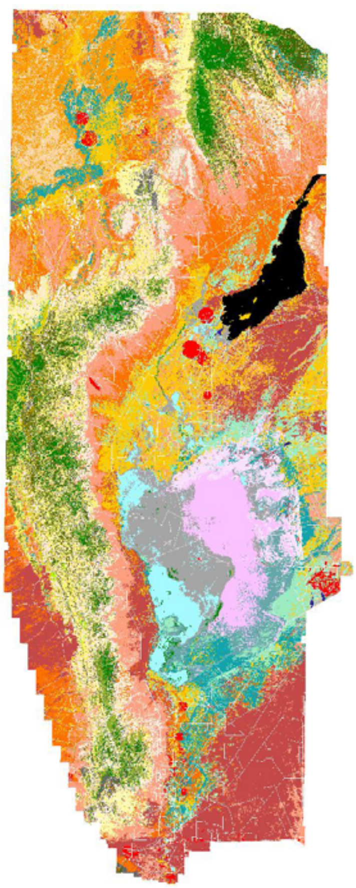
The Vegetation

of

White Sands Missile Range, New Mexico

Volume II



Vegetation Map

The Vegetation of White Sands Missile Range, New Mexico[1]

Volume II: Vegetation Map

Esteban Muldavin, Glenn Harper, Paul Neville, and Yvonne Chauvin[2]

2000

SUMMARY

A vegetation classification and a vegetation map from satellite imagery were developed for White Sands Missile Range (WSMR) of southern New Mexico to be used in environmental review (NEPA and Endangered Species Act) and for general natural resources planning. Volume I, *Handbook of Vegetation Communities*, outlines the vegetation classification for WSMR and provides detailed ecological descriptions of the vegetation communities. This volume (II) presents a vegetation map of WSMR based on the vegetation classification along with details of map production, an annotated legend, and map unit descriptions. The map was developed using Landsat Thematic (TM) Mapper satellite imagery (TM spectral bands 1 through 5 and 7 and a Normalized Difference Vegetation Index (NDVI)). A supervised classification strategy was adopted to develop vegetation spectral classes based on 1,467 ground survey points (mapping "seeds"). Ground survey points were defined in terms of the vegetation classification (Volume I) and precisely located using global positioning systems (GPS). The image analysis was stratified by landscape units of similar topography, geology, soils, and known biological distributions. The spectral classes derived from the 1,467 seeds were aggregated into 35 major map units with an additional 95 sub-units that delineate the vegetation pattern of the study area in high detail. Based on independent ground data, the map gross and marginal error rates among the 35 major map units is estimated at 4.5 % and 18.5%, respectively for a total error rate of 18.5%. Sub-unit error rate is slightly higher at 5.9% and 16.1%, respectively for a total error rate of 22%. A 1:170,000 scale map of the entire study area was produced to facilitate range-wide and regional planning efforts. Map sheets at 1:50,000 scale corresponding to Defense Mapping Agency 15' quadrangles were produced. Accompanying the legends of the map are map unit descriptions that describe the vegetation composition of each unit in detail. These are, in turn, directly linked to the vegetation classification and associated community descriptions of Volume I to make a comprehensive, ecologically based vegetation analysis system. The maps and vegetation classification are available in digital form and can be used in a geographic information system (GIS) as a powerful and dynamic tool for natural resources management applications.

Cover: the western escarpment of the Oscura Mountains from near Millers Watch (Yvonne Chauvin)

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[1] Final Report for Cooperative Agreement No. 14-16-002-91-233 White Sands Missile Range, U.S. Fish and Wildlife Service, The Nature Conservancy, and the University of New Mexico.

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INTRODUCTION

Scope

White Sands Missile Range (WSMR) is a large military installation where the needs of many diverse, and often intertwined, missions must be met within the context of the nation's environmental laws. As one of the largest land withdrawals in the country (2.14 million acres), it also harbors exceptional biological diversity—from big game herds to rare plants and fish—that requires diligent management to maintain it as one of the classical examples of the biological "legacy" inherited by the Department of Defense.

In an effort to fulfill baseline information needs for their natural resources management, White Sands Missile Range Environment and Safety Directorate enlisted the New Mexico Natural Heritage Program (NMNHP) to develop a vegetation classification and a map of current upland vegetation of WSMR (including San Andres National Wildlife Refuge and the NASA space center). The vegetation classification and map were designed to provide high quality biological data for use in environmental review and planning, as well as for various on-going and future biological management projects. Specifically, the classification and map are to provide baseline data for compliance with environmental laws such as National Environmental Policy Act (NEPA) and Endangered Species Act (ESA), and they will also help meet inventory and classification requirements for natural resources management on US Army installations (e.g. AR 200-3 sections 2-2, 3-3 and 11-3). With this information, the land managers of WSMR will be better able to model and predict locations of sensitive species and fragile habitats, enhance wildlife management projects, and evaluate overall biodiversity status of the installation.

This volume of the report details the production of a vegetation map designed to be complementary to the vegetation classification of Volume I. While the vegetation classification describes the composition and habitats of vegetation communities of WSMR along with ecological and management interpretations, the map provides an explicit depiction of these communities in the landscape. Map units are directly linked to the vegetation community descriptions in Volume I, resulting in a map and legend that maximize ecological information content.

This map was developed in the context of a Geographical Information System (GIS) technology and hence exists in digital as well as hard copy paper forms. In its digital form, the map, with its associated spatial/spectral statistics and biological database, can be integrated into the installation GIS and be used as a powerful and dynamic tool in natural resources management applications.

Background

This was a multi-year project that ran from 1991 through 1996. Initially, a pilot study was conducted in 1991 and 1992 in which two remote sensing options were explored for developing a map of the existing vegetation of WSMR: aerial photography and satellite imagery (Muldavin and Mehlhop 1992a & b). From results of that work, the satellite imagery approach was selected because of its analytical power and its highly reduced costs (estimated 60% or more cost reduction over an aerial-photography interpreted map). In 1993, the NMNHP initiated a full-scale project to classify and map the vegetation of WSMR. The vegetation community classification and vegetation map were iteratively improved over a period of three field seasons (1993-95), as reported in various interim reports (Muldavin and Mehlhop 1994a, 1994b, 1996).

A preliminary vegetation map at the 1:100,000 scale was produced in July 1994 based on the data gathered from 1991 to 1993 (567 plots). Intermediate field maps at 1:24,000 scale were then derived from the preliminary 1:100,000 map to guide field sampling for the 1994 and 1995 seasons. These maps have been deposited with WSMR.

A total of 1,739 vegetation plots were gathered on WSMR between 1991 and 1995. A map of plot distribution overlain on a raw image of WSMR with road grid was provided to WSMR in 1996. In addition, during 1993 a vegetation map was developed for the National Park Service for White Sands National Monument (WSNM), including areas that at that time were jointly used by WSMR and WSNM (Muldavin et al. 1994). The data (243 plots) and map from that project were incorporated, where appropriate, into the development of the final classification and map of this project.

Acknowledgements

We wish to acknowledge the following individuals for contributions to this effort: Jamie Thompson, Becky Yaeger, Dave Tessler, Robie Wallace, Elizabeth Milford, and Steven Yanoff for their diligent and dedicated fieldwork; Sanam Radjy, Vince Archer, Teri Bennett and Rebecca Keeshen contributed significantly to the analysis and report preparation. We are also grateful to the support of staffs at the New Mexico Natural Heritage Program and the Earth Data Analysis Center at the University of New Mexico. Lastly, we wish to thank the White Sands Missile Range for their commitment to and financial support of the project.

STUDY AREA

Location

Located in south central New Mexico, the area encompasses 923,358 ha (2.14 million ac) of White Sands Missile Range excluding the buffer extension areas. It does include joint use and management areas of San Andres National Wildlife Refuge, the NASA Test Facility, White Sands National Monument, Holloman Air Force Base, and the USDA Jornada Experimental Range (Figure 1). The missile range forms an irregularly shaped rectangle approximately 60 km wide and 200 km long (35 by 125 miles).

Climate

The climate of the study area ranges from arid high desert with less than 25 cm (10 in) of precipitation in the basins to semi-arid conditions of 25-40 cm (10-16 in) in the foothills and mountains, approaching temperate conditions at the highest elevations. The 1,500 m (5,000 ft) elevation level generally marks the boundary between arid and semi-arid climates (Gile, Hawley, and Grossman 1981). Anderson and Taylor (1983) have summarized the climatic data for two WSMR weather stations. They report that the majority (64%) of the precipitation comes during the summer in the form of intense late-summer thunderstorms of short duration. Mean monthly temperatures range in the basins from minimums of -6° to 1° C (21-34° F) in January to maximums of 33° C to 34° C (92-93° F) in July. Extremes have been recorded at -26 and 41 degrees C (-16° F and 107° F), along with diurnal fluxes of over 25° C (50°F). Temperatures are generally cooler at the north end of the range (a degree further north in latitude). The average frost-free season is long; at the WSMR post it is about 250 days, from May 14 to November 20.

Landscape

The study area lies within the Bolson sub-section, Mexican Highlands section of the Basin and Range physiographic province. It is characterized by broad desert basins and discontinuous mountain ranges (Gile, Hawley, and Grossman 1981). The major mountain ranges are the San Andres and Oscura Mountains, which lie centrally and divide the study area into two major basins to the east and west. The San Andres Mountains are structurally a large west-tilted fault block that rises to a height of 2733.4 m (8,968 ft) at Salinas Peak. The mountain range is cuesta-like with precipitous escarpments facing east and long, gently dipping slopes to the west.

To the east of the San Andres is the Tularosa Basin, a corresponding down-faulted inter-mountain basin with a minimum elevation of 1,175 m (3,855 ft). A long piedmont slope leads from the base of the escarpment of the San Andres to the Tularosa Basin floor, which is notable for its extensive alkali flats, coppice dune fields, gypsum lake deposits, and shifting dunes. The north end of the basin is partly covered by a Holocene basalt flow called the Carrizozo Malpais. To the west of the San Andres is the Jornada del Muerto basin which is divided into two internally drained northern and southern basins with minimum elevations approaching 1,495 m (4,900 ft).

At the north end of WSMR are the smaller Oscura Mountains that are also a cuesta-like, fault block similar to the San Andres but tilted to the east. The escarpment faces west with the corresponding long piedmont slope leading to the bottom of northern Jornada del Muerto basin. To the east, slopes gently dip into the basin fill of the Tularosa Basin. Both ranges lie on Precambrian age granites and are stratigraphically complex with intermixed limestone and sandstone strata ranging in age from Cambrian to Quaternary (Bachman 1968; Bachman and Harbour 1970).

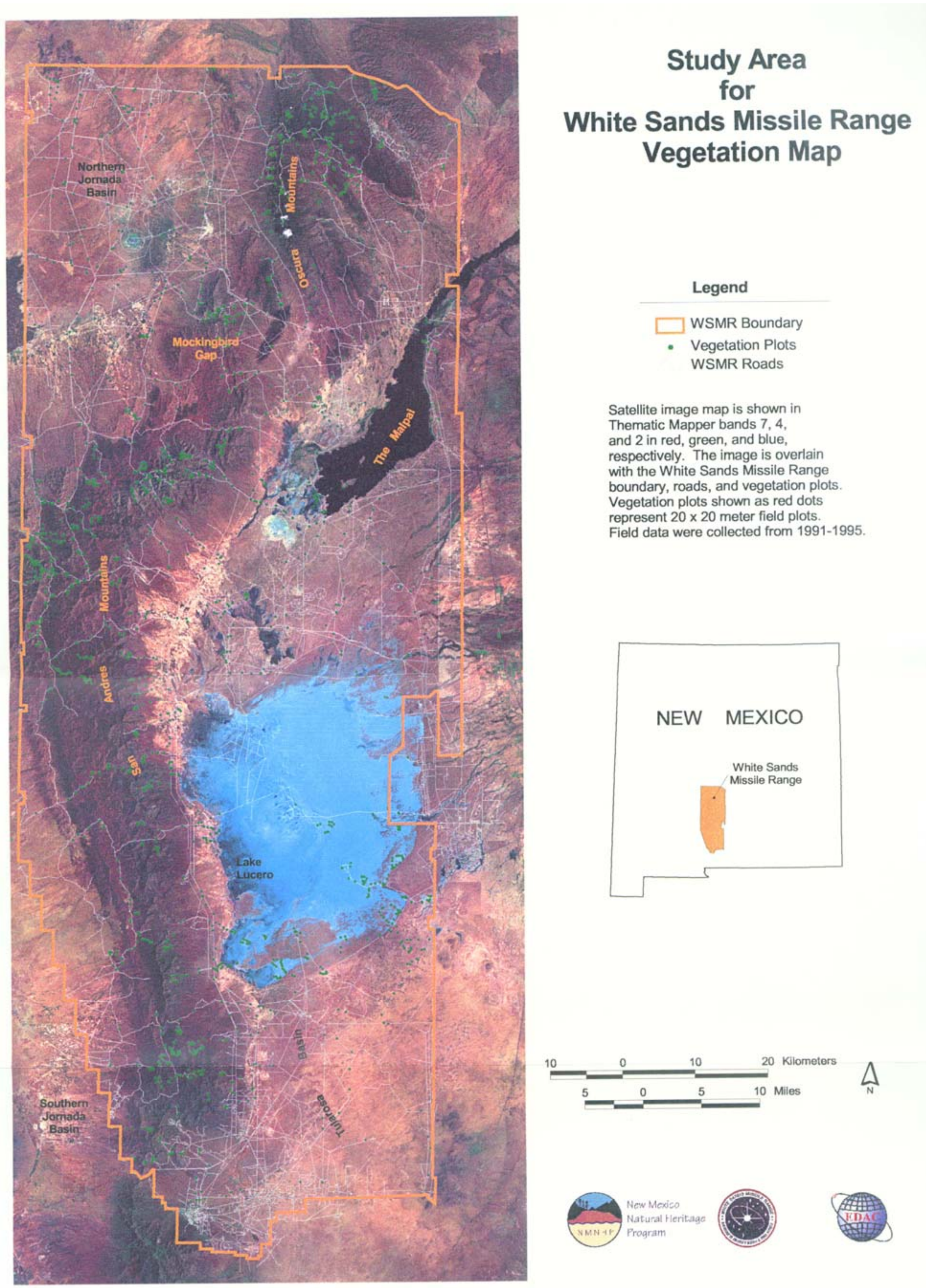


Figure 1. Study area for the White Sands Missile Range Vegetation Map.

At the southern most boundary of the study area is the northern end of the Organ Mountains, which are primarily Tertiary quartz monzonite derived from the Organ Batholith and Precambrian granites (Seager 1981). For the most part, they lack the fault block structure and complex stratigraphy of the San Andres and Oscura ranges, but they are more topographically diverse and rugged.

With respect to maps, the geology of the southern third of WSMR has been mapped at the 1:125,000 scale by Seager et al. (1987). The northern San Andres and the Mockingbird Gap 15' Quadrangle have been mapped at 1:62,500 by Bachman and Harbour (1970) and Bachman (1968), respectively. Seager (1981) mapped in detail the geology of the very southern San Andres and Organ Mountains at 1:31,250. Hawley (1983) has provided detailed descriptions and maps of the geology of the Rhodes Canyon area.

The soils of the study area have been mapped at the 1:100,000 scale by Neher and Bailey (1976). They identified 35 soil series mapped into 29 mapping units for the range. These delineations tend to be generalized and heterogeneous, with most soils falling into the Aridisol order from the Camborthid, Haplargid, Calciorthid, Paleorthid, and Gypsiorthid Great Groups. There were five Entisols and one Mollisol identified. Anderson and Taylor (1983) summarized the soil survey and reported that the most common series were Yesum and Holloman of gypsum flats (320,202 acres), along with 95,800 acres of gypsum duneland. There were 269,500 acres of Nikel and Tencee soils supporting desert shrublands of the alluvial fans. There are 613,035 acres of Hillslope Deama, Gilland and Lozier - rock outcrop complexes plus Rockland, and an additional 40,700 acres of lava flows. Gile, Hawley, and Grossman (1981) gave an in-depth investigation of geology, geomorphology, and soils of the southern Jornada basin. Unless otherwise noted, we follow their terminology in describing landforms and geomorphic surfaces as they relate to the vegetation map units.

Vegetation

Detailed descriptions of the major vegetation communities of the study area are provided in the companion Volume I. In summary, the vegetation is diverse, ranging from Chihuahuan Desert Scrub and Grasslands in the basin bottoms to Rocky Mountain Conifer Forest on the mountain tops.

In the mountains, vegetation zones follow a definite elevation gradient. The foothills and upper alluvial fans support desert shrublands dominated by creosotebush (*Larrea tridentata*) and viscid acacia (*Acacia neomexicana)*, and grasslands dominated by blue, black, hairy, and sideoats gramas (*Bouteloua gracilis, B. eriopoda, B. hirsuta and B. curtipendula*) and New Mexico needlegrass (*Stipa neomexicana).* Yuccas (*Yucca bacata* and *Y. elata*) and sotol *(Dasylirion wheeleri*) are common and conspicuous along with numerous sub-shrubs.

The middle and high elevations support a combination of pinyon (*Pinus edulis*), juniper (*Juniperus monosperma),* and evergreen oak (*Quercus grisea* and *Q. turbinella*) woodlands, and mountain mahogany (*Cercocarpus montanus*) and wavy-leaf (*Quercus undulata*) montane scrub. At the highest elevations, open ponderosa pine (*Pinus ponderosa)* forests and woodlands occur along with deciduous oak (*Quercus gambelii*) woodlands and montane grasslands. Drainage ways contain some riparian forest and shrubland vegetation, particularly where water is perennially present.

In the lowlands, the alluvial fans and piedmonts support a diversity of desert shrub and grassland communities. Common dominants are creosotebush, acacia, honey mesquite (*Prosopis glandulosa*), tarbush (*Flourensia cernua*), and mimosa (*Mimosa aculeaticarpa),* along with grasses such as black grama, fluffgrass (*Erioneuron pulchellus*), and bush muhly (*Muhlenbergia porteri*).

The basin floors support extensive desert shrublands dominated by fourwing saltbush (*Atriplex canescens*) and sandsage (*Artemisia filifolia*) to the north, and honey mesquite and creosotebush to the south. Intermixed among the shrublands are lowland grasslands dominated by mesa dropseed (*Sporobolus flexulosus*), black grama, tobosagrass *(Hilaria mutica*), and sacaton (*Sporobolus airoides*).

There are also large areas of gypsum dunes and outcrops that support unique vegetation communities dominated by gyp dropseed (*Sporobolus nealleyi*), gypsum grama (*Bouteloua breviseta*), and hairy coldenia (*Tiquilia hispidissima*).

With respect to vegetation maps, there are no high-resolution maps of the study area. At a scale of 1:1,000,000, Donart, Sylvester, and Hickey (1978) mapped the potential vegetation of New Mexico including 11 generalized "Associations" for WSMR. The San Andres and Organ Mountains were mapped as Mixed Grama-Rosette Shrub Association; the Oscura Mountains as Mixed Grama-Juniper and Mixed Grama; the bajadas as Creosotebush-Bush Muhly; lower slopes leading to the basin floors as Mixed Dropseeds-Black Grama and Black Grama-Mixed Dropseeds; the basin floors as Sacaton-Tobosa and Fourwing Saltbush-Tobosa, as well as areas of lava and of gypsum dunes.

The 1:1,000,000 scale map of New Mexico Vegetation by Dick-Peddie (1991) is also general but presents actual rather than potential vegetation. The San Andres Mountains are mapped as Montane Coniferous Forest, and Coniferous and Mixed Woodland; the Oscura Mountains as Juniper Savanna and Montane Scrub; the bajadas as Chihuahuan Desert Scrub and Desert Grassland; and the basin bottoms as Closed Basin Scrub and Plains-Mesa Scrub, along with lava beds and gypsum dunes.

MATERIALS and METHODS

In order to develop a map that accurately depicts patterns of vegetation over this mountain-to-desert landscape, a strategy was used that combines ecological field studies and remote sensing imagery in the context of a GIS (Figure 2). The first step was the acquisition and processing of Landsat Thematic Mapper (TM) imagery over the study area. The images were then processed to account for geometric and radiometric distortions of the raw imagery. See Appendix A for technical details of the map production.

A preliminary analysis indicated a need to stratify the subsequent image analyses by broadly defined landscape level elements to overcome disparate but localized misclassifications that occurred across the image. An "eco-area" landscape unit map was developed on the basis of topography, elevation, slope, aspect, soils, geology, known biotic communities and the TM imagery itself.

A supervised image classification was then performed within each landscape unit based on selected classified vegetation data gathered by the ground vegetation survey. Details of how the survey data were gathered and classified into vegetation associations are provided in Volume I. The various landscape unit analyses were then combined into a preliminary vegetation map where each map class is represented by a particular ground sampling point, which in turn is defined in terms of plant associations of the vegetation classification.

Individual map classes were then aggregated into final map units based on vegetation composition, spatial continuity, and similar landscape structure, and then the final vegetation map with a legend was generated. The legend map units are described in general terms here and reference the plant association descriptions in Volume I. The final map was then accuracy tested using independent, ground survey data (Land Condition Trend Analysis [LCTA] transect data provided by WSMR. See Appendix B).

Final TM Image and Seed Distribution

The base TM image used for all subsequent image classifications contained all six TM bands representing the reflective wavelengths, plus the NDVI band. Figure 1depicts this image at a small scale where red is TM band 7 (mid-infrared), green is TM4 (near-infrared), and blue is TM2 (visible green). Also shown are the locations of the 1,467 plots or "seeds" used for the supervised image classification (red dots). Although many of the seeds were located along roads for logistical reasons, there were extensive forays into roadless areas to ensure as comprehensive a coverage as possible. There was a greater emphasis put on the mountainous areas with their heterogeneous terrain and increased vegetation diversity rather than the lowlands. In some cases, coverage was limited by security in restricted areas (Red Rio Impact Area, Oscura Bombing Range, RATSCAT, WITS, etc.). Plans to increase sampling density in the southern Jornada in 1995 were also curtailed by a jurisdictional dispute with the USDA Jornada Experimental Range.

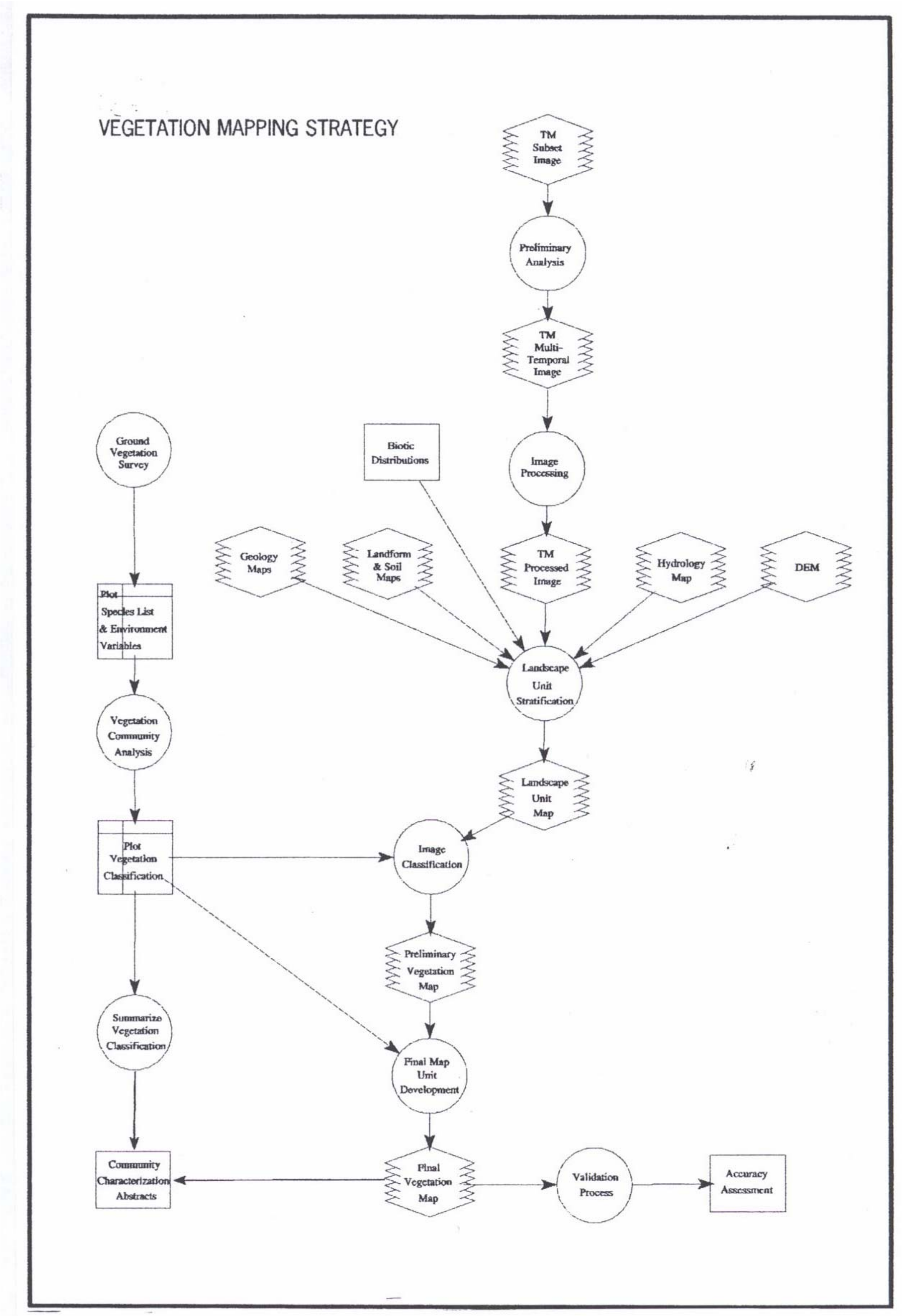


Figure 2. Flow chart detailing the mapping strategy used to develop the White Sands Missile Range Vegetation Map.

