pathway where the first step in CO^2 fixation involves the formation of three-carbon compounds, the stomata are opened, and CO^2 fixation is in the daylight. C4 = The plant uses a pathway where the first step in CO^2 fixation involves the formation of four-carbon compounds, the stomata are opened, and CO^2 fixation is in the daylight.

Appendix M. List of Common and Scientific Names

Common Name	Scientific Name
American vetch	*Vicia americana*
Apache plume	*Fallugia paradoxa*
Aster	*Aster* spp.
Beardtongue	*Penstemon* spp.
Bermuda grass	*Cynodon dactylon*
Big sagebrush	*Artemisia tridentata*
Black grama	*Bouteloua eriopoda*
Blazing star	*Mentzelia* spp.
Blue gilia	*Ipomopsis longiflora*
Blue grama	*Bouteloua gracilis*
Bluegrass	*Poa fendleriana*
Bottlebrush squirreltail	*Sitanion hystrix*
Bristlegrass	*Setaria* spp.
Brome	*Bromus* spp.
Buckwheat	*Eriogonum* spp.
Canadian wildrye	*Elymus canadensis*
Carruth wormwood	*Artemisia carruthii*
Chamisa	*Chrysothamnus nauseosus*
Cheatgrass	*Bromus tectorum*
Cinquefoil	*Potentilla* spp.
Common sunflower	*Helianthus annuus*
Dandelion	*Taraxicum officinale*
Deervetch	*Lotus wrightii*
Desert four o'clock	*Oxybaphus linearis*
Dropseed	*Sporobolus* spp.
Estafiata	*Artemisia frigida*
Evening primrose	*Oenothera* spp.
False buffalo grass	*Munroa squarrosa*
False tarragon	*Artemisia dracunculus*
Fendler's rose	*Rosa fendleri*
Fetid marigold	*Pectis angustifolia*
Wild chrysanthemum	*Bahia dissecta*
Firewheel	*Gaillardia pulchella*
Flax	*Linum* spp.
Fleabane daisy	*Erigeron divergens*
Gambel oak	*Quercus gambelii*
Gayfeather	*Liatris punctata*
Globemallow	*Sphaeralcea* spp.
Goatsbeard	*Tragopogon dubius*
Golden aster	*Chrysopsis villosa*
Goldeneye	*Viguiera* spp.
Greenthread	*Thelesperma trifidum*
Gumweed	*Grindelia aphanactis*
Horseweed	*Conyza canadensis*
Indian grass	*Sorgastrum nutans*
Indian paintbrush	*Castilleja integra*
Hidden flower	*Cryptantha jamesii*
Lamb's quarters	*Chenopodium* spp.
Leafy golden aster	*Chrysopsis foliosa*
Little bluestem	*Schizachyrium scoparium*
Lupine	*Lupinus caudatus*
Longleaf butterweed	*Senecio longilobus*
Milkvetch	*Astragalus* spp.
Mountain muhly	*Muhlenbergia montana*
Mullein	*Verbascum thapsus*
Narrowleaf yucca	*Yucca angustissima*
New Mexico flax	*Linum neomexicanum*
Nightshade	*Solanum* spp.
Nodding buckwheat	*Eriogonum cernuum*
One-seed juniper	*Juniperus monosperma*
Owl-clover	*Orthocarpus* spp.
Peppergrass	*Lepidium* spp.
Pincushion cactus	*Coryphantha vivipara*
Pine dropseed	*Blepharoneuron tricholepis*
Pingüe	*Hymenoxys richardsonii*
Ponderosa pine	*Pinus ponderosa*
Ponymint	*Monarda pectinata*
Poverty three-awn	*Aristida divaricata*
Prairie clover	*Petalostemum* spp.
Prairie sunflower	*Helianthus petiolaris*
Prickly pear cactus	*Opuntia* spp.
Puccoon	*Lithospermum multiflorum*
Pussytoes	*Antennaria parvifolia*
Ragweed	*Franseria* spp.
Redtop	*Agrostis* spp.
Ring muhly	*Muhlenbergia torreyi*
Rock-jasmine	*Androsace septentrionalis*
Russian thistle	*Salsola kali*
Russian wheatgrass	*Agropyron desertorum*
Sand dropseed	*Sporobolus cryptandrus*
Scarlet bee blossom	*Guara* spp.
Scarlet bugler	*Penstemon barbatus*
Scarlet trumpet	*Ipomopsis aggregata*
Sedge	*Carex* spp.
Shepherd's purse	*Capsella bursa-pastoris*
Shrubby potentilla	*Potentilla fruticosa*
Smartweed	*Polygonum* spp.
Skeletonweed	*Stephanomeria* spp.
Snakeweed	*Gutierrezia sarothrae*
Spiny goldenweed	*Haplopappus spinulosus*
Spreading fleabane	*Erigeron flagellaris*
Stickleaf	*Mentzelia pumila*
Stickseed	*Lappula* spp.
Sweetclover	*Melilotus* spp.
Tansey mustard	*Descurainia* spp.
Three-awn	*Aristida longiseta*
Walkingstick cactus	*Opuntia imbricata*
Western wheatgrass	*Agropyron smithii*
Wheatgrass	*Agropyron* spp.
White ragweed	*Hymenopappus* spp.
White sweetclover	*Melilotus albus*
Wild chysanthemum	*Bahia dissecta*
Witchgrass	*Panicum capillare*
Wolftail	*Lycurus phleoides*
Woolly Indian wheat	*Plantago purshii*
Yellow sweetclover	*Melilotus officinalis*