Eco-area Landscape Unit Stratification

Fifty-four eco-area landscape units were derived for the image classification stratification (Figure 3 and Map Sheet 1). These units effectively separated spectrally similar vegetation classes by limiting the distributions of the statistical signatures used to classify the image. For example, a highly vegetated spectral class dominated by pinyon pine distributed in the high elevation Salinas Peak Site (Site 14) would be excluded from classifying in the highly vegetated riparian/wetland Malpais Spring Site (Site 23) of the basin bottom.

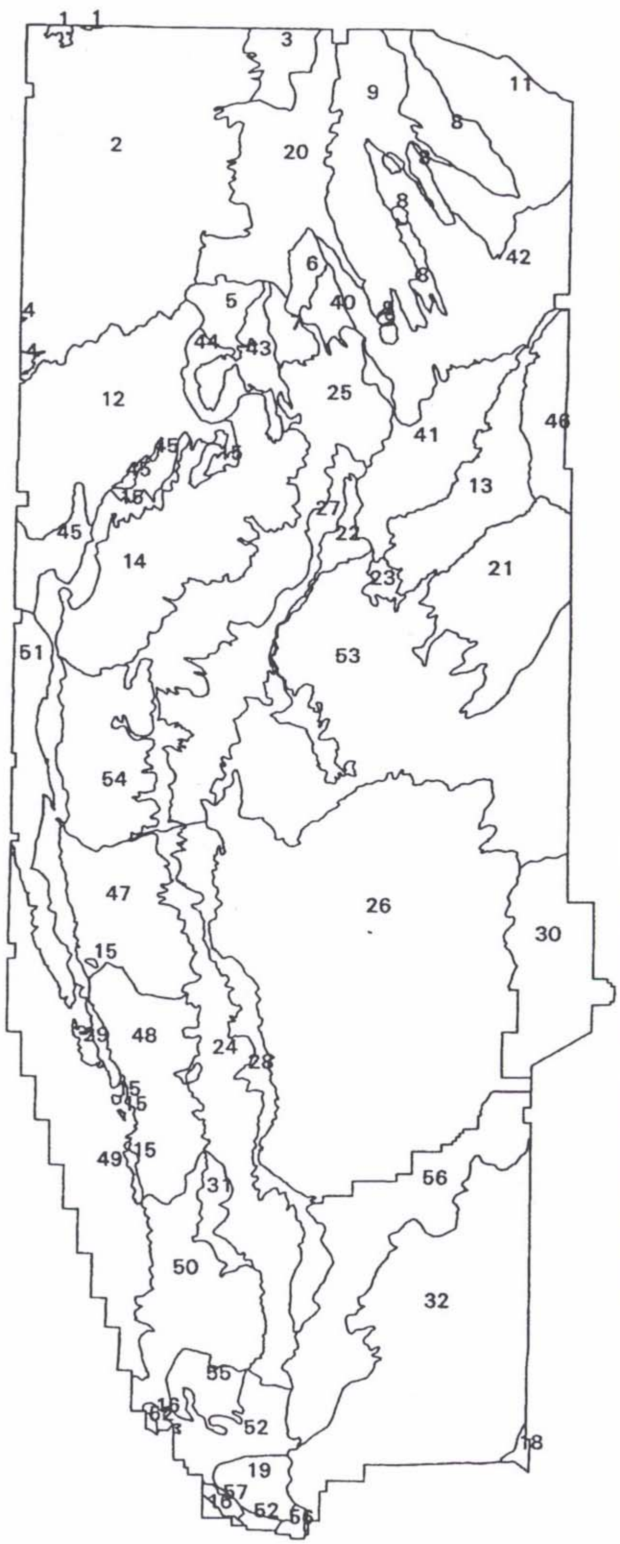
Beyond mapping, the delineation of the eco-areas provides a starting point for defining management units by ecosystems and landscape characteristics. With refinement, these units can act as relatively natural and effective delineations for successful plant, animal, and overall ecosystem management.

Image Classification

The result of the image classification process was a preliminary base map of 1,467 seed classes based on field vegetation plots. The high number of seeds was necessary to adequately represent the high diversity of vegetation communities across WSMR that occur as a function of the variety of geological substrates and inherent topographic complexity. This base map was an intermediary product used in its digital form only for the development of the final map units (no hard copy was produced, although the digital form has been archived).

Eco-area stratification did help alleviate cross-classification errors across the study area, but some difficulties did occur, such as occasional high contrasts between vegetation map units across eco-area boundaries. Additionally, there was some uncertainty in some of the landscape units that were undersampled in the ground survey—there can never be enough ground survey work to account for all contingencies. These problems were solved somewhat by including seeds in the under-sampled landscape unit from adjacent landscape units. Only seeds representing vegetation types and environmental characteristics expected in the undersampled area were used.

Where under-sampling remained a problem (particularly in remote areas), aerial photo interpreted points were used to generate spectral statistics. Although the "photo" seeds were less refined (usually only to the Alliance level or dominance type), they enhanced the resolution and accuracy of the map. There were inherent limits, though, to the interpretability of the available photography. Some remote or heterogeneous areas will need enhancement, but overall, the underlying seed base map provided the best possible foundation for development of the final map given the limits of TM imagery, photography, and the resources for the ground survey work.



WSMR Landscape Units

No.	Eco-Area Landscape Unit
1	Stallion Volcanos
2	Northern Jornada Plains
3	Wyre Peak
4	Crater Lava
5	West Mockingbird Bajada
6	Burrow Mtns
7	East Mockingbird Bajada
8	Oscura Abo-Yeso
9	Oscura Peak
11	Pink Peak
12	Poison Hills Bajada
13	El Malpais
14	Salinas Peak
15	San Andres Abo-Yeso
16	Organ Bajada
18	Jarilla Piedmont
19	WSMR Post
20	Trinity Bajada
21	Three Rivers
22	Salt Creek Drainage
23	Malpais Spring
24	San Andres South Piedmont
25	San Andres North Piedmont
26	Lake Lucero-White Sands
27	Tularosa Flat North
28	Tularosa Flat South
29	Chalk Hills
30	Holloman AFB
31	Refuge Granite Bajada
32	Mesquite Basin
40	Burro Abo
41	Mound Spring
42	Oscura Valley
43	Mockingbird Mountains
44	Fairview Bajada
45	Big Gyp
46	Phillips Hills
47	Hembrillo Canyon
48	Gardner Peak
49	Southern Jornada Bajada
50	Bennet Mountain
51	Chalk Hills
52	San Augustine
53	Tule Central
54	Cottonwood Canyon
55	Mineral Hill
56	Tule South
56	White Sands South
57	WSMR Post West

Figure 3. Eco-area landscape units used to stratify of the image analysis and map development of the White Sands Missile Range Vegetation Map.

RESULTS

Vegetation Maps

A final vegetation map was developed by aggregating floristically and physiographically similar seed classes into 35 major map units with 95 sub-units nested within them. A small-scale version of the map depicting the major map units is presented in Figure 4. A separate 1:170,000 scale wall-sized map sheet was also produced and 100 copies provided to WSMR along with a single set of 1:50,000 scale map sheets corresponding to the Defense Mapping Agency quadrangles. The road grid and hydrological features coverage (stream channels) have been overlain for context. The precision or minimum map unit size is 0.5 hectares (slightly greater than five pixels). Although the maps are based on the aggregation of sub-units, some post-aggregation modifications were done to account for edge matching between eco-area landscape units.

The major units are appropriate for most analysis and natural resource planning functions, but sub-unit maps are available in digital form within the GIS to address, as necessary, specific questions. This approach maintains the flexibility of the map, particularly in a GIS environment. For example, major map units can be reformulated by re-aggregating sub-units into different combinations to address different management questions. In a GIS, cartographic limits of sub-units can be overcome somewhat by projecting the map at finer scales. For example, a map at 1:24,000 and corresponding to 1/4 of a 1:50,000 sheet would contain far fewer units, and the polygons would be correspondingly bigger, perhaps even large enough to be labeled with a number rather than a color. The various coverages used for analysis and the final map have been delivered in a digital form compatible with the WSMR GIS. A list of coverage files and their content is given in Appendix A.

Map Legend

A hierarchically structured legend of general map units and their sub-units is provided in Table 1 and is followed by detailed map unit descriptions. The legend and descriptions are ordered by major vegetation groups at the formation level (forest and woodlands, shrublands, grasslands, and miscellaneous types) and from high to low elevations. The forest and woodland group contains six map units that are restricted to the higher elevation areas of the Oscura, San Andres, San Augustine and Organ Mountains, Chupadera Mesa, and Chalk Hills. The Ponderosa Pine Forest (*Pinus ponderosa var. scopulorum*) unit is very small and limited to the highest elevations of the northern San Andres Mountains. In contrast, the Pinyon Pine Woodland (*Pinus edulis*) is widespread at higher elevations of all the mountainous areas but particularly in the Oscura Mountains. Juniper Woodlands dominated by oneseed juniper (*Juniperus monosperma*) occur at mid to lower elevations of the mountain ranges and hills. Montane Scrub dominated by mountain mahogany (*Cercocarpus montanus*) and wavyleaf oak (*Quercus undulata*) is also found at mid to high elevations, particularly on steep slopes and in areas where pinyon and juniper woodlands have been burned. Montane Scrub significantly increases in extent from north to south. The Interior Chaparral unit is dominated by shrub live oak (*Quercus turbinella*) and occurs primarily in the foothills of the San Andres Mountains. Lastly, the Mountain Valley Dune Woodland dominated by oneseed juniper is a special unit limited to sand-sheets that have accumulated in the interior valleys of the San Andres Mountains.

The shrubland group is made up of 11 units primarily representing Plains-Mesa Sandscrub, Great Basin Desert Scrub, and Chihuahuan Desert Scrub, with one semi-riparian type. The Sandsage Shrubland is a representative Plains-Mesa Sandscrub that is distributed widely through the plains of eastern New Mexico (Muldavin et al 1996). It is dominated by sandsage (*Artemisia filifolia)* and is most prevalent in the northern Jornada basin. Saltbush Shrubland is a Great Basin Desert Scrub element that forms extensive stands dominated by fourwing saltbush (*Atriplex canescens*) in both the Tularosa Basin and northern Jornada. Creosotebush (*Larrea tridentata*), Tarbush *(Flourensia cernua)*, Acacia (*Acacia neomexicana*), Mesquite (*Prosopis glandulosa*), and Mimosa (*Mimosa aculeaticarpa*) Shrublands are all Chihuahuan Desert Scrub elements that are widely distributed throughout the alluvial fan piedmonts at the base of mountain fronts and on basin floors. Mixed Lowland Desert Shrubland is a mixture primarily of creosotebush and tarbush dominated types with some fourwing saltbush and littleleaf sumac (*Rhus microphylla*). The Malpais Lava Scrub is an admixture of the above desert scrub species and is limited to the highly heterogeneous Carrizozo lava flow (The Malpais). The Pickleweed Shrubland is dominated by *Allenrolfea occidentalis* (also known as iodinebush) and is restricted to the alkali flats and playas of the central Tularosa. Also found on the alkali flats and along drainages is Tamarisk Shrubland dominated by the non-native, semi-riparian *Tamarix ramosissima* (salt cedar).

Table 1. A hierarchically structured legend of major map units (bolded) and their subunits for the White Sands Missile Range Vegetation Map. The map unit numbers correspond to numbers in the digital image files of the maps. Estimated size of each unit in hectares derived from the GIS
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Maj. Unit No.	Sub-Unit No.	Map Unit Name	Area (ha)
		Forests and Woodlands	
1		**Ponderosa Pine Forest**	**91**
	166	Ponderosa Pine/Arizona Fescue Forest and Gambel's Oak-Whortleleaf Snowberry or Prairie Junegrass Montane Shrubland	91
2		**Pinyon Pine Woodland**	**21,463**
	116	Pinyon Pine/Wavyleaf Oak Montane Woodland	163
	129	Pinyon Pine-Gambel's Oak Montane Woodland	428
	130	Pinyon Pine/Wavyleaf Oak, Scribner's Needlegrass, or Banana Yucca Montane Woodlands	8,742
	114	Pinyon Pine/Scribner's Needlegrass, New Mexico Muhly, or Blue Grama Montane Woodlands	12,130
3		**Juniper Woodland**	**32,622**
	181	Oneseed Juniper/New Mexico Needlegrass Gypsum Outcrop Montane Woodland	72
	115	Oneseed Juniper/Sideoats Grama or Hairy Grama Montane Woodlands	8,755
	131	Oneseed Juniper/New Mexico Needlegrass, Curlyleaf Muhly or Blue Grama Montane Woodlands	12,634
	146	Oneseed Juniper/Blue Grama, New Mexico Muhly or New Mexico Needlegrass Montane Woodlands	11,161
36		**Montane Valley Dune Woodland**	**328**
	177	Oneseed Juniper/Shrub Live Oak or Sand Dropseed Dune Woodland	328
		Shrublands	
4		**Montane Scrub**	**22,182**
	113	Mountain Mahogany/Sideoats Grama or Curlyleaf Muhly Montane Shrubland	16,752
	22	Mountain Mahogany/Blue Grama, Sideoats Grama, or Plains Lovegrass Montane Shrublands	4,664
	124	Mountain Mahogany/Blue Grama or Curlyleaf Muhly Montane Shrublands	766
5		**Interior Chaparral**	**8,639**
	153 123	Shrub Live Oak/Sideoats Grama Montane Shrublands	7,756
	23	Shrub Live Oak/Blue Grama, Black Grama or Mountain Mahogany Montane Shrublands	883

Table 1. A hierarchically structured legend for the White Sands Missile Range Vegetation Map (continued).

Maj. Unit No.	Sub-Unit No.	Map Unit Name	Area (ha)
6		**Sandsage Shrubland**	**34,571**
	2	Sandsage/Dropseed Low Dune Shrublands	24,753
	8	Sand Sagebrush/Black Grama, Galleta or Indian Ricegrass Sandy Plains Shrublands	9,156
	125	Sand Sagebrush/Black Grama or Blue Grama Piedmont Shrublands	662
7		**Fourwing Saltbush Shrubland**	**37,734**
	109	Fourwing Saltbush/Alkali Sacaton or Mesa Dropseed Basin Shrublands and Alkali Sacaton Basin Grasslands	37,734
8		**Creosotebush Shrubland**	**117,398**
	12	Creosotebush/Bush Muhly, Fluffgrass, or Mariola Foothill Shrublands	285
	159	Creosotebush/Alkali Sacaton or Hairy Coldenia Basin Shrublands	13,650
	100	Creosotebush/Mesa Dropseed or Sparse Piedmont and Basin Shrublands	6,100
	149	Creosotebush-Mariola or Bush Muhly or Fluffgrass Piedmont Shrublands	6,174
	37	Creosotebush/Mariola Foothill Shrubland	430
	142	Creosotebush/Fluffgrass or Sparse Piedmont Shrublands	949
	137	Creosotebush/Black Grama or Alkali Sacaton, and Tarbush/Black Grama Piedmont Shrublands	6,512
	31	Creosotebush/Black Grama, Fluff Grass or Bush Muhly Piedmont Shrublands	18,789
	105	Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands	41,955
	104	Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed Piedmont Shrubland	19,279
	143	Ocotillo-Mariola Foothill Shrubland	1,403
	136	Ocotillo or Creosotebush-Mariola, or Mariola-Pricklyleaf Dogweed Foothill Shrublands	1,872
9		**Tarbush Shrubland**	**1,039**
	172	Tarbush/Alkali Sacaton Basin Shrubland	287
	180	Tarbush/Southwestern Needlegrass or Sideoats Grama Foothill Shrublands	752
10		**Acacia Shrubland**	**5,000**
	121	Viscid Acacia/Southwestern Needlegrass, Mariola, or Tarbush Foothill Shrublands	5,278
11		**Mesquite Shrubland**	**107,203**
	150	Honey Mesquite/Fourwing Saltbush or Snakeweed and Bush Muhly Coppice Dune Shrublands	14,954
	148	Honey Mesquite-Snakeweed Coppice Dune Shrublands	4,851
	7	Honey Mesquite-Snakeweed or Mesa Dropseed Coppice Dune Shrublands	1,931
	110	Honey Mesquite-Fourwing Saltbush or Snakeweed Basin Shrubland	9,854

Table 1. A hierarchically structured legend for the White Sands Missile Range Vegetation Map (continued).

Maj. Unit No.	Sub-Unit No.	Map Unit Name	Area (ha)
11	101	Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands	48,553
	155	Honey Mesquite-Fourwing Saltbush Basin Shrubland	1,287
	102	Honey Mesquite-Fourwing Saltbush or Mesa Dropseed Coppice Dune Shrublands	24,200
	4	Littleleaf Sumac/Dropseed Coppice Dune Shrublands	1,573
13		**Mixed Lowland Desert Scrub**	**76,965**
	151	Creosotebush-Tarbush or Creosote/Sparse Basin Shrublands	11,593
	107	Creosotebush/Alkali Sacaton or Sparse, and Tarbush/Alkali Sacaton Basin Shrublands	36,134
	141	Creosotebush/Sparse or Bush Muhly or Alkali Sacaton Basin Shrublands	3,357
	135	Creosotebush-Tarbush/Sparse or Alkali Sacaton, and Tarbush/Alkali Sacaton Basin Shrublands	18,296
	174	Fourwing Saltbush or Tarbush/Burrograss, and Tarbush/Alkali Sacaton Basin Shrublands	6,790
	29	Littleleaf Sumac/Sideoats Grama or Alkali Sacaton Basin Shrublands	257
	175	Tarbush or Fourwing Saltbush/Alkali Sacaton Basin Shrublands	538
27		**Pickleweed Shrubland**	**34,869**
	120	Pickleweed Alkaline Basin Shrubland	34,869
28		**Malpais Lava Scrub**	**16,442**
	126	Malpais Lava Mixed Shrublands	16,442
32		**Tamarisk Shrubland**	**1,917**
	161	Tamarisk-Pickleweed or Alkali Sacaton Basin Shrublands	1,917
34		**Mimosa Shrubland**	**2,201**
	165	Mimosa/Black Grama or Sideoats Grama Foothill Shrublands	2,201
		Grasslands	
12		**Mixed Foothill-Piedmont Desert Grasslands**	**75,207**
	20	Black Grama/Mariola Piedmont and Foothill Grassland	1,019
	184	Black grama-Blue grama, and Black grama/Torrey's Jointfir Foothill Grasslands	460
	144	Black Grama/Mariola Foothill Grassland	838
	138	Black Grama-Blue Grama or Sideoats Grama and Blue Grama/Banana Yucca Foothill Grasslands	3,765
	179	Black Grama or Blue Grama/Bigelow's Sagebrush Foothill Grasslands	4,644
	122	Black Grama-Blue Grama, Sideoats Grama or Hairy Grama Foothill Grasslands	2,168

Table 1. A hierarchically structured legend for the White Sands Missile Range Vegetation Map (continued).

Maj. Unit No.	Sub-Unit No.	Map Unit Name	Area (ha)
12	103	Black Grama/Mariola or Sideoats Grama Foothill Grasslands and Ocotillo/Mariola Shrublands	40,164
	171	Curlyleaf Muhly-Hairy Grama or Blue Grama, and Black Grama-Blue Grama Foothill Grasslands	3,014
	134	Creosotebush/Black Grama Shrublands, and Black Grama/Mariola or Hairy Grama Grasslands	984
	133	Curlyleaf Muhly Foothill Grasslands	2,120
	30	Hairy Grama/Featherplume Foothill Grassland	208
	170	Hairy Grama-Black Grama, Sideoats Grama, or Sacahuista Foothill Grasslands	3,182
	117	Mixed Grama Foothill Grasslands	3,500
	145	Sideoats, Black or Hairy Grama/Sotol Foothill Grasslands	7,270
15		**Foothill-Montane Temperate Grasslands `**	**38,299**
	183	Blue Grama/ Banana Yucca and Blue Grama-Sideoats Grama Montane Grasslands	31
	128	Blue Grama/Winterfat, Western Wheatgrass or Soaptree Yucca Montane Grasslands	4,444
	132	New Mexico Needlegrass Montane Grasslands and Mountain Mahogany/New Mexico Needlegrass Montane Shrublands	4,834
	119	New Mexico Needlegrass-Grama Grass Montane Grasslands	28,989
16		**Piedmont Desert Grasslands**	**15,599**
	17	Black Grama and Blue Grama/Yucca Piedmont Grasslands	6,378
	24	Black Grama/Longleaf Jointfir Piedmont Grassland	1,274
	27	Black Grama and Blue Grama/Soaptree Yucca Piedmont Grasslands	2,159
	156	Blue Grama-Alkali Sacaton Grassland	1,395
	147	Hairy Grama-Black Grama, and Hairy Grama or Black Grama/Soaptree Yucca Piedmont Grasslands	4,394
17		**Piedmont Temperate Grasslands**	**4,712**
	118	Blue Grama-Sideoats Grama or Winterfat, and Black Grama/Soaptree Yucca Montane Valley Grasslands	4,712
18		**Desert Plains Grasslands**	**16,403**
	5	Black Grama, Galleta or Mesa Dropseed/Soaptree Yucca Sandy Plains Grassland	15,907
	186	Mesa Dropseed/Soaptree Yucca Sandy Plains Grassland	496
19		**Lowland Basin Grasslands**	**82,469**
	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	56,734
	6	Alkali Sacaton-Burrograss or Tobosagrass Basin Grasslands, and Fourwing Saltbush/Alkali Sacaton Basin Shrubland	23,494

Table 1. A hierarchically structured legend for the White Sands Missile Range Vegetation Map (continued).

Maj. Unit No.	Sub-Unit No.	Map Unit Name	Area (ha)
	178	Inland Saltgrass, and Inland Saltgrass-Alkali Sacaton Basin Alkaline Grasslands	1,134
	185	Tobosagrass-Burrograss or Alkali Sacaton Basin Grasslands	1,107
29		**Black Grama Lava Grassland**	**333**
	127	Black Grama/Torrey's Jointfir Lava Grassland	333
33		**Gypsum Interdune Swale Grassland**	**15,315**
	164	Gypsum Grama-New Mexico Bluestem Interdune Swale Grassland	15,315
		Miscellaneous	
20		**Wetlands**	**293**
	140	American Bulrush and Spikerush, Wetlands	293
21		**Alluvial Flats – Barren**	**1,818**
	157	Barren Alluvial Flats	1,818
22		**Gypsum Duneland – Vegetated**	**17,302**
	168	Broom Dalea Dune Shrublands	3,343
	160	Hoary Rosemarymint/Sandhill Muhly or Mesa Dropseed Gypsum Dune Shrubland	13,689
23		**Gypsum Duneland – Barren**	**27,872**
	162	Barren Gypsum Dune	27,872
24		**Rock Outcrop / Talus**	**71**
	182	Rock Outcrop/Talus Slope	71
30		**Vegetated Gypsum Outcrop**	**38,433**
	154	Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland	36,332
	9	Gyp Dropseed/Hairy Coldenia Foothill Grassland	2,101
35		**Playa**	**19,215**
	173	Barren Alkaline Playa	19,215
39		**Road Disturbance**	**28,694**
	189	Road Disturbance	28,694
40		**Military Disturbance**	**7,479**
	190	Military Disturbance	7,479

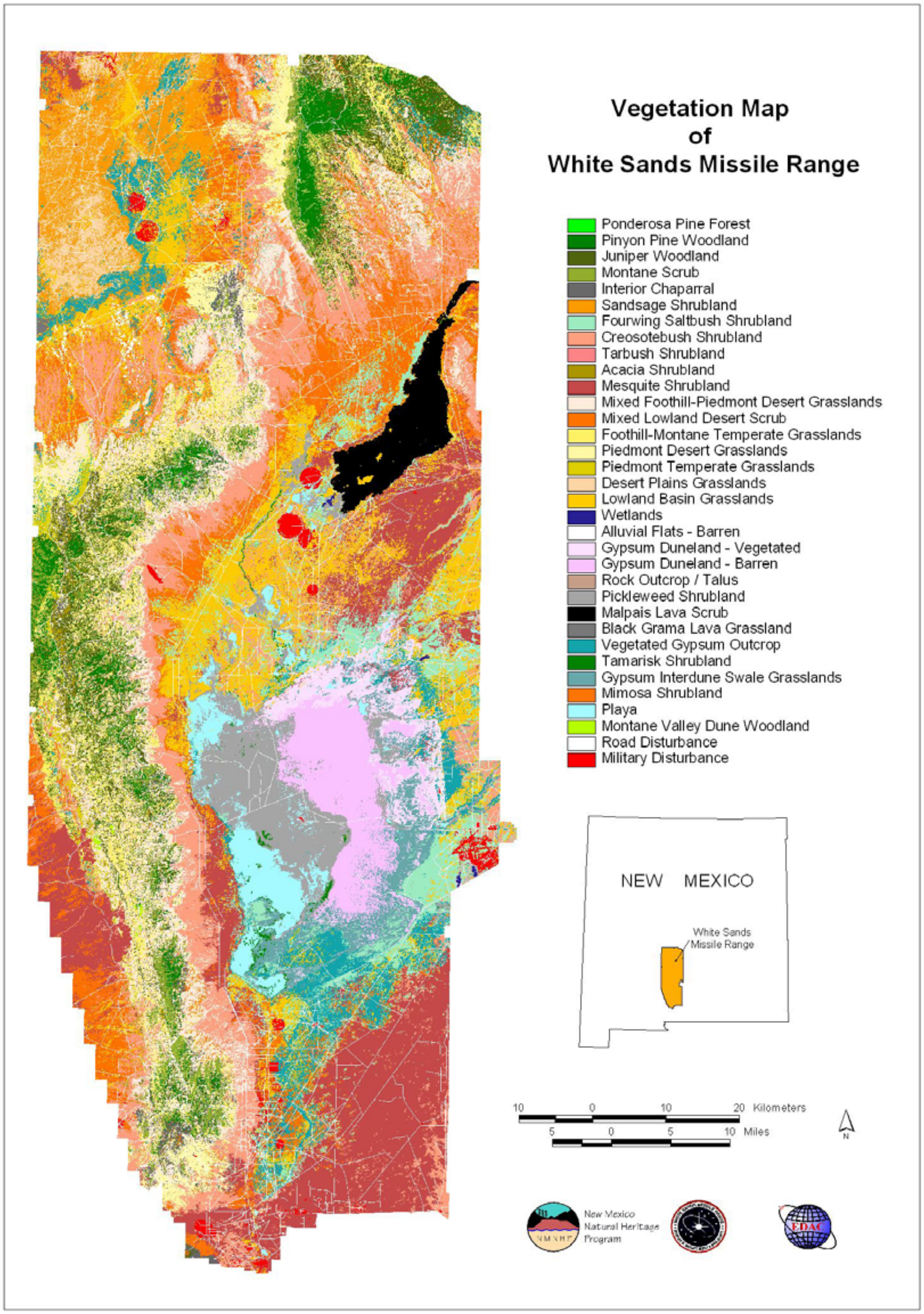

Figure 4. Vegetation Map of White Sands Missile Range.

The grassland group is made up primarily of Chihuahuan Desert Grasslands along with Plains-Mesa-Foothill Grasslands and Great Basin Desert Grasslands. The Foothill-Montane Grassland is dominated by species common to the eastern plains and mesas of New Mexico: blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*), sideoats grama (*B. curtipendula*), western wheatgrass (*Pascopyrum smithii*), and New Mexico Needlegrass (*Stipa neomexicana*). These grasslands occur from the foothills of the various mountain ranges up into higher montane valleys. In the interior valleys of the San Andres are the Piedmont Temperate grasslands which are also dominated by the above grama grasses plus some black grama (*Bouteloua eriopoda*) types, a Chihuahuan Desert element. Piedmont Desert Grasslands are primarily black grama grasslands of the alluvial fan piedmonts or "bajadas" that occur at the base of the Oscura, Mockingbird, and San Augustine Mountains. The Mixed Foothill-Piedmont Desert Grassland occurs on lower elevation foothills and upper alluvial fan piedmonts of the San Andres Mountains. This unit is also made up primarily of black grama dominated grasslands, but also includes some creosotebush and ocotillo (*Fouquieria splendens*) shrublands. The sandy plains of the northern Jornada basin support Desert Plains Grasslands made up of black grama and mesa dropseed (*Sporobolus flexulosus*) dominated grasslands that have a strong soaptree yucca component (*Yucca elata*). The bottoms of the Jornada and Tularosa basins support large expanses of Lowland Basin Grasslands dominated by alkali sacaton (*Sporobolus airoides*), a Great Basin element, and tobosagrass (*Hilaria mutica*), a Chihuahuan element. Burrograss (*Scleropogon brevifolius*) is a common codominant, particularly in degraded areas. The Black Grama Lava Grassland is a special unit limited to the Jornada lava flow along the northwest boundary of WSMR.

Another special unit is the Gypsum Interdune Swale Grassland dominated by gypsophilous species such as gypsum grama (*Bouteloua breviseta*) and New Mexico bluestem (*Schizachyrium neomexicanum*). This unit occurs between individual gypsum dunes of the extensive duneland of the central Tularosa. There are three additional gypsum related units. A Gypsum Duneland – Vegetated unit that encompasses semi-stabilized dunes that support shrublands commonly dominated by hoary rosemarymint (*Poliomintha incana*); a Vegetated Gypsum Outcrop unit that is characterized by gypsum hummocks and outcrops dominated by gyp dropseed (*Sporobolus nealleyi*) and hairy coldenia (*Tiquilia hispidissima*); and Gypsum Duneland – Barren that includes both the dunes and the interdune swales that are essentially devoid of vegetation.

Other non-vegetated classes include Alluvial Flats - Barren, Playa, Rock Outcrop/Talus, Road Disturbance (road and a 60-meter buffer), and Military Disturbance (cantonments, test and impact areas).

Riparian/wetland areas have been lumped into a general wetlands unit. Other than the large wetlands around Malpais Spring and Brazel Lake, most riparian communities could not be reliably delineated with TM imagery because of their linear distribution along water-courses, and hence are subsumed within the other map units.

Accuracy Assessment

The accuracy of the map was tested with independent data provided from the Land Condition Trend Analysis (LCTA) project on WSMR. A total of 168 validation points with vegetation data and known locations were used to evaluate both the major map units and the sub units. Each of the validation points was classified into a community type based on the classification system presented in Volume I. Using the GIS, each point was located on the map and evaluated for how well the map and point corresponded. A circular test area with a radius of 50 meters was created around each validation point. This corresponds to between six and eight pixels and was a conservative estimate of inherent spatial error in the map caused in the geocorrection of the satellite imagery, particularly in mountainous areas (see Appendix A). If the plant association of a validation point did not occur in one of the map units within this test area, then this was considered an error. Errors were further classified into “marginal” errors where the community type was closely related to community types with in the test area, and or “gross” errors where the vegetation was completely unrelated (forest versus grassland, for example). Twenty points were disqualified because they fell within 100-meter buffers of roads or other disturbance. A point by point evaluation is provided in Appendix B.

For the major map units there was a marginal error rate of 14.3% and a gross error rate of 4.2% for a total error rate of 18.5%, or conversely, an 81.5% overall accuracy rating (Table 2). For subunits the error rate was slightly greater at 16.1% for marginal errors and 5.9% for gross errors for an overall error rate of 22.0%, or a 78.0% overall accuracy rating. Some map units performed better than others, and for some units no validation points were available to test accuracy. The most common errors were between Desert shrublands and desert grasslands, and occasionally between desert shrublands and montane shrublands. Less common were errors among grasslands (see Appendix B for unit by unit listings). Overall, the error rate exceeded the project target of 80%, and the error rate was above average when compared to maps of similar scales based on TM imagery.

DISCUSSION

These vegetation maps represented here are the most advanced yet produced for WSMR and perhaps the some of the best representing arid ecosystems of the Southwest. As with all maps, a balance must be struck between cartographic functionality, information content, and the uses of the map. The 1:1700,000 scale should serve well as a range-wide planning tool that gives an overall sense of the distribution of the major ecosystems on WSMR. The 1:50,000 scale is most appropriate for watershed level analysis common in natural resources applications. At scales finer than 1:24,000, additional project level and site specific maps should be developed using higher resolution imagery.

One of the more powerful aspects of these maps is that they exist in digital form that can be readily integrated into a GIS and used with software such as ARCVIEW to produce desktop applications. In this form, the maps themselves can be readily updated and upgraded and, when linked to the ecological database, directly and effectively used in a flexible planning process. Hence, these maps should not be considered static, unchanging views of vegetation of White Sands Missile Range, but rather as changeable maps that can be enhanced as new information becomes available.

Table 2. WSMR Vegetation Map accuracy assessment error rates among major map units and subunits. Based on 168 independent Land Condition Trend Analysis (LCTA) vegetation transects.

Error Type	**Major Map Units**		**Subunits**	
	N	**%**	**N**	**%**
None	137	81.5	131	78.0
Marginal-related	24	14.3	27	16.1
Gross-unrelated	7	4.2	10	5.9

MAP UNIT DESCRIPTIONS

FORESTS and WOODLANDS

Map Unit 1 --- Ponderosa Pine Forest --- [91HA; 220AC]

This Rocky Mountain Montane Forest (Figure 5) unit is characterized by the Ponderosa Pine/Arizona Fescue Plant Association (PA). It is limited to the summit of Salinas Peak and north facing, high elevation drainages of Silver Top Mountain of the San Andres Mountains. These are small stands of open-canopied forest with grassy understories. The unit also includes Gambel's oak shrubland types that occur on steep, unstable talus slopes adjacent to the forests.

Sub-Unit

1.166 ----Ponderosa Pine/Arizona Fescue Forest and Gambel's Oak-Whortleleaf Snowberry or Prairie Junegrass Montane Shrubland [91HA; 220AC]

This minor ponderosa pine forest unit is restricted to the summits of Salinas Peak and Silver Top Mountain within the San Andres Mountains. The Ponderosa Pine/Arizona Fescue forest type accounts for approximately 75% of the map unit. The shrubby Gambel's Oak/Whortleleaf Snowberry and Gambel's Oak/Prairie Junegrass PAs are common on adjacent steep slopes.

Primary Plant Associations	
Ponderosa Pine/Arizona Fescue	*(Pinus ponderosa/Festuca arizonica)*
Gambel's Oak-Whortleleaf Snowberry	*(Quercus gambelii-Symphoricarpos oreophilus)*
Gambel's Oak/Prairie Junegrass	*(Quercus gambelii/Koeleria macrantha)*

Map Unit 2 --- Pinyon Pine Woodland --- [21,465 HA; 53,020 AC]

This Rocky Mountain/Great Basin Woodland (Figure 6) unit is characterized by pinyon pine types that dominate the higher elevations of the mountainous areas including the Chalk Hills, Chupadera Mesa, and the San Andres, San Augustine, Big Gyp, and Oscura Mountains. The Pinyon Pine/Scribner's Needlegrass and Pinyon Pine/Wavyleaf Oak PAs typically occur on platform summits or relatively gentle dipping slopes. In contrast, the steep escarpment and canyon sideslopes commonly support Pinyon Pine/Gambel's Oak (north facing) and Pinyon Pine/New Mexico Muhly (south facing). The Pinyon Pine/Mountain Mahogany is also important, particularly on sites that have been burned. These woodlands are most extensive to the north where they form dense, uniform stands on Chupadera Mesa and in the Oscura Mountains. To the south in the San Andres Mountains, the woodlands become less abundant, more fragmented, and increasingly intermixed with Montane Scrub. At lower elevations, pinyon pine decreases and juniper woodlands become more prevalent.

Sub-Units

2.129 ---- Pinyon Pine-Gambel's Oak Montane Woodland [428 HA; 1,058 AC]

A minor pinyon pine-Gambel's oak woodland unit that occurs on cool, high elevation slopes on the eastern slope of the Oscura Mountains.

Primary Plant Association	
Pinyon Pine-Gambel's Oak	(*Pinus edulis-Quercus* gambelii)

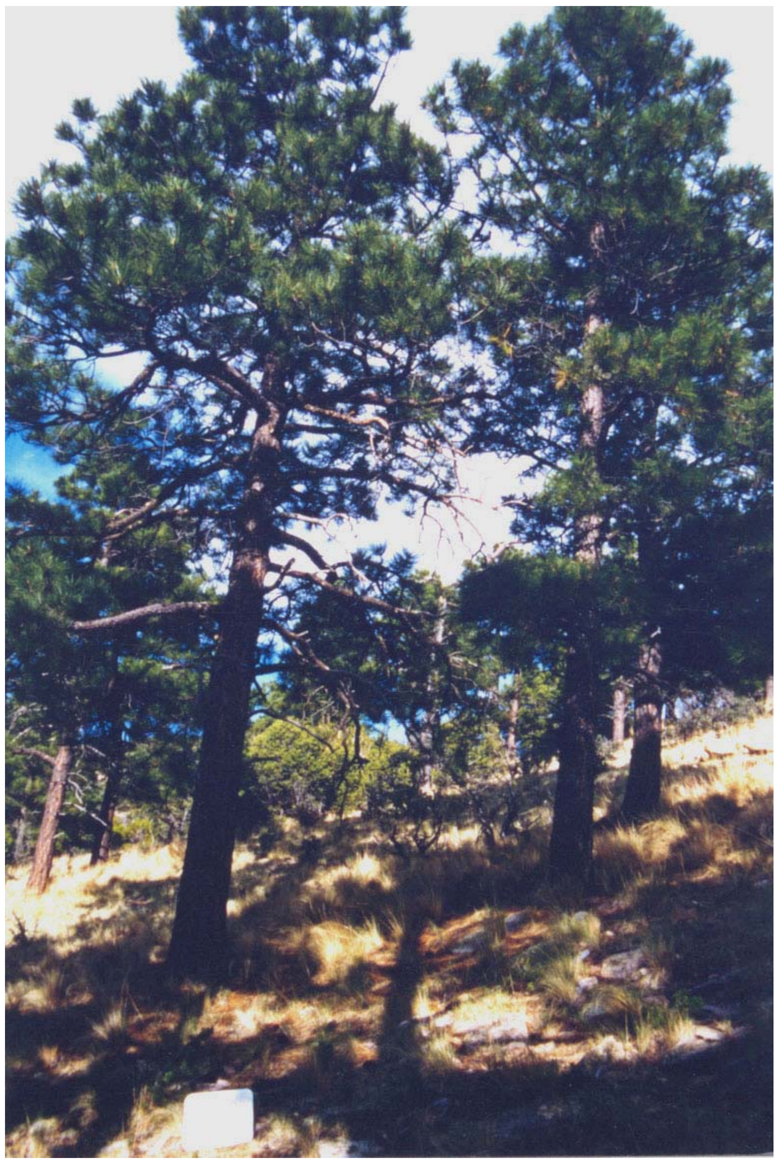

Figure 5. Ponderosa Pine Forest with an understory of Arizona Fescue. These relictual forests occur as small stands on Salinas Peak and Silvertop Mountain.

Photo: Yvonne Chauvin

2.114 ---- Pinyon Pine/Scribner's Needlegrass, New Mexico Muhly, or Blue Grama Montane Woodlands [12,131 HA; 29,975 AC]

This major montane pinyon pine woodland unit occurs on cool high elevation slopes of the Chalk Hills and the San Andres, San Augustine, and Big Gyp Mountains. Pinyon Pine/Scribner's Needlegrass and Pinyon Pine/New Mexico Muhly represent the highest elevation grassy understory PAs. These types tend to occur on north facing slopes in the central portions of the map unit. The Pinyon Pine/Banana Yucca and Pinyon Pine/Wavyleaf Oak PAs represent less common, high elevation shrubby understory types that occur on steep slopes of canyons and near mountain or ridge tops. At the edge of the unit at lower elevations, the Pinyon Pine/Blue Grama and Pinyon Pine/Curlyleaf Muhly woodland PAs become more prevalent. In addition, the Pinyon Pine/Mountain Mahogany PA occurs in woodlands that have been recently burned.

Primary Plant Associations	
Pinyon Pine/Scribner's Needlegrass	(*Pinus edulis/Stipa scribneri*)
Pinyon Pine/New Mexico Muhly	(*Pinus edulis/Muhlenbergia pauciflora*)
Pinyon Pine/Blue Grama	(*Pinus edulis/Bouteloua gracilis*)
Inclusions	
Pinyon Pine/Wavyleaf Oak	(*Pinus edulis/Quercus undulata*)
Pinyon Pine/Mountain Mahogany	(*Pinus edulis/Cercocarpus montanus*)
Pinyon Pine/Banana Yucca	(*Pinus edulis/Yucca baccata*)

2.116 --- Pinyon Pine/Wavyleaf Oak Montane Woodland [163 HA; 403 AC]

This incidental Pinyon Pine/Wavyleaf Oak montane woodland map unit type typically occurs on high elevation north facing slopes and in montane drainages of the Chalk Hills and the San Andres and San Augustine Mountains.

Primary Plant Association	
Pinyon Pine/Wavyleaf Oak	(*Pinus edulis/Quercus undulata*)

2.130 --- Pinyon Pine/Wavyleaf Oak, Scribner's Needlegrass, or Banana Yucca Montane Woodlands [8,743 HA; 21,604 AC]

A major montane pinyon pine woodland unit that occurs on high to mid elevation slopes across both the Oscura Mountains and Chupadera Mesa. The Pinyon Pine/Wavyleaf Oak and Pinyon Pine/Scribner's Needlegrass PAs represent approximately 70% of the unit and typically occur at the highest elevations and usually on relatively gentle slopes. The Pinyon Pine/Mountain Mahogany and Pinyon Pine/Banana Yucca PAs are common on valley sideslopes and represent approximately 15% of the unit.

Primary Plant Associations	
Pinyon Pine/Wavyleaf Oak	(*Pinus edulis/Quercus undulata*)
Pinyon Pine/Scribner's Needlegrass	(*Pinus edulis/Stipa scribneri*)
Pinyon Pine/Banana Yucca	(*Pinus edulis/Yucca baccata*)
Inclusions	
Pinyon Pine/Mountain Mahogany	(*Pinus edulis/Cercocarpus montanus*)
Pinyon Pine/Blue Grama	(*Pinus edulis/Bouteloua gracilis*)
Pinyon Pine-Gambel's Oak	(*Pinus edulis-Quercus gambelii*)

Figure 6. An example of Pinyon Pine Woodland with an understory of Scribner's needlegrass that is typical on higher slopes throughout the Oscura and San Andres Mountains. Photo: Yvonne Chauvin

Figure 7. Juniper Woodland canopies vary between open and closed. This example represents an open-canopied woodland as it occurs in the Oscura Mountains. Photo: Yvonne Chauvin

Map Unit 3 --- Juniper Woodland --- [32,621 HA; 80,574 AC]

These Rocky Mountain/Great Basin Woodlands are typified by open canopied stands of oneseed juniper with grassy understories (Figure 7). They occur at mid-elevations of the Chalk Hills, Chupadera Mesa and the San Andres, San Augustine, Big Gyp, Organ, and Oscura Mountains. Gentle mountain and piedmont slopes are dominated by the Oneseed Juniper/Blue Grama, Oneseed Juniper/Black Grama, or Oneseed Juniper/Hairy Grama PAs. Steeper slopes tend to support the Oneseed Juniper/New Mexico Needlegrass, Oneseed Juniper/Sideoats Grama, and Oneseed Juniper/New Mexico Muhly PAs. The Oneseed Juniper/Mountain Mahogany PA is also prevalent, particularly on sites that have been burned. As elevation increases, this unit gives way to Pinyon Pine Woodlands. At lower elevations, canopy becomes increasingly open as sites grade into grasslands or even Chihuahuan Desert Scrub types.

Sub-Units

3.131----Oneseed Juniper/New Mexico Needlegrass, Curlyleaf Muhly or Blue Grama Montane Woodlands [12,634 HA; 31,216 AC]

This major woodland unit is dominated by oneseed juniper types and occurs on mid to low-elevation slopes of the Oscura Mountains and Chupadera Mesa. The Oneseed Juniper/New Mexico Needlegrass and Oneseed Juniper/Sideoats Grama PAs are dominant on the steeper, more dissected slopes of mid elevations. In contrast, the Oneseed Juniper/Blue Grama and Oneseed Juniper/Hairy Grama PAs are found on the gentler slopes with deeper soils. At the lower elevation limit of the unit, One-seed Juniper/Curlyleaf Muhly and Oneseed Juniper/Black Grama PAs are more prevalent.

Primary Plant Associations	
Oneseed Juniper/New Mexico Needlegrass	*(Juniperus monosperma/Stipa neomexicana)*
Oneseed Juniper/Blue Grama	*(Juniperus monosperma/Bouteloua gracilis)*
Oneseed Juniper/Curlyleaf Muhly	*(Juniperus monosperma/Muhlenbergia setifolia)*
Inclusions	
Oneseed Juniper/Sideoats Grama	*(Juniperus monosperma/Bouteloua curtipendula)*
Oneseed Juniper/Hairy Grama	*(Juniperus monosperma/Bouteloua hirsuta)*
Oneseed Juniper/Black Grama	*(Juniperus monosperma/Bouteloua eriopoda)*

3.115----Oneseed Juniper/Sideoats Grama or Hairy Grama Montane Woodlands [8,755 HA; 21,634 AC]

This major montane woodland unit occurs across low to mid elevation slopes of the Chalk Hills and the San Andres, San Augustine, Organ, and Big Gyp Mountains. Steep rocky slopes within the map unit support the Oneseed Juniper/Sideoats Grama PA with occasional inclusions of Oneseed Juniper/Curlyleaf Muhly and Oneseed Juniper/New Mexico Needlegrass PAs. In contrast, the Oneseed Juniper/Hairy Grama PA is generally found on more gently sloped red sandstone uplifts (San Andres Mountains) or low elevation granitic slopes across the map unit. The Oneseed Juniper/Black Grama PA is a common inclusion at lower elevations and on warmer aspects.

Primary Plant Associations	
Oneseed Juniper/Sideoats Grama	*(Juniperus monosperma/Bouteloua curtipendula)*
Oneseed Juniper/Hairy Grama	*(Juniperus monosperma/Bouteloua hirsuta)*
Inclusions	
Oneseed Juniper/Curlyleaf Muhly	*(Juniperus monosperma/Muhlenbergia setifolia)*
Oneseed Juniper/New Mexico Needlegrass	*(Juniperus monosperma/Stipa neomexicana)*
Oneseed Juniper/Black Grama	*(Juniperus monosperma/Bouteloua eriopoda)*

3.146----Oneseed Juniper/Blue Grama, New Mexico Muhly or New Mexico Needlegrass Montane Woodlands [11,161 HA; 27,579 AC]

This major montane juniper woodland occurs at mid to high elevations of the Chalk Hills and in the San Andres, San Augustine, and Big Gyp Mountains. The Oneseed Juniper/New Mexico Muhly and Oneseed Juniper/Banana Yucca PAs commonly occur on steep, dissected slopes and, along with inclusions of Oneseed Juniper/Mountain Mahogany, represent approximately 50% of the unit. The Oneseed Juniper/New Mexico Needlegrass and Oneseed Juniper/Blue Grama PAs occur on cooler slopes and ridgetops and account for about 40% of the unit.

Primary Plant Associations	
Oneseed Juniper/Blue Grama	*(Juniperus monosperma/Bouteloua gracilis)*
Oneseed Juniper/New Mexico Muhly	*(Juniperus monosperma/Muhlenbergia pauciflora)*
Oneseed Juniper/New Mexico Needlegrass	*(Juniperus monosperma/Stipa neomexicana)*
Inclusions	
Oneseed Juniper/Banana Yucca	*(Juniperus monosperma/Yucca baccata)*
Oneseed Juniper/Sparse Undergrowth	*(Juniperus monosperma/Sparse)*
Oneseed Juniper/Mountain Mahogany	*(Juniperus monosperma/Cercocarpus montanus)*

3.181----Oneseed Juniper/New Mexico Needlegrass Gypsum Outcrop Montane Woodland [72 HA; 178 AC]

This minor open woodland is dominated by the Oneseed Juniper/New Mexico Needlegrass PA and is restricted to gypsum outcrops on Chupadera Mesa.

Primary Plant Associations	
Oneseed Juniper/New Mexico Needlegrass	*(Juniperus monosperma/Stipa neomexicana)*
Inclusions	
Gyp Dropseed/Hairy Coldenia	*(Sporobolus nealleyi/Tiquilia hispidissima)*
Black Grama/Bigelow's Sagebrush	*(Bouteloua eriopoda/Artemisia bigelovii)*

Map Unit 36 --- Montane Valley Dune Woodland --- [328 HA; 810 AC]

This Rocky Mountain Montane Woodland is dominated by oneseed juniper types and is restricted to dunes that occur in the interior valleys of the San Andres Mountains (Figure 10). The Oneseed Juniper/Shrub Live Oak PA is predominant, but Shrub Live Oak and Sandsage types can also occur on the dunes deposited on steeper slopes.

Sub-Unit

36.177----Oneseed Juniper/Shrub Live Oak or Sand Dropseed Montane Valley Dune Woodland

This minor open woodland unit is restricted to small dunelands that occur in valleys of the south-central San Andres Mountains. The Oneseed Juniper/Shrub Live Oak PA is predominant with patches of Oneseed Juniper/Sand Dropseed PA. The Shrub Live Oak/Thin Paspalum PA is an unusual inclusion.

Primary Plant Associations	
Oneseed Juniper/Shrub Live Oak	*(Juniperus monosperma/Quercus turbinella)*
Oneseed Juniper/Sand Dropseed	*(Juniperus monosperma/Sporobolus cryptandrus)*
Inclusions	
Sand Sagebrush/Mesa Dropseed	*(Artemisia filifolia/Sporobolus flexuosus)*
Shrub Live Oak/Thin Paspalum	*(Quercus turbinella/Paspalum setaceum)*

SHRUBLANDS

Map Unit 4 --- Montane Scrub --- [22,182 HA; 54,790 AC]

This temperate, Rocky Mountain Montane Scrub unit is characterized by mountain mahogany dominated communities (Figure 8) with wavyleaf oak as a common associate. They occur on slopes and ridges within the Chalk Hills and the San Andres, San Augustine, Organ, Mockingbird, Big Gyp, Fairview, and Oscura Mountains. The Mountain Mahogany/Blue Grama, Sideoats or Plains Lovegrass PAs occur throughout the unit, mostly on steeply sloped sites. The Mountain Mahogany/Curlyleaf Muhly PA is prevalent on ridges with exposed bedrock. Stands often occur where fire has removed Pinyon or Oneseed Juniper Woodlands.

Sub-Units

4.124----Mountain Mahogany/Blue Grama or Curlyleaf Muhly Montane Shrublands [766 HA; 1,893 AC]

This minor mountain mahogany shrubland subunit occurs on steep, high elevation slopes in the Mockingbird and Fairview Mountains. The Mountain Mahogany/Blue Grama PA occurs predominantly in the Mockingbird Mountains. In contrast, the Mountain Mahogany/Curlyleaf Muhly PA is predominantly present on exposed limestone bedrock in the Fairview Mountains and parts of the southern Mockingbird Mountains.

<u>Primary Plant Associations</u>	
Mountain Mahogany/Blue Grama	*(Cercocarpus montanus/Bouteloua gracilis)*
Mountain Mahogany/Curlyleaf Muhly	*(Cercocarpus montanus/Muhlenbergia setifolia)*

4.22---- Mountain Mahogany/Blue Grama, Sideoats Grama, or Plains Lovegrass Montane Shrublands [4,664 HA; 11,525 AC]

This temperate montane shrubland is a major sub-unit characterized by several mountain mahogany-dominated plant associations. It occurs predominantly across the high elevation and steep western and southern slopes of the Oscura Mountain range. Most of the component PAs have grassy undergrowths except for the Mountain Mahogany/Wavyleaf Oak PA. The unit may be representative of post-fire regrowth of pinyon-juniper woodlands.

<u>Primary Plant Associations</u>	
Mountain Mahogany/Sideoats Grama	*(Cercocarpus montanus/Bouteloua curtipendula)*
Mountain Mahogany/Blue Grama	*(Cercocarpus montanus/Bouteloua gracilis)*
Mountain Mahogany/Plains Lovegrass	*(Cercocarpus montanus/Eragrostis intermedia)*
<u>Inclusions</u>	
Mountain Mahogany/Black Grama	*(Cercocarpus montanus/Bouteloua eriopoda)*
Mountain Mahogany/New Mexico Muhly	*(Cercocarpus montanus/Muhlenbergia pauciflora)*
Mountain Mahogany-Wavyleaf Oak	*(Cercocarpus montanus-Quercus undulata)*

4.113----Mountain Mahogany/Sideoats Grama or Curlyleaf Muhly Montane Shrublands [16,752 HA; 41,394 AC]

A mountain mahogany-dominated montane shrubland that is a major unit on the cool slopes of the Chalk Hills and the San Andres, San Augustine, and Big Gyp Mountains. The Mountain Mahogany/Sideoats Grama PA with inclusions of the Mountain Mahogany/Plains Lovegrass and Mountain Mahogany/Sacahuista PAs occurs on shallow soils of moderate to steep slopes. In contrast, Mountain Mahogany/Curlyleaf Muhly typically occupies steep escarpment slopes and exposed bedrock sites at or near mountain summits or ridge tops.

<u>Primary Plant Associations</u>	
Mountain Mahogany/Sideoats Grama	*(Cercocarpus montanus/Bouteloua curtipendula)*
Mountain Mahogany/Curlyleaf Muhly	*(Cercocarpus montanus/Muhlenbergia setifolia)*
<u>Inclusions</u>	
Mountain Mahogany/Plains Lovegrass	*(Cercocarpus montanus/Eragrostis intermedia)*
Mountain Mahogany-Sacahuista	*(Cercocarpus montanus-Nolina microcarpa)*
Mountain Mahogany/New Mexico Muhly	*(Cercocarpus montanus/Muhlenbergia pauciflora)*

Map Unit 5 --- Interior Chaparral --- [8,640 HA; 21,340 AC]

This Interior Chaparral unit is dominated by shrub live oak types (Figure 9) and typically occurs on mid to low elevation slopes throughout the Chalk Hills and the San Andres, San Augustine, Organ, Mockingbird, and Oscura Mountains. The Shrub Live Oak/Black Grama, Shrub Live Oak/Hairy Grama, and Shrub Live Oak/Sideoats Grama PAs predominate. These types are commonly found adjacent to Oneseed Juniper Woodlands or grasslands. At higher elevations, the unit grades to Montane Scrub or Pinyon Woodlands.

Sub-Units

5.23---- Shrub Live Oak/Sideoats Grama, Mountain Mahogany Montane Shrublands [883 HA; 2,182 AC]

This minor montane shrub live oak-dominated shrubland sub-unit occurs predominantly on the steep southern and western slopes of the Oscura Mountain range. There are three main shrubland associations that occur: the grassy Shrub Live Oak/Black Grama and Shrub Live Oak/Blue Grama Pas occur primarily at lower elevations, while the Shrub Live Oak-Mountain Mahogany PA is found at higher elevations and is often adjacent to mountain mahogany-dominated units.

<u>Primary Plant Associations</u>	
Shrub Live Oak/Sideoats Grama	*(Quercus turbinella/Bouteloua curtipendula)*
Mountain Mahogany-Shrub Live Oak	*(Cercocarpus montanus-Quercus turbinella)*

Figure 8. Dense stands of Montane Scrub are especially common on burned pinyon pine sites high in the San Andres and Oscura Mountains. Photo: Yvonne Chauvin

Figure 9. Interior Chaparral canopies vary from open, such as this one, to closed and are dominated by shrub live oak. This example is from the Oscura Mountain escarpment. Photo: Yvonne Chauvin

5.153 and 5.123----Shrub Live Oak/Sideoats Grama, Hairy Grama or Black Grama Montane Shrubland [7,756 HA; 19,165 AC]

A major montane shrubland sub-unit dominated by shrub live oak communities with grassy understories. The unit occurs on granitic or red sandstone slopes in the Mockingbird and Fairview Mountains, Chalk Hills and in the San Andres, San Augustine, and Organ Mountains. The Shrub Live Oak/Sideoats Grama, Blue Grama and Hairy Grama Phases account for about 70% of the unit and occur mostly at higher elevations. The Black Grama Phase accounts for approximately 15% and is found at lower elevations. In addition, steep slopes commonly support the Shrub Live Oak-Mountain Mahogany PA.

<u>Primary Plant Associations</u>	
Shrub Live Oak/Sideoats Grama	*(Quercus turbinella/Bouteloua curtipendula)*
<u>Inclusions</u>	
Shrub Live Oak-Mountain Mahogany	*(Quercus turbinella-Cercocarpus montanus)*
Shrub Live Oak/Prairie Junegrass	*(Quercus turbinella/Koeleria macrantha)*

Map Unit 6 --- Sandsage Shrubland --- [34,572 HA; 85,392 AC]

This Plains-Mesa Sandscrub unit is dominated by sand sagebrush communities and forms extensive stands on the rolling, sandy plains of the northern Jornada Del Muerto basin and to a lesser extent on alluvial fan piedmonts at the bases of the Oscura, San Andres, and Mockingbird Mountains (Figure 11). The Sand Sagebrush/Dropseed PA typically is found on low sand dunes, while the Sand Sagebrush/Black Grama and Sand Sagebrush/Blue Grama PAs are more prevalent on the rolling plains and alluvial fans. The unit is intermixed with Desert Plains and Lowland Basin Grasslands.

Sub-Units

6.125----Sand Sagebrush/Black Grama or Blue Grama Piedmont Shrublands [662 HA; 1,636 AC]
This sand sagebrush desert shrubland is an incidental sub-unit on alluvial fan piedmonts of the western slopes of the Oscura and the eastern slopes of the Mockingbird and San Andres Mountains. The Sand Sagebrush/Black Grama PA occurs in both locations, while the Sand Sagebrush/Blue Grama PA is restricted to the Oscura Mountain fans.

<u>Primary Plant Associations</u>	
Sand Sagebrush/Black Grama	*(Artemisia filifolia/Bouteloua eriopoda)*
Sand Sagebrush/Blue Grama	*(Artemisia filifolia/Bouteloua gracilis)*

6.08----Sand Sagebrush/Black Grama, Galleta or Indian Ricegrass Sandy Plains Shrublands [9,156 HA; 22,624 AC]

This is a major shrubland map sub-unit of the rolling, sandy plains in the north-central portion of the northern Jornada basin. Sand Sagebrush/Black Grama and Sand Sagebrush/Galleta are the predominant plant associations. Sand Sagebrush/Black Grama occurs throughout the map unit, while Sand Sagebrush/Galleta primarily occurs in the western and more northern portions. To the north and east, as the sands become deeper, the Sand Sagebrush/Indian Ricegrass PA becomes more prevalent.

Figure 10. Montane Valley Dune Woodlands are common on sand sheets deposited within Lead Camp and San Andrecito Canyons. Photo: Yvonne Chauvin

Figure 11. Sandsage Shrubland on the sandy plains of the Northern Jornada del Muerto in the northwest portion of WSMR. Photo: Yvonne Chauvin

Primary Plant Associations

Sand Sagebrush/Black Grama	*(Artemisia filifolia/Bouteloua eriopoda)*
Sand Sagebrush/Galleta	*(Artemisia filifolia/Hilaria jamesii)*
Sand Sagebrush/Indian Ricegrass	*(Artemisia filifolia/Oryzopsis hymenoides)*

6.02----Sandsage/Dropseed Low Dune Shrublands [24,752 HA; 61,162 AC]

This sand sagebrush-dominated shrubland is a major map sub-unit in the northern Jornada Del Muerto basin. It primarily occurs as a low duneland on the sandy plains of the western side and northern end of the basin. The Sand Sagebrush/Mesa Dropseed shrubland plant association is predominant and accounts for approximately 80% of the map unit area (where deeper sands and taller dunes occur, the Giant Dropseed phase is prevalent). Sand Sagebrush/Alkali Sacaton PA is a less common component that typically occupies the edges of the inter-dune swales.

Primary Plant Associations

Sand Sagebrush/Mesa Dropseed	*(Artemisia filifolia/Sporobolus flexuosus)*
Sand Sagebrush/Alkali Sacaton	*(Artemisia filifolia/Sporobolus airoides)*

Inclusions

Sand Sagebrush/Black Grama	*(Artemisia filifolia/Bouteloua eriopoda)*
Sand Sagebrush/Galleta	*(Artemisia filifolia/Hilaria jamesii)*

Map Unit 7 --- Fourwing Saltbush Shrubland --- [37,734 HA; 93,204 AC]

This Great Basin Desert Scrub unit is dominated by fourwing saltbush types and is found on lowland alluvial plains and flats of the Tularosa and Jornada Del Muerto basins (Figure 12). The Fourwing Saltbush/Alkali Sacaton PA is the dominant community and forms extensive, relatively uniform stands intermixed with alkali sacaton grasslands throughout the unit. In addition, the Fourwing Saltbush/Mesa Dropseed PA is common in the southern portion of the Tularosa Basin.

Sub-Unit

7.109----Fourwing Saltbush/Alkali Sacaton or Mesa Dropseed Basin Shrublands, and Alkali Sacaton Basin Grasslands [37,734 HA; 93,204 AC]

This major lowland desert shrubland subunit occurs on silty and clayey alluvial flats in the central and southern areas of the Tularosa Basin bottom. The Fourwing Saltbush/Alkali Sacaton PA is the overwhelming component of the unit (80%) and occurs both north and south of the gypsum dunes. The other components of the unit also have fourwing saltbush as an element (even the Alkali Sacaton/Monotypic PA is characterized here with a Fourwing Saltbush Phase). The Fourwing Saltbush/Mesa Dropseed PA is occasionally found on sandy soils in the southern portions of the map unit.

Primary Plant Associations

Fourwing Saltbush/Alkali Sacaton	*(Atriplex canescens/Sporobolus airoides)*
Fourwing Saltbush/Mesa Dropseed	*(Atriplex canescens/Sporobolus flexuosus)*

Inclusions

Fourwing Saltbush/Sparse Undergrowth	*(Atriplex canescens/Sparse)*

Figure 12. An extensive stand of a Saltbush Shrubland on alluvial flats within the Tularosa Basin. Alkali sacaton is the dominant grass pictured here and is the most common associate found in these shrublands.
Photo: Glenn Harper

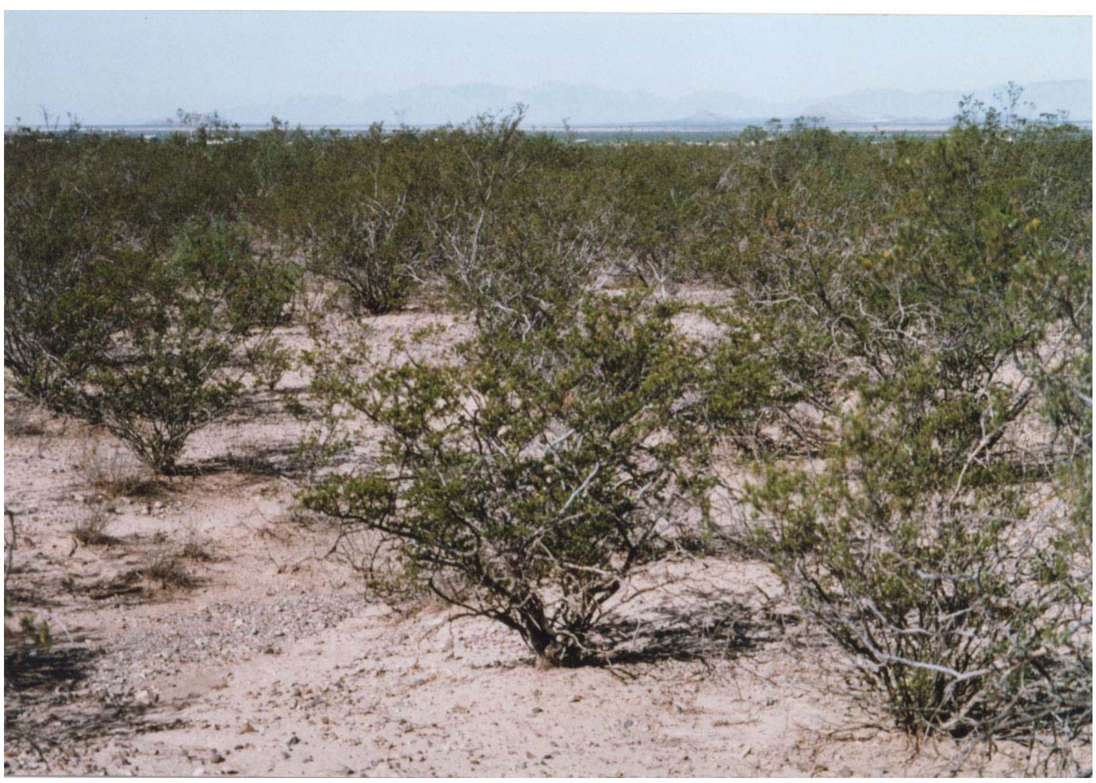

Figure 13. This sparse type of Creosotebush Shrubland occurs on gravelly piedmonts on the west side of the Tularosa basin.
Photo: Glenn Harper

Map Unit 8 --- Creosotebush Shrubland --- [115,526 HA; 285,349 AC]

This Chihuahuan Desert Scrub unit is typified by creosotebush dominated associations and occurs from low elevation basin bottoms up through the alluvial fan piedmonts, into foothills of the mountain ranges (Figure 13). The Creosotebush-Mariola, Ocotillo-Mariola, Creosotebush/Black Grama, and Creosotebush/Fluff Grass shrubland types generally occupy low foothill slopes and mid to upper portions of alluvial fans. In contrast to the Creosotebush/Alkali Sacaton, Creosotebush/Bush Muhly, and Creosotebush/Sparse PAs are generally found on basin bottoms and on mid to low portions of alluvial fans. Honey mesquite and tarbush can be codominant in the stands, and at lower elevations, the unit is often adjacent to the Mesquite Shrubland, Tarbush Shrubland, or Mixed Lowland Scrub units. At the upper elevations, it is commonly intermixed with Mixed Foothill-Piedmont Desert Grasslands.

Sub-Units

8.104----Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed Piedmont Shrublands [19,279 HA; 47,638 AC]

This desert shrubland is a major sub-unit across erosional mid to upper slopes of gravelly alluvial piedmonts of the San Andres and southern portions of the Oscura Mountains. The Creosotebush-Mariola PA dominates the subunit, sometimes with high additional cover of honey mesquite. In the southeastern portions of the San Andres, creosotebush is often less prominent and is replaced by the sub-shrub dominated Mariola-Pricklyleaf Dogweed PA.

Primary Plant Associations	
Creosotebush-Mariola	*(Larrea tridentata-Parthenium incanum)*
Mariola-Pricklyleaf Dogweed	*(Parthenium incanum-Thymophylla acerosa)*
Inclusions	
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/Sparse)*
Honey Mesquite-Fourwing Saltbush	*(Prosopis glandulosa-Atriplex canescens)*
Black Grama/Mariola	*(Bouteloua eriopoda/Parthenium incanum*
Creosotebush/Black Grama	*(Larrea tridentata/Bouteloua eriopoda*
Black Grama-Blue Grama	*(Bouteloua eriopoda-Bouteloua gracilis)*

8.149----Creosotebush-Mariola or Bush Muhly or Fluffgrass Piedmont Shrublands [6,174 HA; 15,256 AC]

A creosotebush-dominated desert shrubland that is a major subunit on gravelly alluvial fan piedmonts that extend from the southern foothills of the San Andres Mountains into the southern Jornada Basin. On the upper, gravelly slopes, the Creosotebush/Mariola PA is the common community. Further downslope, the Creosotebush/Bush Muhly and Creosotebush/Fluffgrass PAs become more prevalent along with the less common Creosotebush/Sparse PA. Honey mesquite is a common codominant throughout the subunit.

Primary Plant Associations	
Creosotebush-Mariola	*(Larrea tridentata-Parthenium incanum)*
Creosotebush/Bush Muhly	*(Larrea tridentata/Muhlenbergia porteri)*
Creosotebush/Fluffgrass	*(Larrea tridentata/Erioneuron pulchellum)*
Inclusions	
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/Sparse)*
Honey Mesquite-Threadleaf Snakeweed	*(Prosopis glandulosa-Gutierrezia microcephala)*

8.159----Creosotebush/Alkali Sacaton or Hairy Coldenia Basin Shrublands [13,650 HA; 33,729 AC]

This major creosotebush-dominated desert shrubland subunit is associated with gypsum soils in the central Tularosa Basin. The Creosotebush/Alkali Sacaton PA is found primarily on alluvial flats and accounts for approximately 80% of the subunit. The Creosotebush-Hairy Coldenia PA is found intermixed on gypsum mounds in the flats and accounts for approximately 10% of the subunit. Honey Mesquite is a common codominant.

<u>Primary Plant Associations</u>	
Creosotebush/Alkali Sacaton	*(Larrea tridentata/Sporobolus airoides)*
Creosotebush-Hairy Coldenia	*(Larrea tridentata/Tiquilia hispidissima)*
<u>Inclusions</u>	
Gyp Dropseed/Hairy Coldenia	*(Sporobolus nealleyi/Tiquilia hispidissima)*
Creosotebush/Mesa Dropseed	*(Larrea tridentata/Sporobolus flexuosus)*

8.137----Creosotebush/Black Grama or Alkali Sacaton, and Tarbush/Black Grama Piedmont Shrublands [6,512 HA; 16,091 AC]

This creosotebush-dominated desert shrubland is a major subunit that occurs in the northern Tularosa Basin on alluvial fans and flats immediately south and east of the Oscura Mountains. Creosotebush/Black Grama and Creosotebush/Alkali Sacaton PAs account for approximately 80% of the subunit. Intermixed with them is the Tarbush/Black Grama PA, particularly on alluvial flats in the northern portions of the subunit.

<u>Primary Plant Associations</u>	
Creosotebush/Black Grama	*(Larrea tridentata/Bouteloua eriopoda)*
Creosotebush/Alkali Sacaton	*(Larrea tridentata/Sporobolus airoides)*
Tarbush/Black Grama	*(Flourensia cernua/Bouteloua eriopoda)*

8.31----Creosotebush/Black Grama, Fluff Grass or Bush Muhly Piedmont Shrublands [18,789 HA; 46,428 AC]

This creosotebush-dominated desert shrubland is a major subunit that occurs both on footslopes and on gravelly alluvial fans leading onto the northern Jornada Basin from the Oscura, Little Burro, Mockingbird, and San Andres mountain ranges. The Creosotebush/Black Grama PA typically occurs upslope from the Creosotebush/Fluff Grass PA. In some downslope areas, the Creosotebush/Bush Muhly PA is intermixed with the latter.

<u>Primary Plant Associations</u>	
Creosotebush/Black Grama	*(Larrea tridentata/Bouteloua eriopoda)*
Creosotebush/Fluffgrass	*(Larrea tridentata/Erioneuron pulchellum)*
Creosotebush/Bush Muhly	*(Larrea tridentata/Muhlenbergia porteri)*
<u>Inclusions</u>	
Tarbush/Black Grama	*(Flourensia cernua/Bouteloua eriopoda)*

8.12----Creosotebush/Bush Muhly, Fluffgrass, or Mariola Foothill Shrublands [285 HA; 704 AC]

This minor creosotebush dominated desert shrubland subunit occurs on low volcanic hills in the northwestern corner of WSMR (Stallion Volcanoes Site). Typical of the subunit are stands of the Creosotebush/Bush Muhly PA and Creosotebush/Fluff Grass PA growing on gentle slopes with shallow soils.

Primary Plant Associations

Creosotebush/Bush Muhly	*(Larrea tridentata/Muhlenbergia porteri)*
Creosotebush/Fluffgrass	*(Larrea tridentata/Erioneuron pulchellum)*
Creosotebush-Mariola	*(Larrea tridentata-Parthenium incanum)*
Inclusions	
Littleleaf Sumac/Arroyo	*(Rhus microphylla/*Arroyo*)*
Black Grama/Mariola	*(Bouteloua eriopoda/Parthenium incanum)*
Littleleaf Sumac-Threadleaf Snakeweed	*(Rhus microphylla-Gutierrezia microcephala)*

8.142----Creosotebush/Fluffgrass or Sparse Piedmont Shrublands [949 HA; 2,345 AC]

This minor creosotebush desert shrubland subunit occurs on gravelly alluvial fans and slopes of the Phillips Hills on the eastern side the Malpais Lava Flow in the Tularosa Basin. The Creosotebush/Fluffgrass and Creosotebush/Sparse PAs dominate the gravelly slopes. Honey mesquite is a common codominant in these stands. At the upper end of the subunit, Creosotebush-Mariola is a common inclusion.

Primary Plant Associations

Creosotebush/Fluffgrass	*(Larrea tridentata/Erioneuron pulchellum)*
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/*Sparse*)*
Inclusions	
Creosotebush-Mariola	*(Larrea tridentata-Parthenium incanum)*

8.37----Creosotebush/Mariola Foothill Shrubland [430 HA; 1,063 AC]

This creosotebush-dominated desert shrubland is a minor subunit that occurs on small hillsides in the northeastern portion of the northern Jornada basin. The Creosotebush-Mariola PA is characteristic, but inclusions of the Tarbush/Galleta PA are known to occur.

Primary Plant Association

Creosotebush-Mariola	*(Larrea tridentata-Parthenium incanum)*

8.100----Creosotebush/Mesa Dropseed or Sparse Piedmont and Basin Shrublands [6,100 HA; 15,073 AC]

A major desert shrubland subunit dominated by the Creosotebush/Mesa Dropseed PA. It is primarily distributed as disjunct occurrences within the rolling honey mesquite coppice dune shrublands on the Tularosa Basin bottom and on the sandy alluvial fans on the west side of the Jarilla Mountains. The Creosotebush/Sparse PA is also an important member of the subunit and occurs further up the fans on less sandy soils.

Primary Plant Associations

Creosotebush/Mesa Dropseed	*(Larrea tridentata/Sporobolus flexuosus)*
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/*Sparse*)*
Inclusions	
Sand Sagebrush/Mesa Dropseed	*(Artemisia filifolia/Sporobolus flexuosus)*

8.105---Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands [41,955 HA; 103,671 AC]

This is the largest creosotebush-dominated desert shrubland subunit. It is extensively distributed on erosional mid-slopes of the gravelly alluvial fan piedmonts of the San Andres and southern Oscura Mountains. The Creosotebush/Sparse, Creosotebush/Bush Muhly, and Creosotebush/Fluffgrass PAs dominate the map unit. Honey mesquite is often a codominant, but overall species diversity is very low.

Primary Plant Associations	
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/*Sparse*)*
Creosotebush/Bush Muhly	*(Larrea tridentata/Muhlenbergia porteri)*
Creosotebush/Fluffgrass	*(Larrea tridentata/Erioneuron pulchellum)*
Inclusions	
Tarbush-Mariola	*(Flourensia cernua-Parthenium incanum)*
Honey Mesquite/Bush Muhly	*(Prosopis glandulosa/Muhlenbergia porteri)*
Creosotebush-Mariola	*(Larrea tridentata-Parthenium incanum)*

8.136----Ocotillo or Creosotebush-Mariola, or Mariola-Pricklyleaf Dogweed Foothill Shrublands [1,872 HA; 4,626 AC]

This is a minor desert shrubland complex restricted to rocky limestone and red sandstone slopes within the Little Burro Mountains. Typically, the Ocotillo-Mariola type occurs on the steeper, rockier slopes, while the Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed shrubland types occupy gravelly, less steep lower slopes.

Primary Plant Associations	
Ocotillo-Mariola	*(Fouquieria splendens-Parthenium incanum)*
Mariola-Pricklyleaf Dogweed	*(Parthenium incanum-Thymophylla acerosa)*
Creosotebush-Mariola	*(Larrea tridentata-Parthenium incanum)*
Inclusions	
Tarbush-Mariola	*(Flourensia cernua-Parthenium incanum)*

8.143----Ocotillo-Mariola Foothill Shrubland [1,403 HA; 3,467 AC]

This is a minor ocotillo-dominated desert shrubland subunit that is restricted to rocky slopes of the Phillips Hills on the eastern side the Malpais lava flow in the northern Tularosa basin.

Primary Plant Associations	
Ocotillo-Mariola	*(Fouquieria splendens-Parthenium incanum)*
Inclusions	
Creosotebush-Mariola	*(Larrea tridentata-Parthenium incanum)*

Map Unit 9 --- Tarbush Shrubland --- [1,039 HA; 2,567 AC]

This Chihuahuan Desert Scrub unit is characterized by tarbush types and occurs within montane valleys of the San Andres and Oscura Mountains (Figure 14). The Tarbush/Alkali Sacaton PA occurs on alluvial soils in the Green Valley within the San Andres Mountains. The Tarbush/Southwestern Needlegrass PA occupies rocky foothill slopes of the eastern Oscura Mountains.

Sub-Units

9.172----Tarbush/Alkali Sacaton Basin Shrubland [287 HA; 709 AC]

This minor desert shrubland subunit is dominated by the Tarbush/Alkali Sacaton PA. It is restricted to alluvial fan flats between the Chalk Hills and red sandstone uplifts within the south-central portion of the San Andres Mountains.

<u>Primary Plant Associations</u>	
Tarbush/Alkali Sacaton	*(Flourensia cernua/Sporobolus airoides)*
<u>Inclusions</u>	
Tarbush/Burrograss	*(Flourensia cernua/Scleropogon brevifolius)*
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/*Sparse*)*

9.180----Tarbush/Southwestern Needlegrass or Sideoats Grama Foothill Shrublands [752 HA; 1,858 AC]

This tarbush-dominated shrubland is a minor subunit of low-elevation foothill escarpment slopes of the southern portions of the Oscura Mountains. The Tarbush/Southwestern Needlegrass PA is the most common, occupying approximately 75% of the subunit, and is intermixed with the Tarbush/Sideoats Grama PA.

<u>Primary Plant Associations</u>	
Tarbush/Southwestern Needlegrass	*(Flourensia cernua/Stipa eminens)*
Tarbush/Sideoats Grama	*(Flourensia cernua/Bouteloua curtipendula)*
<u>Inclusions</u>	
Blue Grama/Mariola	*(Bouteloua gracilis/Parthenium incanum)*
Tarbush/Black Grama	*(Flourensia cernua/Bouteloua eriopoda)*

Map Unit 10 --- Acacia Shrubland --- [5,278 HA; 13,036 AC]

This Chihuahuan Desert Scrub unit is characterized by viscid acacia dominated communities that generally occur on foothill slopes and valley alluvial fans south of Rhodes Canyon within the San Andres Mountains (Figure 15). Viscid Acacia/Southwestern Needle and Viscid Acacia-Mariola PAs are predominant and typically form large continuous occurrences on red sandstone uplifts within the Green and Yonder Valleys.

Sub-Unit

10.121----Viscid Acacia/Southwestern Needlegrass, Mariola, or Tarbush Foothill Shrublands [5,278 HA; 13,036 AC]

This major viscid acacia desert shrubland subunit occurs on low to mid elevation warm slopes, primarily in the Chalk Hills and the San Andres and San Augustine Mountains. The Viscid Acacia/Southwestern Needlegrass and Viscid Acacia-Mariola PAs dominate the map subunit and are common on red sandstone uplifts in the central portions of the San Andres Mountains. The Viscid Acacia-Tarbush PA is less common and occurs within the central and southern portions of the subunit.

Figure 14. Typical Tarbush Shrubland with a dense tobosagrass understory, and often found on alluvial flats. of basin bottoms Photo: Yvonne Chauvin

Figure 15. Acacia Shrublands often occur on slopes Abo sandstone such as this one in the central San Andres Mountains. Photo: Yvonne Chauvin

Primary Plant Associations	
Viscid Acacia/Southwestern Needlegrass	*(Acacia neovernicosa/Stipa eminens)*
Viscid Acacia-Mariola	*(Acacia neovernicosa-Parthenium incanum)*
Viscid Acacia-Tarbush	*(Acacia neovernicosa-Flourensia cernua)*
Inclusions	
Viscid Acacia/Black Grama	*(Acacia neovernicosa/Bouteloua eriopoda)*
Tarbush/Sideoats Grama	*(Flourensia cernua/Bouteloua curtipendula)*
Tarbush/Black Grama	*(Flourensia cernua/Bouteloua eriopoda)*

Map Unit 11 --- Mesquite Shrubland --- [107,203 HA; 264,792 AC]

This Chihuahuan Desert Scrub unit is composed primarily of honey mesquite dominated communities (Figure 16) with inclusions of littleleaf sumac and is distributed throughout the Tularosa and Jornada Del Muerto basins. The Honey Mesquite-Fourwing Saltbush and Honey Mesquite-Snakeweed PAs are coppice dune types that cover large areas, particularly in the southern and central portions of the basins. The Littleleaf Sumac/Mesa Dropseed PA primarily occurs in the northern portion of the northern Jornada basin. Broom Dalea/Mesa Dropseed PA also occurs as a minor inclusion. Sand Sagebrush and Fourwing Saltbush and Creosotebush Shrublands are common adjacent units on the basin floors.

Sub-Units

11.155----Honey Mesquite-Fourwing Saltbush Basin Shrubland [1,287 HA; 3,180 AC]

This minor desert shrubland subunit is characterized by the Honey Mesquite-Fourwing Saltbush PA. It occupies alkaline soils north of the Malpais Lava Flow in the northern Tularosa Basin.

Primary Plant Associations	
Honey Mesquite-Fourwing Saltbush	*(Prosopis glandulosa-Atriplex canescens)*
Inclusions	
Fourwing Saltbush/Alkali Sacaton	*(Atriplex canescens/Sporobolus airoides)*

11.102----Honey Mesquite-Fourwing Saltbush or Mesa Dropseed Coppice Dune Shrublands [24,200 HA; 59,798 AC]

This honey mesquite coppice dune desert shrubland is a major subunit south of the The Malpais lava flow in the central Tularosa Basin floor (Tule Central and Three Rivers sites). The low diversity Honey Mesquite-Fourwing Saltbush PA comprises the majority of the subunit (85%). The closely related, but grassier Honey Mesquite/Mesa Dropseed PA constitutes the remaining 15%, primarily in the western portion of the subunit.

Primary Plant Associations	
Honey Mesquite-Fourwing Saltbush	*(Prosopis glandulosa-Atriplex canescens)*
Honey Mesquite/Mesa Dropseed	*(Prosopis glandulosa/Sporobolus flexuosus)*
Inclusions	
Honey Mesquite/Sand Dropseed	*(Prosopis glandulosa/Sporobolus cryptandrus)*
Broom Dalea/Mesa Dropseed	*(Psorothamnus scoparius/Sporobolus flexuosus)*

Figure 16. Mesquite Shrublands generally occur on coppice dunes, which form large, continuous stands, and are primarily found within the Tularosa and southern Jornada Basins. Photo: Glenn Harper

Figure 17. Mixed Lowland Desert Scrub dominated by tarbush (deciduous) and creosotebush (evergreen) on basin flats within the Tularosa basin. Photo: Glenn Harper

11.110----Honey Mesquite-Fourwing Saltbush or Snakeweed Basin Shrubland [9,854 HA; 24,349 AC]

This major desert shrubland subunit predominantly occurs on eastern, lower slopes of alluvial fans of the southern San Andres and Organ Mountains. It is also present in disjunct occurrences across the Tularosa Basin. The Honey Mesquite-Fourwing Saltbush and Honey Mesquite-Snakeweed PAs account for 90% of the subunit with occasional inclusions of the Creosotebush/Sparse Undergrowth PA. Desert seepweed is a common codominant on highly alkaline alluvial flat soils at the periphery of the Lake Lucero and Alkaline Flat areas.

Primary Plant Associations	
Honey Mesquite-Fourwing Saltbush	*(Prosopis glandulosa-Atriplex canescens)*
Honey Mesquite-Broom Snakeweed	*(Prosopis glandulosa-Gutierrezia sarothrae)*
Inclusions	
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/*Sparse*)*

11.101----Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands [48,533 HA; 119,925 AC]

This major subunit is characterized by honey mesquite coppice dunes that are distributed across large areas of the Tularosa Basin bottom in the southern part of WSMR. In terms of size, it is the second largest subunit in the study area with nearly 70% of it occupied by the Honey Mesquite-Fourwing Saltbush PA. The closely related Honey Mesquite-Snakeweed and Honey Mesquite/Mesa Dropseed PAs comprise the remaining 30% and tend to occur on the periphery of the subunit.

Primary Plant Associations	
Honey Mesquite-Fourwing Saltbush	*(Prosopis glandulosa-Atriplex canescens)*
Honey Mesquite-Broom Snakeweed	*(Prosopis glandulosa-Gutierrezia sarothrae)*
Honey Mesquite/Mesa Dropseed	*(Prosopis glandulosa/Sporobolus flexuosus)*
Inclusions	
Broom Dalea/Mesa Dropseed	*(Psorothamnus scoparius/Sporobolus flexuosus)*
Honey Mesquite/Bush Muhly	*(Prosopis glandulosa/Muhlenbergia porteri)*

11.148----Honey Mesquite-Snakeweed Coppice Dune Shrublands [4,851 HA; 11,987 AC]

This major honey mesquite shrubland subunit occurs on gently sloping granitic alluvial fan piedmonts at the base of the eastern Organ Mountains in the Tularosa Basin. The subunit is characterized by the low diversity Honey Mesquite/Threadleaf Snakeweed PA with phases where fourwing saltbush codominates.

Primary Plant Associations	
Honey Mesquite-Threadleaf Snakeweed	*(Prosopis glandulosa/Gutierrezia microcephala)*

11.07----Honey Mesquite-Snakeweed or Mesa Dropseed Coppice Dune Shrublands [1,931 HA; 4,772 AC]

This honey mesquite desert dune shrubland occurs on deep sands between and around small volcanic hills in the far northwestern portion of the northern Jornada basin. Honey Mesquite-Broom Snakeweed and Honey Mesquite/Mesa Dropseed PAs predominate, but small stands of the Littleleaf Sumac/Mesa Dropseed PA also occur within the map subunit. Sand sagebrush becomes more prevalent at the periphery of the subunit out into the basin, while creosotebush becomes more important further uphill.

<u>Primary Plant Associations</u>	
Honey Mesquite-Broom Snakeweed	*(Prosopis glandulosa-Gutierrezia sarothrae)*
Honey Mesquite/Mesa Dropseed	*(Prosopis glandulosa/Sporobolus flexuosus)*
<u>Inclusions</u>	
Littleleaf Sumac/Mesa Dropseed	*(Rhus microphylla/Sporobolus flexuosus)*
Honey Mesquite-Banana Yucca	*(Prosopis glandulosa-Yucca baccata)*

11.150----Honey Mesquite/Fourwing Saltbush or Snakeweed and Bush Muhly Coppice Dune Shrublands [14,954 HA; 36,951 AC]

This major honey mesquite coppice dune shrubland occurs on deep sand west of the southern foothills of the San Andres Mountains in the southern Jornada Basin. The Honey Mesquite-Fourwing Saltbush, Honey Mesquite/Bush Muhly, and Honey Mesquite-Broom Snakeweed PAs form relatively uniform duneland throughout the subunit with broom dalea as an occasional codominant.

<u>Primary Plant Associations</u>	
Honey Mesquite-Fourwing Saltbush	*(Prosopis glandulosa-Atriplex canescens)*
Honey Mesquite-Broom Snakeweed	*(Prosopis glandulosa-Gutierrezia sarothrae)*
Honey Mesquite/Bush Muhly	**(***Prosopis glandulosa/Muhlenbergia porteri)*
<u>Inclusions</u>	
Littleleaf Sumac/Mesa Dropseed	*(Rhus microphylla/Sporobolus flexuosus)*
Broom Dalea/Mesa Dropseed	*(Psorothamnus scoparius/Sporobolus flexuosus)*
Honey Mesquite/Mesa Dropseed	*(Prosopis glandulosa/Sporobolus flexuosus)*

11.04----Littleleaf Sumac/Dropseed Coppice Dune Shrublands [1,573 HA; 3,887 AC]

This minor desert coppice dune shrubland subunit is dominated by the large littleleaf sumac shrubs. It occurs on deep sands at the base of small hills in the far northeast portion of the northern Jornada basin. Littleleaf Sumac/Mesa Dropseed is the major plant association and accounts for about 60% of the subunit. The Littleleaf Sumac/Giant Dropseed PA is also important and occurs on deeper sands. The distribution of the subunit is patchy and is commonly found in a matrix with sand sagebrush and creosotebush desert shrubland communities.

<u>Primary Plant Associations</u>	
Littleleaf Sumac/Mesa Dropseed	*(Rhus microphylla/Sporobolus flexuosus)*
Littleleaf Sumac/Giant Dropseed	*(Rhus microphylla/Sporobolus giganteus)*
<u>Inclusions</u>	
Broom Dalea/Mesa Dropseed	*(Psorothamnus scoparius/Sporobolus flexuosus)*

Map Unit 13 --- Mixed Lowland Desert Scrub --- [76,966 HA; 190,105 AC]

This Chihuahuan Desert Scrub complex occurs on alluvial fans and basin bottom flats of the Tularosa and Jornada Del Muerto basins (Figure17). The map unit is characterized by inter-mixed Creosotebush, Tarbush, and Fourwing Saltbush Shrublands. In general, the northern Tularosa Basin is occupied by large occurrences of Creosotebush-Tarbush, Creosotebush/Alkali Sacaton, and Creosotebush/Sparse PAs. In contrast, to the south, Tarbush/Burrograss, Tarbush/Alkali Sacaton, Creosotebush/Sparse, and Fourwing Saltbush/Burrograss PAs predominate. Littleleaf Sumac/Alkali Sacaton is an additional shrubland component occurring in broad drainages within the Jornada Del Muerto Basin.

Sub-Units

13.151----Creosotebush-Tarbush or Creosote/Sparse Basin Shrublands [11,593 HA; 28,646 AC]

This major creosotebush desert shrubland subunit occurs on alluvial fan flats in the southern Jornada Basin west of the foothills of the San Andres Mountains. The low diversity Creosotebush/Tarbush and Creosotebush/Sparse PAs are interspersed throughout the subunit along with inclusions of Tarbush/Burrograss flats.

Primary Plant Associations	
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/Sparse)*
Creosotebush-Tarbush/Sparse Undergrowth	(*Larrea tridentata-Flourensia cernua/Sparse)*
Inclusions	
Tarbush/Tobosagrass	*(Flourensia cernua/Hilaria mutica)*

13.135----Creosotebush-Tarbush/Sparse or Alkali Sacaton, and Tarbush/Alkali Sacaton Basin Shrublands [18,296 HA; 45,209 AC]

This is a major lowland desert shrubland complex that occurs in the Jornada basin on alluvial fans and flats along the fronts of the Oscura, Little Burro, Mockingbird, and San Andres Mountains. Tarbush and/or creosotebush are the major community components. The Creosotebush-Tarbush/Sparse and Creosotebush/Alkali Sacaton PAs account for 40% of the subunit and are predominant in the northern and southwestern portions of the map subunit. The Tarbush/Alkali Sacaton PA is present on alluvial flats across the map subunit, with large occurrences west of the Mockingbird Mountains.

Primary Plant Associations	
Creosotebush-Tarbush/Sparse Undergrowth	*(Larrea tridentata-Flourensia cernua/*Sparse*)*
Creosotebush/Alkali Sacaton	*(Larrea tridentata/Sporobolus airoides)*
Tarbush/Alkali Sacaton	*(Flourensia cernua/Sporobolus airoides)*
Inclusions	
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/*Sparse*)*
Creosotebush/Bush Muhly	*(Larrea tridentata/Muhlenbergia porteri)*
Tarbush/Bush Muhly	*(Flourensia cernua/Muhlenbergia porteri)*

13.107----Creosotebush/Alkali Sacaton or Sparse, and Tarbush/Alkali Sacaton Basin Shrublands [36,134 HA; 89,287 AC]

This creosotebush-dominated desert shrubland is a major subunit distributed across lower alluvial fan piedmont of the eastern front of the San Andres Mountains and southern Oscura Mountains and extends onto the alluvial flats of the Jornada basin. Typically, the Creosotebush/Alkali Sacaton and Tarbush/Alkali Sacaton PAs are found at lower elevations, primarily on alluvial flats. In contrast, the Creosotebush/Sparse and Creosotebush/Bush Muhly PAs are usually found further up slope on the erosional alluvial fans. The Creosotebush/Mesa Dropseed is a common inclusion in sandier sites. In addition, honey mesquite is often a codominant.

Primary Plant Associations	
Creosotebush/Alkali Sacaton	*(Larrea tridentata/Sporobolus airoides)*
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/*Sparse*)*
Tarbush/Alkali Sacaton	*(Flourensia cernua/Sporobolus airoides)*
Inclusions	
Creosotebush/Bush Muhly	*(Larrea tridentata/Muhlenbergia porteri)*
Creosotebush/Mesa Dropseed	*(Larrea tridentata/Sporobolus flexuosus)*

13.141----Creosotebush/Sparse or Bush Muhly or Alkali Sacaton Basin Shrublands [3,357 HA; 8,295 AC]

This is a minor creosotebush-dominated desert shrubland subunit restricted to the alluvial fan at the base of the Phillips Hills on the eastern side of The Malpais lava flow in the Tularosa Basin. The Creosotebush/Sparse and Creosotebush/Bush Muhly PAs are found on the slopes and account for 90% of the subunit. The Creosotebush/Alkali Sacaton PA is an inclusion in the broad drainages and at the periphery of The Malpais lava flow.

Primary Plant Associations	
Creosotebush/Sparse Undergrowth	*(Larrea tridentata/*Sparse*)*
Creosotebush/Bush Muhly	*(Larrea tridentata/Muhlenbergia porteri)*
Inclusions	
Creosotebush/Alkali Sacaton	*(Larrea tridentata/Sporobolus airoides)*

13.174----Fourwing Saltbush or Tarbush/Burrograss, and Tarbush/Alkali Sacaton Basin Shrublands [6,790 HA; 16,778 AC]

This lowland desert shrubland is a major subunit of the southern Tularosa Basin that occurs on alluvial flats and in drainages on alluvial fans. The Fourwing Saltbush/Burrograss and Fourwing Saltbush/Bush Muhly PAs are the major components and are found primarily in the southeastern portion of the subunit (honey mesquite is commonly a codominant). The Tarbush/Alkali Sacaton and Tarbush/Burrograss PAs are less common and more restricted to drainages on the alluvial fans at the base of the southern San Andres Mountains.

Primary Plant Associations	
Fourwing Saltbush/Burrograss	*(Atriplex canescens/Scleropogon brevifolius)*
Tarbush/Burrograss	*(Flourensia cernua/Scleropogon brevifolius)*
Fourwing Saltbush/Bush Muhly	*(Atriplex canescens/Muhlenbergia porteri)*
Inclusions	
Tarbush/Tobosagrass	*(Flourensia cernua/Hilaria mutica)*
Tarbush/Alkali Sacaton	*(Flourensia cernua/Sporobolus airoides)*
Fourwing Saltbush/Sparse Undergrowth	*(Atriplex canescens/*Sparse*)*

13.29----Littleleaf Sumac/Sideoats Grama or Alkali Sacaton Basin Shrublands [257 HA; 635 AC]

This minor desert shrubland subunit is dominated by littleleaf sumac. It is restricted to swales or broad drainage bottoms that occur in the extensive alluvial fan piedmont that extends northward from the Poison Hills (southern end of the northern Jornada basin). The component plant associations have heavy grass undergrowths of either sideoats grama or alkali sacaton. The Littleleaf Sumac/Tobosagrass PA is also an occasional inclusion.

Primary Plant Associations	
Littleleaf Sumac/Sideoats Grama	*(Rhus microphylla/Bouteloua curtipendula)*
Littleleaf Sumac/Alkali Sacaton	*(Rhus microphylla/Sporobolus airoides)*
Inclusions	
Littleleaf Sumac/Tobosagrass	*(Rhus microphylla/Hilaria mutica)*

13.175----Tarbush or Fourwing Saltbush/Alkali Sacaton Basin Shrublands [538 HA; 1,329 AC]

This minor desert shrubland subunit is restricted to swales and to broad drainages of valleys leading out from the Oscura Mountains (FADS Valley and Red Rio). The Tarbush/Alkali Sacaton and Fourwing Saltbush/Alkali Sacaton PAs are characteristic here and account for 60% and 30% of the subunit respectively.

Primary Plant Associations

Tarbush/Alkali Sacaton	*(Flourensia cernua/Sporobolus airoides)*
Fourwing Saltbush/Alkali Sacaton	*(Atriplex canescens/Sporobolus airoides)*

Inclusions

Giant Sacaton/Monotypic Stand	*(Sporobolus wrightii/*Monotypic*)*
Fourwing Saltbush/Bush Muhly	*(Atriplex canescens/Muhlenbergia porteri)*

Map Unit 27 --- Pickleweed Shrubland --- [34,869 HA; 86,125 AC]

This Pickleweed Desert Shrubland occurs on alkaline flats and along the Salt Creek Drainage at the bottom of the Tularosa Basin lowlands (Figure 18). The Pickleweed/Sparse PA typifies the unit's extremely low shrub cover and densities, approaching barren alkaline flats in some areas. The most extensive continuous occurrence is found just north of Lake Lucero.

Sub-Unit

27.120----Pickleweed Alkaline Basin Shrubland [34,869 HA; 86,125 AC]

This pickleweed-dominated shrubland is a major subunit across the alkaline lowlands of the Tularosa Basin bottom. The Pickleweed/Sparse PA is predominant (>80%) and has very low diversity and cover undergrowth, with fourwing saltbush an occasional codominant. The Pickleweed/Hairy Coldenia PA is associated with gypsum substrates that are typical to the western side of the subunit in and among the gypsum dunes. All of these desert shrublands have sparse understories and may be mixed in with Alkaline Flats and other gypsum types.

Primary Plant Associations

Pickleweed/Sparse Undergrowth	*(Allenrolfea occidentalis/*Sparse*)*
Pickleweed-Hairy Coldenia	*(Allenrolfea occidentalis-Tiquilia hispidissima)*

Inclusions

Pickleweed/Alkali Sacaton	*(Allenrolfea occidentalis/Sporobolus airoides)*
Pickleweed/Transpecos Sealavender	*(Allenrolfea occidentalis/Limonium limbatum)*
Pickleweed/Spreading Alkaliweed	*(Allenrolfea occidentalis/Cressa truxillensis)*

Map Unit 28 --- Malpais Lava Scrub --- [16,441 HA; 40,610 AC]

This mixed desert shrubland complex occurs on The Malpais lava flow at the northern end of the Tularosa Basin (Figure 19). The heterogeneous topography of the lava flow supports a high diversity of shrub and grass species in a mixture that includes creosotebush, honey mesquite, Wright's beebrush, and tarbush along with black grama, sideoats grama, bush muhly, threeawns, and assorted annual forbs and grasses.

Sub-Unit

28.126----Malpais Lava Mixed Shrublands [16,441 HA; 40,610 AC]

This mixed desert shrubland map subunit characterizes the Malpais lava flow in the northern Tularosa Basin. It is composed of a complex mosaic of Creosotebush, Honey Mesquite, and Fourwing Saltbush Shrublands with small patches of Black Grama and Sideoats Grama Grasslands.

Primary Plant Association

Wright's Beebrush/Lava	*(Aloysia wrightii/Lava)*

Figure 18. Typically, Pickleweed Shrublands occur as large and uninterrupted stands such as this example on an alkaline alluvial flat within the Tularosa basin. Photo: Glenn Harper

Figure 19. Malpais Lava Scrub is found on The Malpais lava flow and is a complex of mesquite, creosotebush, saltbush, beebrush and tarbush, and other desert shrubs and grasses. Photo: Yvonne Chauvin

Map Unit 31 --- Tamarisk Shrubland --- [1,917 HA; 4,735 AC]

This semi-riparian shrubland occurs on alkaline flats along playa peripheries and the in the Salt Creek Drainage of the Tularosa Basin (Figure 20). The Tamarisk/Alkali Sacaton PA primarily occurs along the Salt Creek Drainage. In contrast, the Tamarisk/Pickleweed PA is typically found on alkaline flats.

Sub-Unit

31.161----Tamarisk-Pickleweed or Alkali Sacaton Basin Shrublands [1,917 HA; 4,735 AC]

A minor shrubland subunit dominated by exotic tamarisk (salt cedar) communities and associated with alkaline soils within the Tularosa Basin. The Tamarisk/Alkali Sacaton PA is primarily found along the Salt Creek drainage. The Tamarisk/Pickleweed PA occurs on alkali flats and playa peripheries in the Lake Lucero area.

<u>Primary Plant Associations</u>	
Saltcedar/Pickleweed	*(Tamarix ramosissima/Allenrolfea occidentalis)*
Saltcedar/Alkali Sacaton	*(Tamarix ramosissima/Sporobolus airoides)*
<u>Inclusions</u>	
Saltcedar/Utah Swampfire	*(Tamarix ramosissima/Sarcocornia utahensis)*

Map Unit 34 --- Mimosa Shrubland --- [2,201 HA; 5,436 AC]

This Chihuahuan Desert Scrub unit is characterized by mimosa dominated communities with grassy understories (Figure 21). It is distributed on granitic substrates of the foothills and alluvial fans of the southern San Andres, San Augustine, and Organ Mountains. Mimosa/Black Grama and Mimosa/Sideoats Grama PAs dominate with the most extensive occurrence on the alluvial fan leading out from Texas Canyon of the Organ Mountains.

Sub-Unit

34.165----Mimosa/Black Grama or Sideoats Grama Foothill Shrublands [2,201 HA; 5,436 AC]

This mimosa shrubland is a minor subunit of granitic foothills and alluvial fans along the eastern bases of the San Augustine, Organ, and southern San Andres Mountains. The Mimosa/Black Grama PA is most characteristic and accounts for 80% of the subunit. The Mimosa/Sideoats Grama PA is less common (15%) and is normally found further upslope.

<u>Primary Plant Associations</u>	
Mimosa/Black Grama	*(Mimosa aculeaticarpa/Bouteloua eriopoda)*
Mimosa/Sideoats Grama	*(Mimosa aculeaticarpa/Bouteloua curtipendula)*
<u>Inclusions</u>	
Mimosa/Tanglehead	*(Mimosa aculeaticarpa/Heteropogon contortus)*
Sideoats Grama/Common Sotol	*(Bouteloua curtipendula/Dasylirion wheeleri)*

Figure 20. Tamarisk Shrublands occur along stream drainages and may periodically be inundated. They can have dense, grassy understories, as in this example found in the Tularosa basin. Alternatively, Tamarisk shrublands can also occur on salt-crusted soils of alluvial flats and be sparsely vegetated.
Photo: Glenn Harper

GRASSLANDS

Map Unit 12 --- Mixed Foothill-Piedmont Desert Grasslands

[75,208 HA; 185,763 AC]

This map unit is an extensive complex of Plains-Mesa-Foothill Grasslands and Chihuahuan Desert Grasslands (Figure 22) that occurs on mid to low elevation mountain slopes, foothills, and upper alluvial fan piedmonts. These grasslands are represented by Hairy Grama, Black Grama, Curlyleaf Muhly, Blue Grama, and Sideoats Grama types. In general, the footslopes of the San Andres Mountains support the Black Grama-Sideoats Grama PA, while the upper alluvial fans are typified by the Black Grama/Mariola PAs. The interior mid elevation canyon slopes support Hairy Grama-Black Grama, Black Grama/Ocotillo PAs and various grama grasses with sotol types. The Curlyleaf Muhly/Bigelow's Sage, Black Grama/Bigelow's Sage, and Curlyleaf Muhly-Grama Grass PAs tend to be restricted to the valleys and basins of the eastern Oscura Mountains. At lower elevations, the unit commonly gives way to Piedmont Desert Grasslands, at higher elevations, Foothill-Montane Temperate Grasslands.

Sub-Units

12.179----Black Grama or Blue Grama/Bigelow's Sagebrush Foothill Grasslands [4,644 HA; 11,475 AC]

This desert grassland is a major subunit but restricted to the low gypsum foothills east of the Oscura Mountains. The Black Grama/Bigelow's Sage and Black Grama-Blue Grama/Bigelow's Sage PAs are characteristic and occupy approximately 90% of the subunit. The Blue Grama/Bigelow's Sage only accounts for approximately 10%.

<u>Primary Plant Associations</u>	
Black Grama/Bigelow's Sagebrush	*(Bouteloua eriopoda/Artemisia bigelovii)*
Blue Grama/Bigelow's Sagebrush	*(Bouteloua gracilis/Artemisia bigelovii)*
Black Grama-Blue Grama/Bigelow's Sagebrush	*(Bouteloua eriopoda-Bouteloua gracilis/Artemisia bigelovii)*

12.138----Black Grama-Blue Grama or Sideoats Grama and Blue Grama/Banana Yucca Foothill Grasslands [3,765 HA; 9,303 AC]

This major desert grassland subunit is found along the foothills and valley alluvial piedmonts in the south-east portion of the Oscura Mountains and southern Chupadera Mesa (FADS Valley and Red Rio). The Black Grama-Blue Grama, Blue Grama/Banana Yucca, and Black Grama-Sideoats Grama PAs together account for about 60% of the subunit. The Hairy Grama-Blue Grama PA is a common inclusion restricted to red sandstone hills in the valley bottoms.

<u>Primary Plant Associations</u>	
Black Grama-Blue Grama	*(Bouteloua eriopoda-Bouteloua gracilis)*
Blue Grama/Banana Yucca	*(Bouteloua gracilis/Yucca baccata)*
Black Grama-Sideoats Grama	*(Bouteloua eriopoda-Bouteloua curtipendula)*
<u>Inclusions</u>	
Hairy Grama-Blue Grama	*(Bouteloua hirsuta-Bouteloua gracilis)*
Black Grama/Torrey's Jointfir	*(Bouteloua eriopoda/Ephedra torreyana)*
Black Grama-Purple Threeawn	*(Bouteloua eriopoda-Aristida purpurea)*

Figure 21. Catclaw Mimosa Shrubland occurs on granitic soils pictured here in the southern San Andres Mountains and in the Organ Mountains. Photo: Yvonne Chauvin

Figure 22. Typical Mixed Foothill-Piedmont Desert Grassland (with a sotol shrub component) found on escarpments and upper bajadas throughout WSMR. Photo: Yvonne Chauvin

12.184----Black grama-Blue grama, and Black grama/Torrey's Jointfir Foothill Grasslands [460 HA; 1,137 AC]

This desert grama grassland is a minor subunit dominated by black grama plant associations and is found on the limestone foothills of the northern San Andres Mountains. Black Grama-Blue Grama and Black Grama/Blue Grama/Soaptree Yucca PAs dominate up to 90% of the subunit. Black Grama/Torrey's Jointfir accounts for the remaining 10% and is restricted to lower elevation toe slopes and upper alluvial fans.

Primary Plant Associations	
Black Grama-Blue Grama	*(Bouteloua eriopoda-Bouteloua gracilis)*
Black Grama-Blue Grama/Soaptree Yucca	*(Bouteloua eriopoda-Bouteloua gracilis/ Yucca elata)*
Black Grama/Torrey's Jointfir	*(Bouteloua eriopoda/Ephedra torreyana)*

12.122----Black Grama-Blue Grama, Sideoats Grama or Hairy Grama Foothill Grasslands [2,168 HA; 5,357 AC]

This minor black grama desert grassland subunit is restricted to the lower steep granitic slopes in the Mockingbird and Fairview Mountains. The Black Grama-Blue Grama, Hairy Grama-Black Grama, and Black Grama-Sideoats Grama PAs account for approximately 30% each of the subunit. There are inclusions where black grama is not important, and the Blue Grama-Sideoats Grama or Sideoats Grama/Sacahuista PAs are prominent.

Primary Plant Associations	
Black Grama-Blue Grama	*(Bouteloua eriopoda-Bouteloua gracilis)*
Hairy Grama-Black Grama	*(Bouteloua hirsuta-Bouteloua eriopoda)*
Black Grama-Sideoats Grama	*(Bouteloua eriopoda-Bouteloua curtipendula)*
Inclusions	
Blue Grama-Sideoats Grama	*(Bouteloua gracilis-Bouteloua curtipendula)*
Sideoats Grama/Sacahuista	*(Bouteloua curtipendula/Nolina microcarpa)*

12.144----Black Grama/Mariola Foothill Grassland [838 HA; 2,071 AC]

This minor Black Grama/Mariola desert grassland subunit occurs on the slopes of the Phillips Hills on the eastern side the Malpais Lava Flow in the Tularosa Basin

Primary Plant Associations	
Black Grama/Mariola	*(Bouteloua eriopoda/Parthenium incanum)*
Inclusions	
Black Grama/Ocotillo	*(Bouteloua eriopoda/Fouquieria splendens)*

12.103----Black Grama/Mariola or Sideoats Grama Foothill Grasslands and Ocotillo/Mariola Shrublands [40,164 HA; 99,245 AC]

This is a major black grama-dominated desert grassland that occurs in areas of transition from upper alluvial fans to steep foothill slopes of the San Andres and Oscura Mountains and elsewhere. On the upper portions of alluvial fans, the Black Grama/Mariola PA is often intermixed with the Creosotebush/Black Grama PA. Black Grama-Sideoats Grama grasslands dominate foothill slopes throughout the subunit. The relatively heterogeneous foothills may also include patches of Black Grama/Skeletonleaf Goldeneye, Black Grama/Ocotillo, Curlyleaf Muhly/Ocotillo, and Sideoats Grama/Mariola PAs. The Ocotillo-Mariola PA occurs primarily on very rocky slopes or rock outcrops.

Primary Plant Associations

Black Grama/Mariola	*(Bouteloua eriopoda/Parthenium incanum)*
Black Grama-Sideoats Grama	*(Bouteloua eriopoda-Bouteloua curtipendula)*
Ocotillo-Mariola	*(Fouquieria splendens-Parthenium incanum)*
Inclusions	
Creosotebush/Black Grama	*(Larrea tridentata/Bouteloua eriopoda)*
Black Grama/Ocotillo	*(Bouteloua eriopoda/Fouquieria splendens)*
Black Grama/Skeletonleaf Goldeneye	*(Bouteloua eriopoda/Viguiera stenoloba)*

12.20----Black Grama/Mariola Piedmont and Foothill Grassland [1,019 HA; 2,518 AC]

This minor desert grassland subunit is composed primarily of the Black Grama/Mariola PA. It is limited to the southern portion of an alluvial fan piedmont and to foothills at the base of the western escarpment of the Oscura Mountains. Commonly, along the southern and western limits of the subunit, creosotebush and honey mesquite shrublands may also occur as inclusions within this subunit.

Primary Plant Associations

Black Grama/Mariola	*(Bouteloua eriopoda/Parthenium incanum)*
Inclusions	
Creosotebush-Mariola	*(Larrea tridentata-Parthenium incanum)*
Creosotebush/Black Grama	*(Larrea tridentata/Bouteloua eriopoda)*
Black Grama/Ocotillo	*(Bouteloua eriopoda/Fouquieria splendens)*

12.134----Creosotebush/Black Grama Shrublands, and Black Grama/Mariola or Hairy Grama Grasslands [984 HA; 2,431 AC]

This minor desert grassland subunit occurs on slopes of small hills west of the Oscura Mountains, in the northeastern portion of the northern Jornada basin. The Black Grama/Mariola and Hairy Grama-Black Grama PAs are most common and are typically found higher up the slopes then the Creosotebush/Black Grama PA.

Primary Plant Associations

Creosotebush/Black Grama	*(Larrea tridentata/Bouteloua eriopoda)*
Black Grama/Mariola	*(Bouteloua eriopoda/Parthenium incanum)*
Hairy Grama-Black Grama	*(Bouteloua hirsuta-Bouteloua eriopoda)*
Inclusions	
Black Grama/Torrey's Jointfir	*(Bouteloua eriopoda/Ephedra torreyana)*

12.133----Curlyleaf Muhly Foothill Grasslands [2,120 HA; 5,239 AC]

This minor desert grassland subunit is dominated by curlyleaf muhly communities. It occurs on low elevation foothills and hilly plains south of Chupadera Mesa and east of the Oscura Mountains. The Curlyleaf Muhly/Bigelow's Sage, Curlyleaf Muhly/Ocotillo, and Curlyleaf Muhly-Hairy Grama PAs form a complex matrix in an area where soils are very heterogeneous and include outcrops of gypsum as well as limestone. Grassland types are the major components of the subunit.

Primary Plant Associations

Curlyleaf Muhly/Bigelow's Sagebrush	*(Muhlenbergia setifolia/Artemisia bigelovii)*
Curlyleaf Muhly/Ocotillo	*(Muhlenbergia setifolia/Fouquieria splendens)*
Curlyleaf Muhly-Hairy Grama	*(Muhlenbergia setifolia-Bouteloua hirsuta)*

Inclusions

Curlyleaf Muhly-New Mexico Needlegrass	*(Muhlenbergia setifolia-Stipa neomexicana)*
Curlyleaf Muhly-Blue Grama	*(Muhlenbergia setifolia-Bouteloua gracilis)*

12.171----Curlyleaf Muhly-Hairy Grama or Blue Grama, and Black Grama-Blue Grama Foothill Grasslands [3,014 HA; 7,448 AC]

This minor desert grassland subunit is restricted to rocky limestone slopes in the foothills of the Big Gyp Mountains and Poison Hills. The Curlyleaf Muhly-Hairy Grama and Curlyleaf Muhly-Blue Grama PAs typify these rocky sites and, along with the Curlyleaf Muhly/Mariola PA, account for at least 60% of the subunit. The rocky conditions are also reflected by the presence of an Ocotillo Phase of the Black Grama-Blue Grama PA that occupies slopes of exposed bedrock limestone.

Primary Plant Associations

Curlyleaf Muhly-Hairy Grama	*(Muhlenbergia setifolia-Bouteloua hirsuta)*
Curlyleaf Muhly-Blue Grama	*(Muhlenbergia setifolia-Bouteloua gracilis)*
Black Grama-Blue Grama	*(Bouteloua eriopoda-Bouteloua gracilis)*

Inclusions

Black Grama/Mariola	*(Bouteloua eriopoda/Parthenium incanum)*
Curlyleaf Muhly/Mariola	*(Muhlenbergia setifolia/Parthenium incanum)*

12.170----Hairy Grama-Black Grama, Sideoats Grama, or Sacahuista Foothill Grasslands [3,182 HA; 7,863 AC]

This is a major temperate grassland subunit dominated by hairy grama plant associations. It typically occurs on steep granitic slopes of the San Andres and San Augustine Mountains. Hairy Grama-Black Grama and Hairy Grama-Sideoats Grama PAs account for approximately 60% of the subunit, mostly on the steeper slopes. The Hairy Grama-Sacahuista PA is less common and is associated with gentler slopes, along with inclusions of Hairy Grama-Blue Grama and Hairy Grama/Featherplume PAs.

Primary Plant Associations

Hairy Grama-Black Grama	*(Bouteloua hirsuta-Bouteloua eriopoda)*
Hairy Grama-Sideoats Grama	*(Bouteloua hirsuta-Bouteloua curtipendula)*
Hairy Grama/Sacahuista	*(Bouteloua hirsuta/Nolina microcarpa)*

Inclusions

Hairy Grama-Blue Grama	*(Bouteloua hirsuta-Bouteloua gracilis)*
Hairy Grama/Featherplume	*(Bouteloua hirsuta/Dalea formosa)*
Black Grama/Apacheplume	*(Bouteloua eriopoda/Fallugia paradoxa)*

12.30----Hairy Grama/Featherplume Foothill Grassland [208 HA; 514 AC]

This minor foothill desert grassland subunit is dominated by the Hairy Grama/Featherplume PA that is limited to the slopes of the Poison Hills along the south rim of the northern Jornada basin.

Primary Plant Associations

Hairy Grama/Featherplume	*(Bouteloua hirsuta/Dalea formosa)*

Inclusions

Hairy Grama-Black Grama	*(Bouteloua hirsuta-Bouteloua eriopoda)*

12.117-----Mixed Grama Foothill Grassland [3,500 HA; 8,649 AC]

This minor foothill grassland subunit is dominated by a mixture of grama grass types, and the subunit occurs predominantly on mid elevation red sandstone uplifts in the central portion of the San Andres Mountains. The Sideoats Grama/Featherplume PA is the predominant component (50%) with inclusions of Hairy Grama/Sideoats Grama and is most often found on the cooler slopes. On warmer aspects, the Black Grama-Blue Grama and Hairy Grama-Black Grama PAs are most common.

Primary Plant Associations	
Sideoats Grama/Featherplume	*(Bouteloua curtipendula/Dalea formosa)*
Black Grama-Blue Grama	*(Bouteloua eriopoda-Bouteloua gracilis)*
Hairy Grama-Black Grama	*(Bouteloua hirsuta-Bouteloua eriopoda)*
Inclusions	
Hairy Grama-Sideoats Grama	*(Bouteloua hirsuta-Bouteloua curtipendula)*

12.145----Sideoats, Black or Hairy Grama/Sotol Foothill Grasslands [7,270 HA; 17,964 AC]

This is a major foothill desert grassland subunit dominated by various grasslands with sotol as a significant shrub element. The subunit typically occurs on steep, rocky canyon slopes within the Chalk Hills and the San Andres and San Augustine Mountains. Sideoats Grama/Common Sotol, Black Grama/Common Sotol, and Hairy Grama/Common Sotol PAs account for nearly 90% of the subunit, but New Mexico Needlegrass/Common Sotol and Curlyleaf Muhly/Common Sotol are also common inclusions. On occasion, ocotillo is a common codominant, particularly on exposed bedrock sites.

Primary Plant Associations	
Sideoats Grama/Common Sotol	*Bouteloua curtipendula/Dasylirion wheeleri*
Black Grama/Common Sotol	*Bouteloua eriopoda/Dasylirion wheeleri*
Hairy Grama/Common Sotol	*Bouteloua hirsuta/Dasylirion wheeleri*
Inclusions	
New Mexico Needlegrass/Common Sotol	*Stipa neomexicana/Dasylirion wheeleri*
Curlyleaf Muhly/Common Sotol	*Muhlenbergia setifolia/Dasylirion wheeleri*
New Mexico Needlegrass-Sideoats Grama	*Stipa neomexicana-Bouteloua curtipendula*

Map Unit 15 --- Foothill Montane Temperate Grasslands

[38,299 HA; 94,597 AC]

This temperate grassland unit is characterized by blue grama, New Mexico needlegrass (Figure 23), and western wheatgrass dominated communities and occurs on mid to high elevation mountain slopes and in mountain valleys of the Chalk Hills and Chupadera Mesa, and the Oscura, San Andres, San Augustine, and Big Gyp Mountains. New Mexico Needlegrass/Hairy, Blue, or Black Grama PAs along with Blue Grama-Sideoats and Blue Grama/Banana Yucca PAs are common on steep mountain and foothill slopes, while Blue Grama-Western Wheatgrass and Blue Grama/Winterfat PAs occur in the valleys. The Mountain Mahogany/New Mexico Needlegrass shrubland is also a common component. The unit is commonly surrounded by Montane Shrublands, or Pinyon Pine or Oneseed Juniper Woodlands.

Figure 23. Foothill Montane Temperate Grassland dominated by hairy grama and New Mexico needlegrass at higher elevations of the San Andres Mountains. Photo: Yvonne Chauvin

Figure 24. Piedmont Desert Grassland dominated by black grama and longleaf jointfir (Mormon tea) at the base of the eastern side of the Mockingbird Mountains. Photo: Yvonne Chauvin

Sub-Units

15.183----Blue Grama/ Banana Yucca and Blue Grama-Sideoats Grama Montane Grasslands [31 HA; 77 AC]

This is a minor montane grassland subunit of higher elevation ridgetops of the San Andres Mountains. Blue Grama/Banana Yucca accounts for approximately 90% of the subunit. Blue Grama-Sideoats Grama is an additional but limited component. At the periphery of the subunit adjacent to woodlands, oneseed juniper and pinyon pine trees become more prevalent in the grassland.

Primary Plant Associations	
Blue Grama-Sideoats Grama	*(Bouteloua gracilis-Bouteloua curtipendula)*
Blue Grama/Banana Yucca	*(Bouteloua gracilis/Yucca baccata)*
Inclusions	
Tobosagrass-Blue Grama	*(Hilaria mutica-Bouteloua gracilis)*

15.128----Blue Grama/Winterfat, Western Wheatgrass or Soaptree Yucca Montane Grasslands [4,444 HA; 10,981 AC]

This major montane temperate grassland subunit occurs in mid to high elevation valleys on the eastern slopes of the Oscura Mountains and Chupadera Mesa. At high elevations, valleys are commonly narrow and support dense stands of Blue Grama-Western Wheatgrass. At mid-elevations, the Blue Grama/Winterfat PA becomes more common, and in the lower elevations, broad drainages between the Oscura Mountains and Chupadera Mesa support the Blue Grama/Soaptree Yucca PA.

Primary Plant Associations	
Blue Grama/Winterfat	*(Bouteloua gracilis/Krascheninnikovia lanata)*
Blue Grama-Western Wheatgrass	*(Bouteloua gracilis-Pascopyrum smithii)*
Blue Grama/Soaptree Yucca	*(Bouteloua gracilis/Yucca elata)*
Inclusions	
Blue Grama/Monotypic Stand	*(Bouteloua gracilis/*Monotypic*)*
Galleta-Alkali Sacaton	*(Hilaria jamesii-Sporobolus airoides)*

15.132---New Mexico Needlegrass Montane Grasslands and Mountain Mahogany/New Mexico Needlegrass Montane Shrublands [4,834 HA; 11,945 AC]

This is a major temperate grassland dominated by New Mexico Needlegrass communities that occurs on mid to lower elevation moderately steep slopes of the Oscura Mountains and Chupadera Mesa. The New Mexico Needlegrass-Sideoats Grama PA is more prevalent at higher elevations, while the New Mexico Needlegrass-Black Grama PA is dominant lower; both make up about 80% of the subunit. In addition, the Mountain Mahogany/New Mexico Needlegrass shrubland type accounts for approximately 15% of the subunit and generally occurs at the upper elevation woodland/shrubland grassland transition on the western slope of the Oscura Mountains.

Primary Plant Associations	
New Mexico Needlegrass-Sideoats Grama	*(Stipa neomexicana-Bouteloua curtipendula)*
New Mexico Needlegrass-Black Grama	*(Stipa neomexicana-Bouteloua eriopoda)*
Mountain Mahogany/New Mexico Needlegrass	*(Cercocarpus montanus/Stipa neomexicana)*
Inclusions	
New Mexico Needlegrass-Blue Grama	*(Stipa neomexicana-Bouteloua gracilis)*
New Mexico Needlegrass-Hairy Grama	*(Stipa neomexicana-Bouteloua hirsuta)*
Sideoats Grama/Common Sotol	*(Bouteloua Curtipendula/Dasylirion wheeleri)*

15.119----New Mexico Needlegrass-Grama Grass Montane Grasslands
[28,989 HA; 71,632 AC]

This major montane temperate grassland subunit occurs on mid to high elevation slopes across the Chalk Hills and the San Andres, San Augustine, and Big Gyp Mountains. The New Mexico Needlegrass-Sideoats Grama, New Mexico Needlegrass-Hairy Grama, and New Mexico Needlegrass-Black Grama PAs account for approximately 70% of the subunit and occur on cool, steep slopes. There are inclusions of the shrubby Mountain Mahogany/New Mexico Needlegrass (20% of the subunit). They typically occur at higher elevations adjacent to pinyon-juniper woodlands.

<u>Primary Plant Associations</u>	
New Mexico Needlegrass-Sideoats Grama	*(Stipa neomexicana-Bouteloua curtipendula)*
New Mexico Needlegrass-Hairy Grama	*(Stipa neomexicana-Bouteloua hirsuta)*
New Mexico Needlegrass-Black Grama	*(Stipa neomexicana-Bouteloua eriopoda)*
<u>Inclusions</u>	
Mountain Mahogany/New Mexico Needlegrass	*(Cercocarpus montanus/Stipa neomexicana)*
New Mexico Needlegrass/Sacahuista	*(Stipa neomexicana/Nolina microcarpa)*
Curlyleaf Muhly-New Mexico Needlegrass	*(Muhlenbergia setifolia-Stipa neomexicana)*

Map Unit 16 --- Piedmont Desert Grasslands --- [15,599 HA; 38,530]

This Chihuahuan Desert Grassland unit is dominated by black grama types and occurs on alluvial fan piedmonts of the Mockingbird, San Augustine, San Andres, Big Gyp, and Oscura Mountains (Figure 24). The western Oscura Mountain piedmont is occupied by Black and Blue Grama Yucca grasslands. Granitic alluvial fans leading out from the east and west slopes of the Mockingbird Mountains are dominated by Black Grama/Longleaf Jointfir and Black and Blue Grama/Soaptree Yucca PAs. Low sloped alluvial drainages leading out north from the Big Gyp and northern San Andres Mountains are occupied by the Blue Grama-Alkali Sacaton PAs. The San Augustine Mountain alluvial fan supports Hairy and Black Grama/Soaptree Yucca PAs. At lower elevations, the unit gives way to Lowland Basin Grasslands or various Chihuahuan Desert Scrub units. Commonly upslope are Mixed Foothill-Piedmont Grasslands or Interior Chaparral.

Sub-Unit

16.27----Black Grama and Blue Grama/Soaptree Yucca Piedmont Grasslands
[2,159 HA; 5,335 AC]

This desert grassland is a minor subunit that occurs along the upper slopes of the granitic alluvial fans that extend out from the east and west sides of the Mockingbird Mountains. The Black Grama-Blue Grama/Soaptree Yucca PA predominates along with inclusions of the less shrubby Black Grama-Blue Grama PA. There are also areas where blue grama is absent and the Black Grama/Soaptree Yucca PA is prevalent.

<u>Primary Plant Associations</u>	
Black Grama-Blue Grama/Soaptree Yucca	*(Bouteloua eriopoda-Bouteloua gracilis/ Yucca elata)*
Black Grama/Soaptree Yucca	*(Bouteloua eriopoda/Yucca elata)*
<u>Inclusions</u>	
Black Grama-Blue Grama	*(Bouteloua eriopoda-Bouteloua gracilis)*

16.17-----Black Grama and Blue Grama/Yucca Piedmont Grasslands [6,378 HA; 15,760 AC]

This major desert grassland subunit occurs on a wide, gently sloping alluvial fan leading out from the western escarpment front of the Oscura Mountains. Among black and/or blue grama-dominated grasslands are scattered but conspicuous banana or soaptree yuccas. There are occasional inclusions of the non-yucca Black Grama-Blue Grama or Black Grama-Cane Bluestem PAs.

Primary Plant Associations	
Black Grama/Banana Yucca	*(Bouteloua eriopoda/Yucca baccata)*
Black Grama-Blue Grama/Soaptree Yucca	*(Bouteloua eriopoda-Bouteloua gracilis/ Yucca elata)*
Inclusions	
Black Grama-Blue Grama	*(Bouteloua eriopoda-Bouteloua gracilis)*
Black Grama-Cane Bluestem	*(Bouteloua eriopoda-Bothriochloa barbinodis)*
Black Grama-Blue Grama/Banana Yucca	*(Bouteloua eriopoda-Bouteloua gracilis/ Yucca baccata)*

16.24----Black Grama/Longleaf Jointfir Piedmont Grassland [1,274 HA; 3,148 AC]

This is a minor desert grassland subunit characterized by extensive stands of the Black Grama/Longleaf Jointfir PA, but limited to the granitic alluvial fans that extend out from the base of the eastern and western slopes of the Mockingbird Mountains.

Primary Plant Associations	
Black Grama/Longleaf Jointfir	*(Bouteloua eriopoda/Ephedra trifurca)*
Inclusions	
Black Grama-Alkali Sacaton	*(Bouteloua eriopoda-Sporobolus airoides)*
Black Grama-Blue Grama/Soaptree Yucca	*(Bouteloua eriopoda-Bouteloua gracilis/ Yucca elata)*

16.156----Blue Grama-Alkali Sacaton Grassland [1,395 HA; 3,447 AC]

This minor Blue Grama-Alkali Sacaton grassland subunit occupies broad drainage bottoms that extend out from the northern San Andres and Big Gyp Mountains in the northern Jornada basin.

Primary Plant Associations	
Blue Grama-Alkali Sacaton	*(Bouteloua gracilis-Sporobolus airoides)*
Inclusions	
Alkali Sacaton/Monotypic Stand	*(Sporobolus airoides/*Monotypic*)*
Blue Grama/Soaptree Yucca	*(Bouteloua gracilis/Yucca elata)*

16.147----Hairy Grama-Black Grama, and Hairy Grama or Black Grama/Soaptree Yucca Piedmont Grasslands [4,394 HA; 10,858 AC]

This major desert grassland occurs on mid to upper portions of wide alluvial fans at the base of the San Augustine Mountains and the southern portion of San Andres Mountains. The Hairy Grama-Black Grama PA, which lacks soaptree yucca as a shrub element, is the predominant component at about 40% of the subunit. Together the Hairy Grama and Black Grama/ Soaptree Yucca PAs account for another 40% with inclusions of Black Grama-Blue Grama/Soaptree Yucca, particularly near the upper portions of the alluvial fans. The presence of creosotebush increases at the lower portions of the fans.

Primary Plant Associations	
Hairy Grama-Black Grama	*(Bouteloua hirsuta-Bouteloua eriopoda)*
Hairy Grama/Soaptree Yucca	*(Bouteloua hirsuta/Yucca elata)*
Black Grama/Soaptree Yucca	*(Bouteloua eriopoda/Yucca elata)*
Inclusions	
Black Grama/Longleaf Jointfir	*(Bouteloua eriopoda/Ephedra trifurca)*
Hairy Grama/Sacahuista	*(Bouteloua hirsuta/Nolina microcarpa)*
Black Grama-Blue Grama/Soaptree Yucca	*(Bouteloua eriopoda-Bouteloua gracilis/ Yucca elata)*

Map Unit 17 --- Piedmont Temperate Grasslands --- [4,712 HA; 11,638 AC]

This grassland occurs within the interior valleys of the San Andres Mountains in the valley bottoms or adjacent alluvial toeslopes. Black Grama/Soaptree Yucca and Hairy Grama/Soaptree Yucca (Figure 25) PAs are the dominant types of the lower slopes and bottoms, with Blue Grama-Sideoats Grama PAs on the upper slopes.

Sub-Unit

17.118----Blue Grama-Sideoats Grama or Winterfat, and Black Grama/Soaptree Yucca Montane Valley Grasslands [4,712 HA; 11,638 AC]

This major grassland subunit occurs in montane valleys in the central portions of the San Andres Mountains. In the valley bottoms, the Black Grama/Soaptree Yucca is common to the north, the Blue Grama/Winterfat PA in the central, and the Hairy Grama/Soaptree Yucca PA to the southern portions of the subunit. The rocky valley fringes support the Blue Grama-Sideoats Grama and Hairy Grama-Sacahuista PAs.

Primary Plant Associations	
Blue Grama-Sideoats Grama	*(Bouteloua gracilis-Bouteloua curtipendula)*
Black Grama/Soaptree Yucca	*(Bouteloua eriopoda/Yucca elata)*
Blue Grama/Winterfat	*(Bouteloua gracilis/Krascheninnikovia lanata)*
Inclusions	
Hairy Grama/Sacahuista	*(Bouteloua hirsuta/Nolina microcarpa)*
Hairy Grama/Soaptree Yucca	*(Bouteloua hirsuta/Yucca elata)*
Black Grama-Blue Grama/Soaptree Yucca	*(Bouteloua eriopoda-Bouteloua gracilis/ Yucca elata)*

Map Unit 18 --- Desert Plains Grasslands --- [16,403 HA; 40,516 AC]

This Chihuahuan Desert Grassland occurs on rolling sandy plains within the Jornada Del Muerto (Figure 26) and Tularosa Basins. Large occurrences of the Black Grama/Soaptree Yucca PA dominate central portions of the northern Jornada basin. The less common Mesa Dropseed/Soaptree Yucca PA is primarily in the Tularosa Basin but can be inter-mixed with the Black Grama/Soaptree Yucca PA in the northern Jornada. On deeper sands, the unit gives way to Sand Sagebrush Shrubland or Mesquite Shrublands. Adjacent alluvial flats are commonly occupied by Lowland Basin Grasslands

Figure 25. Piedmont Temperate Grassland of hairy grama and yucca as found near Wood Ranch within the central valley of the San Andres Mountains. Photo: Yvonne Chauvin

Figure 26. Black grama and soaptree yucca are major components Desert Plains Grassland on the sandy soils of the northern Jornada del Muerto Basin. Photo: Glenn Harper

Sub-Units

18.05----Black Grama, Galleta or Mesa Dropseed/Soaptree Yucca Sandy Plains Grassland [15,907 HA; 39,306 AC]

This major desert grassland subunit occurs on rolling sandy plains of the northern Jornada basin along the northwestern boundary of WSMR. It is dominated by large stands of the Black Grama/Soaptree Yucca PA. Patches of the Galleta/Soaptree Yucca and the Mesa Dropseed/Soaptree Yucca PAs inter-mix here and occupy approximately 20% and 10% of the subunit respectively. The Galleta-dominated grasslands occur mostly in the far northwest portion of the subunit, while the Mesa Dropseed grasslands occur in areas with deeper sands throughout the subunit.

Primary Plant Associations	
Black Grama/Soaptree Yucca	*(Bouteloua eriopoda/Yucca elata)*
Galleta/Soaptree Yucca	*(Hilaria jamesii/Yucca elata)*
Mesa Dropseed/Soaptree Yucca	*(Sporobolus flexuosus/Yucca elata)*
Inclusions	
Sand Sagebrush/Black Grama	*(Artemisia filifolia/Bouteloua eriopoda)*
Black Grama/Torrey's Jointfir	*(Bouteloua eriopoda/Ephedra torreyana)*
Blue Grama/Banana Yucca	*(Bouteloua gracilis/Yucca baccata)*

18.186----Mesa Dropseed/Soaptree Yucca Sandy Plains Grassland [496 HA; 1,226 AC]

This minor desert grassland subunit is dominated by the Mesa Dropseed/Soaptree Yucca PA is found on rolling sandy plains of the central Tularosa Basin. Honey mesquite increases at the periphery of the subunit adjacent to the coppice dunes.

Primary Plant Associations	
Mesa Dropseed/Soaptree Yucca	*(Sporobolus flexuosus/Yucca elata)*
Inclusions	
Broom Dalea/Mesa Dropseed	*(Psorothamnus scoparius/Sporobolus flexuosus)*

Map Unit 19 --- Lowland Basin Grasslands --- [82,469 HA; 203,698 AC]

This desert grassland is characterized by alkali sacaton dominated types and occurs on the alluvial flats of the Tularosa and Jornada del Muerto basin bottoms. In the northern Jornada, the Alkali Sacaton-Burrograss and Tobosagrass-Alkali Sacaton (Figure 27) PAs along with Fourwing Saltbush/Alkali Sacaton shrublands are predominant. The Tularosa Basin is typified by large expanses of relatively uniform alkali sacaton and tobosagrass grasslands, intermixed with areas dominated by the shrubby Honey Mesquite/Alkali Sacaton PA. Inland Saltgrass-Alkali sacaton grasslands occur adjacent to the wetlands of the Malpais Spring area and along the Salt Creek Drainage within the Tularosa Basin. Fourwing Saltbush and Mesquite Shrublands are the most common adjacent units.

Sub-Units

19.108----Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland [56,734 HA; 140,190 AC]

This major desert grassland subunit is dominated either by low diversity, uniform alkali sacaton grasslands, or by honey mesquite with alkali sacaton undergrowth (Alkali Sacaton/Monotypic, Tobosagrass-Alkali Sacaton, and Honey Mesquite/Alkali Sacaton PAs). Burrograss, tobosagrass, and tarbush are also common elements. The center of the subunit's distribution is in the northern Tularosa Basin bottom and in swales or broad drainages between or on alluvial fans. Inclusions of Honey Mesquite/Tobosagrass and Fourwing Saltbush/Alkali Sacaton PAs are common and typically occur at the periphery of the subunit.

Primary Plant Associations	
Alkali Sacaton/Monotypic Stand	*(Sporobolus airoides/Monotypic)*
Honey Mesquite/Alkali Sacaton	*(Prosopis glandulosa/Sporobolus airoides)*
Tobosagrass-Alkali Sacaton	*(Hilaria mutica-Sporobolus airoides)*
Inclusions	
Burrograss/Monotypic Stand	*(Scleropogon brevifolius/Monotypic)*
Fourwing Saltbush/Alkali Sacaton	*(Atriplex canescens/Sporobolus airoides)*
Honey Mesquite/Tobosagrass	*(Prosopis glandulosa/Hilaria mutica)*

19.06----Alkali Sacaton-Burrograss or Tobosagrass Basin Grasslands, and Fourwing Saltbush/Alkali Sacaton Basin Shrubland [23,494 HA; 58,054 AC]

These desert basin grasslands are a major subunit across the basin floor of the northern Jornada. The Alkali Sacaton-Burrograss PA dominates and occurs throughout the subunit, along with inclusions of uniform stands of alkali sacaton without burrograss (Alkali Sacaton/Monotypic). There are also large occurrences of Tobosagrass-Alkali Sacaton PA, particularly in the south-central portion of the subunit at the foot of large alluvial fans leading out from the northern San Andres Mountains. The Fourwing Saltbush/Alkali Sacaton desert shrubland PA is common in the subunit (15%) and occurs either in the central alluvial flats or in broad drainages across the landscape.

Primary Plant Associations	
Alkali Sacaton-Burrograss	*(Sporobolus airoides-Scleropogon brevifolius)*
Tobosagrass-Alkali Sacaton	*(Hilaria mutica-Sporobolus airoides)*
Fourwing Saltbush/Alkali Sacaton	*(Atriplex canescens/Sporobolus airoides)*
Inclusions	
Alkali Sacaton/Monotypic Stand	*(Sporobolus airoides/Monotypic)*
Blue Grama-Burrograss	*(Bouteloua gracilis-Scleropogon brevifolius)*
Black Grama-Alkali Sacaton	*(Bouteloua eriopoda-Sporobolus airoides)*

19.178----Inland Saltgrass, and Inland Saltgrass-Alkali Sacaton Basin Alkaline Grasslands [1,134 HA; 2,802 AC]

This is a minor semi-riparian grassland subunit found in portions of the Salt Creek and Malpais Spring floodplains of the central Tularosa Basin. Large, monotypic stands of inland saltgrass with scattered pickleweed shrubs are characteristic of the subunit and account for 75% of the subunit. The closely related Inland Saltgrass-Alkali Sacaton PA accounts for another 15%. The Common Reed-Inland Saltgrass PA is less common and occurs near the edge of the Malpais Springs wetlands.

Primary Plant Associations	
Inland Saltgrass/Monotypic Stand	*(Distichlis spicata/Monotypic)*
Inland Saltgrass-Alkali Sacaton	*(Distichlis spicata-Sporobolus airoides)*
Inclusions	
Common Reed-Inland Saltgrass	*(Phragmites australis/Distichlis spicata)*

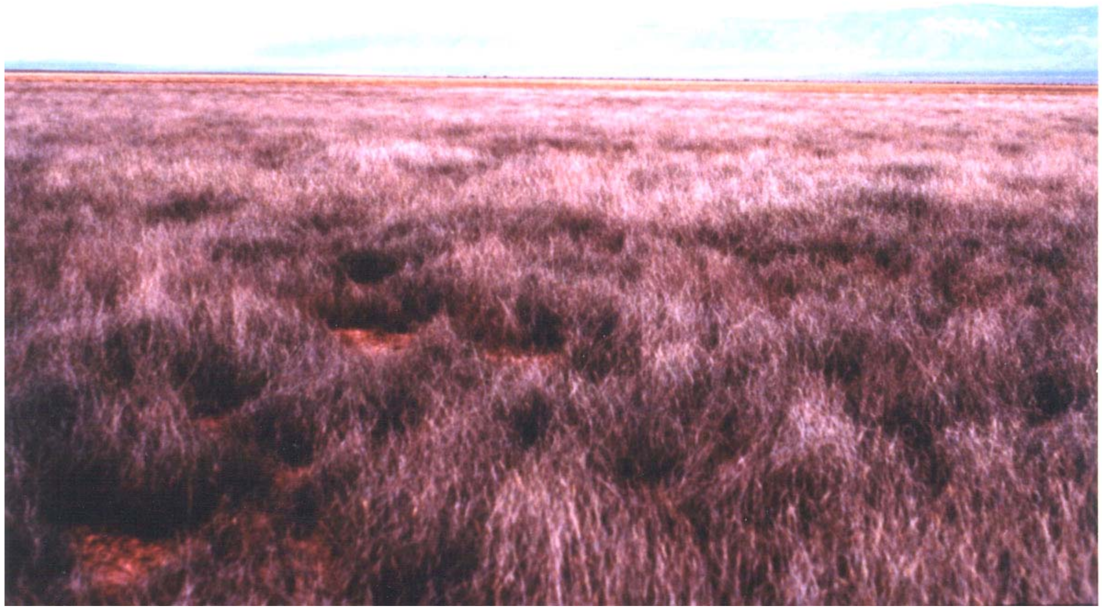

Figure 27. Lowland Basin Grassland of dominated by tobosagrass (foreground) and alkali sacaton (background) found within the northern Jornada del Muerto. Photo: Yvonne Chauvin

Figure 28. Black Grama Lava Grassland found along WSMR’s western boundary within the northern Jornada del Muerto basin. Photo: Yvonne Chauvin

19.185----Tobosagrass-Burrograss or Alkali Sacaton Basin Grasslands [1,107 HA; 2,735 AC]

This minor lowland desert grassland subunit occurs in the transition from lower piedmont slopes to basin floor alluvial flats west of the San Andres Mountains. The Tobosagrass-Burrograss and Tobosagrass-Alkali Sacaton PAs dominate the subunit with scattered creosotebush and honey mesquite near the periphery of the subunit.

Primary Plant Associations	
Tobosagrass-Burrograss	*(Hilaria mutica-Scleropogon brevifolius)*
Tobosagrass-Alkali Sacaton	*(Hilaria mutica-Sporobolus airoides)*
Inclusions	
Tarbush/Tobosagrass	*(Flourensia cernua/Hilaria mutica)*
Burrograss/Monotypic Stand	*(Scleropogon brevifolius/Monotypic)*

Map Unit 29 --- Black Grama Lava Grassland --- [333 HA; 822 AC]

This Chihuahuan Desert Grassland is dominated by the Black Grama/Torrey's Jointfir PA and occurs on the Jornada Lava Flow along the western side of the northern Jornada basin (Figure28).

Sub-Unit

29.127---Black Grama/Torrey's Jointfir Lava Grassland [333 HA; 822 AC]

This Black Grama grassland is an incidental subunit on the northern Jornada Del Muerto lava flow along the western boundary of WSMR. The Black Grama/Torrey's Jointfir PA is the predominant vegetation community and extends beyond WSMR across most of the lava flow to the west

Primary Plant Association	
Black Grama/Torrey's Jointfir	*(Bouteloua eriopoda/Ephedra torreyana)*
Inclusion	
Black Grama-Blue Grama	*(Bouteloua eriopoda-Bouteloua gracilis)*

Map Unit 33 --- Gypsum Interdune Swale Grassland --- [15,315 HA; 3 7,828 AC]

This desert grassland occurs in interdune swales within the gypsum dunelands of the central Tularosa Basin. The Gypsum Grama-New Mexico Bluestem PA (Figure 29) is the typical community, with inclusions of alkali sacaton and sandhill muhly communities on more alkaline or sandy soils respectively.

Sub-Unit

33.164----Gypsum Grama-New Mexico Bluestem Interdune Swale Grassland [15,315 HA; 37,828 AC]

This Gypsum Grama-New Mexico Bluestem desert grassland is a major subunit that occurs in interdune swales of dunes primarily on the periphery and eastern portion of the extensive gypsum duneland in the central Tularosa Basin.

Primary Plant Associations	
Gypsum Grama-New Mexico Bluestem	*(Bouteloua breviseta-Schizachyrium neomexicanum)*
Inclusions	
New Mexico Bluestem-Sandhill Muhly	*(Schizachyrium neomexicanus-Muhlenbergia pungens)*

Figure 29. Gypsum Interdune Swale Grassland of gyp grama and New Mexico little bluestem commonly found near the duneland peripheries on HAFB and WSMR. Photo: Yvonne Chauvin

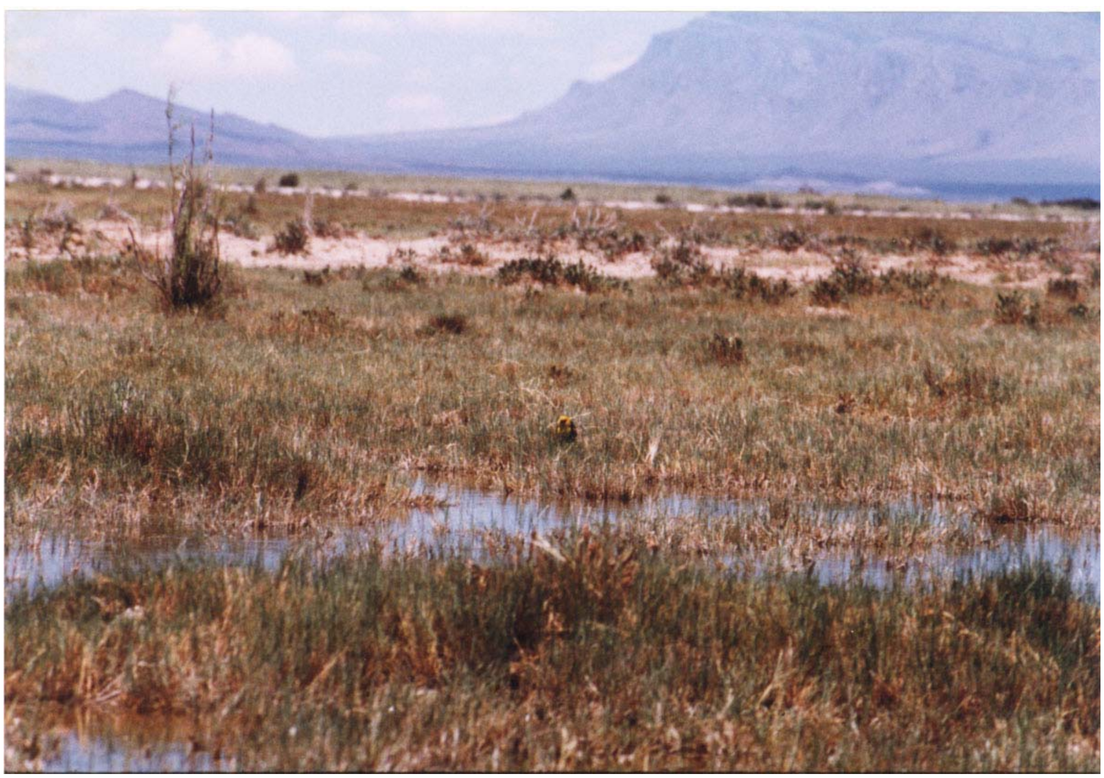

Figure 30. Luxuriant wetland of bullrush and spikerush growing at Malpais Spring within the Tularosa basin. Photo: Yvonne Chauvin

MISCELLANEOUS

Map Unit 20 --- Wetlands ---[293 HA; 724 AC]

This is a general wetland unit that encompasses spikerush, American bullrush and sedge dominated communities of the Malpais Spring and Brazel Lake areas within the Tularosa Basin (Figure 30). The upland area surrounding the Malpais Spring wetlands is dominated by inland saltgrass, which grades into spikerush and bullrush with greater inundation and greater water depths. Brazel Lake is similar, but saltcedar is abundant within the inland saltgrass community. Spikerush is also less abundant, and cattail and threesquare dominate inundated areas.

Sub-Unit

20.140----Spikerush, American Bulrush or Sedge Wetlands [293 HA; 724 AC]

This wetland subunit is restricted to the areas south of Malpais Spring in the central Tularosa Basin. Although it is a relatively minor subunit surrounded by extensive stands of desert scrub and grassland, it is the largest wetland in the Tularosa Basin and in south-central New Mexico. It is dominated by Spikerush-Sedge, American Bulrush-Common Spikerush PAs with Cattail stands near the center. Towards the drier margins are Sedge-Alkali Muhly and Common Reed-Inland Saltgrass flats.

Primary Plant Associations	
American Bulrush-Alkali Muhly	*(Scirpus americanus-Muhlenbergia asperifolia)*
American Bulrush-Common Spikerush	*(Scirpus americanus-Eleocharis palustris)*
Inclusions	
Common Reed-Inland Saltgrass	*(Phragmites australis/Distichlis spicata)*
Broadleaf Cattail/Monotypic Stand	*(Typha latifolia/Monotypic)*

Map Unit 21 --- Alluvial Flats--Barren --- [1,818 HA; 4,492 AC]

This unit represents non-vegetated alluvial fan flats that occur on the piedmont leading out of the northern San Andres Mountains into the northern Jornada basin.

Sub-Unit

21.157----Barren Alluvial Flats [1,818 HA; 4,492 AC]
This is a small subunit of barren alluvial flats and fans that extend out from the northern San Andres Mountains into the northern Jornada Basin.

Map Unit 22 --- Gypsum Duneland -- Vegetated --- [17,032 HA; 42,069 AC]

This desert shrubland occupies the periphery of the extensive gypsum dunelands in the central Tularosa Basin. In general, the Hoary Rosemarymint/Sandhill Muhly (Figure 31) or Sand Dropseed PAs predominate on the dunes, but there are stands of the Broom Dalea/Mesa Dropseed PA at the northern end of the unit. Commonly between the dunes is Gypsum Interdune Swale Grassland. Further to the interior of the dunes, the vegetation declines as it approaches the Gypsum Duneland -- Barren unit.

Sub-Units

22.168----Broom Dalea Dune Shrublands [3,343 HA; 8,261 AC]

This minor dune shrubland occupies dunes at the extreme northeast periphery of the extensive gypsum duneland of the central Tularosa Basin. The Broom Dalea/Mesa Dropseed PA characterizes the subunit with common inclusions of Jointfir/Mesa Dropseed in the inter-dune swales.

Primary Plant Associations

Broom Dalea/Mesa Dropseed	*(Psorothamnus scoparius/Sporobolus flexuosus)*

Inclusions

Mesa Dropseed/Torrey's Jointfir	*(Sporobolus flexuosus/Ephedra torreyana/)*
Hoary Rosemarymint/Mesa Dropseed	*(Poliomintha incana/Sporobolus flexuosus)*
Honey Mesquite-Fourwing Saltbush	*(Prosopis glandulosa-Atriplex canescens)*

22.160----Hoary Rosemarymint/Sandhill Muhly or Mesa Dropseed Gypsum Dune Shrubland [13,689 HA; 33,826 AC]

This hoary rosemarymint shrubland is major subunit that occurs on dunes along the periphery of the extensive gypsum duneland of the central Tularosa Basin. The subunit is characterized by the Hoary Rosemarymint/Sandhill Muhly PA which occupies approximately 90% of the subunit. Hoary Rosemarymint/Mesa Dropseed is an additional component occupying the remaining 10%.

Primary Plant Associations

Hoary Rosemarymint/Sandhill Muhly	*(Poliomintha incana/Muhlenbergia pungens)*
Hoary Rosemarymint/Mesa Dropseed	*(Poliomintha incana/Sporobolus flexuosus)*

Map Unit 23 --- Gypsum Duneland -- Barren --- [27,872 HA; 68,843 AC]

This unit represents active, non-vegetated gypsum dunes and interdune swales in the interior of the central duneland of the Tularosa Basin (Figure 32).

Sub-Unit

23.162----Barren Gypsum Dune [27,872 HA; 68,843 AC]

This is a major subunit of barren, active gypsum dunes within the extensive duneland of the central Tularosa Basin.

Map Unit 24 --- Rock Outcrop / Talus --- [71 HA; 174 AC]

This unit is characterized by non-vegetated rock outcrops and unstable talus occurring on the steep slopes of Salinas Peak within the San Andres Mountains.

Sub-Unit

24.182----Rock Outcrop/Talus Slope [71 HA; 174 AC]

This minor map subunit primarily contains talus slopes and rock outcrops derived from volcanic rocks near the top of Salinas Peak of the northern San Andres Mountains.

Map Unit 30 --- Vegetated Gypsum Outcrop --- [38,433 HA; 94,929 AC]

This map unit is restricted to gypsum outcrops within basin bottoms and on foothills throughout WSMR. The basin bottoms of the Tularosa and northern Jornada are characterized by Gyp Dropseed/Hairy Coldenia (Figure 33) and Fourwing Saltbush/Gyp Dropseed PAs. Foothill slopes of the Chalk Hills, Big Gyp Mountains, and Chupadera Mesa are characterized by the Gyp Dropseed/Hairy Coldenia PA intermixed with Oneseed Juniper Woodlands.

Figure 31. Vegetated Gypsum Duneland dominated by hoary rosemarymint and sandhill muhly, and most commonly found near the periphery of the Tularosa basin gypsum dune fields. Photo: Glenn Harper

Figure 32. Barren Gypsum Duneland near the center of the Tularosa basin dune fields.
Photo: Esteban Muldavin

Sub-Units

30.09----Gyp Dropseed/Hairy Coldenia Foothill Grassland [2,101 HA; 5,192 AC]
This minor gypsophilous desert grassland subunit occurs in patches where there are gypsum outcrops on the steep slopes of the Chalk Hills, Big Gyp Mountains, and Chupadera Mesa (Yeso and San Andres Formations). The Gyp Dropseed/Hairy Coldenia PA is predominant, but the closely related Gyp Dropseed/Bigelow's Sage and Gyp Dropseed/Hartweg's Sundrops PAs are sometimes intermixed, along with scattered pinyon and juniper woodlands.

Primary Plant Associations	
Gyp Dropseed/Hairy Coldenia	*(Sporobolus nealleyi/Tiquilia hispidissima)*
Inclusions	
Oneseed Juniper/New Mexico Needlegrass	*(Juniperus monosperma/Stipa neomexicana)*
Pinyon Pine/New Mexico Needlegrass	*(Pinus edulis/Stipa neomexicana)*

30.154----Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland [36,332 HA; 89,776 AC]

This major subunit occurs on lowland gypsum soils in the northern Jornada basin and throughout much of the Tularosa Basin. The Gyp Dropseed/Hairy Coldenia PA occupies gypsum mounds or outcrops and constitutes approximately 50% of the subunit. Swales between the mounds and basin bottom flats are commonly dominated by the Fourwing Saltbush/Gyp Dropseed and Gyp Dropseed-Alkali Sacaton PAs which together account for approximately 40% of the remaining subunit.

Primary Plant Associations	
Gyp Dropseed/Hairy Coldenia	*(Sporobolus nealleyi/Tiquilia hispidissima)*
Fourwing Saltbush/Gyp Dropseed	*(Atriplex canescens/Sporobolus nealleyi)*
Gyp Dropseed-Alkali Sacaton	*(Sporobolus nealleyi-Sporobolus airoides)*
Inclusions	
Gyp Dropseed/Torrey's Jointfir	*(Sporobolus nealleyi/Ephedra torreyana)*
Alkali Sacaton/Monotypic Stand	*(Sporobolus airoides/Monotypic)*

Map Unit 35 --- Playa --- [19,215 HA; 47,460 AC]

This unit is characterized by barren playas and alkaline alluvial flats of the Tularosa Basin bottom that are periodically inundated (Figure 34). Lake Lucero is the largest continuous occurrence within the map unit, but occurrences are also distributed northward in the Malpais Spring area and Salt Creek drainage.

Sub-Unit

35.173----Barren Alkaline Playa [19,215 HA; 47,460 AC]

This is a major map subunit of playas and alkaline flats primarily associated with Lake Lucero in the central Tularosa Basin.

Map Unit 39 --- Road Disturbance --- [28,694 HA; 70,905 AC]

This unit includes all roads and associated disturbances within a sixty-meter-wide road corridor.

Map Unit 40 --- Military Disturbance --- [7,479 HA; 18,482 AC]

This unit represents military development including WIT's, airstrips, range camps, the main post, and other extensive development.

Figure 33. Vegetated Gypsum Outcrop dominated by gyp dropseed with hairy coldenia, and found in both Tularosa and Jornada del Muerto Basins. Photo: Glenn Harper

Figure 34. An example of expansive alkaline alluvial flats or playas common within the lowlands of the Tularosa basin. Photo: Glenn Harper

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APPENDIX A.

Map Production Technical Reference

Satellite Imagery

Landsat Thematic Mapper (TM) satellite imagery was selected for mapping the natural vegetation cover for the study area. TM imagery was chosen over aerial photography for a variety of reasons. The cost-per-square-mile of satellite data is less than that of aerial photography, both in terms of direct costs and in terms of the ensuing map development. It takes only one full scene and an additional smaller sub-scene to cover the study area, and imagery comes in a digital form suitable for analytical and computerized map production. The satellite imagery, with its stable sensor platform, is relatively easy to geometrically correct to known coordinates of a base map, thus avoiding the complex geometry of orthorectifying and mosaicking hundreds of aerial photos. Further, the height of the sensor above the earth (705 km for Landsat) negates most parallax problems which are associated with aerial photography (parallax is the apparent change in positions of stationary objects affected by the viewing angle -- creating greater distortions at greater distances from the center of an aerial photo). In addition, satellite data do not have the radiometric problems of air photos, such as hot spots, dark edges, or different contrasts for each photo due to sun-angle changes during the overflight.

The quantitative spectral and spatial aspects of TM imagery add particularly important dimensions to the mapping process. Multi-spectral satellite imagery records the variable reflection of natural radiation of surface materials such as rocks, plants, soils, and water. These groups have different chemical compositions so that incident radiation will react differently. Variations in plant reflection and absorption due to biochemical composition will register distinct spectral 'signatures' (Wickland 1991, Lillesand and Kiefer 1987). These signatures provide a quantitative measure of reflectance of specific wavelengths that can then be statistically analyzed to develop a vegetation map of spectrally similar plant communities.

Landsat TM has the highest spectral discrimination, with six spectral bands and one thermal band, among commercially available space-based sensors. Each band represents a specific range of light wavelength. For vegetation mapping, bands 2, 3, 4, and 5 are particularly useful. TM bands 3, 5, and 7 are useful for detecting variations in surface geology. Surface geology and soil discrimination are important to developing mapping units of the vegetation communities in sparsely vegetated areas that commonly occur on WSMR. Table A-1 summarizes the function of each band.

TM integrates the spectral characteristics of each band over the Instantaneous Field of View (IFOV) of an area of 28.5 m x 28.5 m; this is the smallest area resolvable by the sensor and is represented on the computer screen by individual "pixels" (picture elements). Individual occurrences of plants are not resolved by the sensor; therefore, TM is particularly suited for evaluating and quantitatively identifying more generalized vegetation "community" occurrence patterns and their associated surface substrate characteristics.

There are constraints to using TM imagery. Some of the principal problems occur when vegetation is not the major cover type and differential reflectances of various geologic substrates dominate. As with aerial photography, topographic effects creating shadows within narrow valleys and steep escarpments can also cause problems. A proper combination of field sampling and image processing techniques helps to alleviate many problems. Furthermore, the sensor cannot penetrate clouds or snow, but other TM images covering the same area free of clouds or snow can be acquired to fill these "gaps" in coverage. Finally, because of edge effects among a small number of spatially contiguous pixels, small occurrences of vegetation types are difficult to reliably map. Hence, the minimum mapping unit polygon size is normally 0.5 ha or larger. Other digital imagery was considered. French SPOT imagery was rejected because of low spectral resolution and the higher costs of acquisition and analysis of higher spatial resolution data (10 m resolution of SPOT significantly increases data storage and processing times). Russian high resolution digital satellite photographs were also reviewed, but these images were very expensive and had extensive geometric distortion and only one spectral band.

Table A-1. Landsat Thematic Mapper bands, their spectral ranges, and principal remote sensing applications for earth research (derived from Lillesand and Kiefer 1987).

Band	Wavelength (microns)	Spectral location	Principal applications
1	0.45-0.52	Blue	Designed for water body penetration, making it useful for coastal water mapping. Also useful for soil/vegetation discrimination, forest type mapping, and cultural feature identification.
2	0.52-0.60	Green	Designed to measure green reflectance peak of vegetation for vegetation discrimination and vigor assessment. Also useful for cultural feature identification.
3	0.63-0.69	Red	Designed to sense in a chlorophyll absorption region aiding in plant species differentiation. Also useful for cultural feature identification.
4	0.76-0.90	Near-infrared	Useful for determining vegetation types, vigor, and biomass content, for delineating water bodies, and for soil moisture discrimination.
5	1.55-1.75	Mid-infrared	Indicative of vegetation moisture content and soil moisture. Also useful for differentiation of snow from clouds.
6	10.4-12.5	Thermal infrared	Useful in vegetation stress analysis, soil moisture discrimination, and thermal mapping applications.
7	2.08-2.35	Mid-infrared	Useful for discrimination of mineral and rock types. Also sensitive to vegetation moisture content.

In order to attain complete satellite coverage of WSMR, two Landsat Thematic Mapper (TM) scenes from the Landsat 5 (L5) satellite were acquired over the region on August 13, 1991. The images were purchased directly from Earth Observation Satellite Company (EOSAT) and are archived at Earth Data Analysis Center at the University of New Mexico. EOSAT is a private corporation that offers Landsat TM data on a scene basis covering a 185 km x 185 km area, with repetitive coverage over the same scene area every 16 days. One full scene covered most of the range above Highway 70, and a smaller sub-scene covered the area below the highway. The scenes chosen had the least cloud cover, were taken at a time of maximum seasonal green-up of vegetation, and had no apparent sensor errors (scan lines).

Terrain Models

A surface terrain model was created by acquiring and stitching (mosaicking) together the 96 US Geological Survey (USGS) 7.5-minute Digital Elevation Models (DEMs) that cover the study area. The DEMs were further processed to create slope and aspect images. A digital line coverage representing 80-foot contour intervals was developed as a grid from the raster DEMs using Arc/Info.

Ancillary Map Coverages

USGS Digital Line Graphs (DLGs) of road and drainage networks were downloaded from the USGS internet site and were compiled for the study area in Arc/Info (7.03). The road coverage was updated based on additional roads found on the image as well as new roads noted by the San Andres Wildlife Refuge staff. The new road coverage was buffered by a radius of 28.5 m for later masking.

Aerial Photography

WSMR placed on loan to us 1:24,000 color infrared print photographs that were used in the field to guide sampling for the map and in the map development process and error checking.

Biological Data

The mapping process was dependent on ground survey vegetation data gathered by NMNHP in the study area since 1991. This data resides in the NMNHP Biological and Conservation Database on a Microsoft Access platform and was exported to image processing software as needed. There were 1,982 plots available for map development and validation (WSMR and WSNM). This ground data was gathered following established NMNHP protocols and subjected to extensive quality control as described in the companion Volume I.

A point coverage of selected field plots was developed in ERDAS and Arc/Info and attributed with salient plot characteristics, such as species abundance values and percent surface soil, gravel, and rock cover, as well as vegetation type according to the NMNHP vegetation classification. This file also served to hold attribute information for the subsequent image analysis and map unit development. Once the classification process was completed, this file was then updated with the specific and general map unit codes and descriptions (see Final Map Unit Development below).

Image Processing

Pre-Processing of Raster Thematic Mapper Satellite Data

The TM scenes acquired from EOSAT were imported into ERDAS Imagine (Version 8.2) where all raster processing and analysis was done. The image quality was good for both scenes except for relatively small cloud cover and associated shadow near and on the Oscura Mountains in the northern scene. These areas were filled in from another TM scene acquired over this area on August 15, 1992. The new scene was registered to the August 13, 1991 scene. Linear regression was used to match the histograms of each of the new scene's bands with each of the previous scene's bands. After its histograms were transformed, the new scene was substituted into cloud obscured areas.

Geometric Corrections

The scenes were rectified to a map-based coordinate system using a nearest-neighbor interpolation. This process makes the image planimetric so that area, direction, and distance measurements can be performed. The image-to-map rectification process involves selecting a point on the map with its coordinate and the same point on the image with its x and y coordinate. The root mean square error (RMS_{error}) is computed to determine how well the map and image coordinates fit in a least-squares regression equation. The RMS_{error} for these images was less than 1.00 pixel error (or approximately 28.5 m). The images were projected into Universal Transverse Mercator (UTM), Zone 13, using the 1927 North American Datum and the Clarke 1866 Spheroid. The two scenes were then mosaicked together to create one image file for further processing.

Radiometric Corrections

A radiometric correction was performed on all TM bands to account for the systematic signal distortion of the sensor. One major source of distortion that occurs is the sensor offset, the residual "black noise" that is recorded by the sensor when there is no input signal (Lillesand and Kiefer, 1987). The other major distortion is from the channel gain, which is the slope transfer relation between the signal received and the sensor's response. Differential offsets and gains between bands will cause problems when comparing their responses to a certain feature, so it is necessary to calibrate all the bands to each other. Gain and offset coefficients for each band are provided for by

EOSAT for Landsat TM5 in the original image header. The effect of these deviations on the original data can be modeled as:

$$L = (DN * Gain) + Offset$$

where **L** is the radiometrically corrected signal and **DN** is the input pixel digital number value. The gains and offsets found in Table A-2 were used to transform the image **DN** values.

Atmospheric Corrections

The reflected response received by the satellite is attenuated due to both solar and atmospheric effects. The intensity of the reflected light is dependent on its wavelength (solar gain) and the angle of the sun above the horizon (solar elevation). The solar gain was calculated using the LOWTRAN 6 Atmospheric Modeling Program (Table A-3). The solar elevation can be calculated as:

$$\Theta = 90 - \Phi$$

where $\boldsymbol{\Theta}$ is the solar elevation angle and $\boldsymbol{\Phi}$ is the solar zenith angle as found in the image header. For these images, the solar zenith angle was 34.0.

The lightwave can be scattered by both atmospheric molecules (Rayleigh Scattering) and atmospheric dust (Mie Scattering). Rayleigh scattering **R** is a function of the inverse of the wavelength $\boldsymbol{\lambda}$ to the fourth power.

$$R = 1/\lambda^4$$

Mie scattering is calculated using Deirmendjian's continental type aerosol model. Atmospheric gasses, namely water vapor, carbon dioxide, and ozone, can absorb light depending on its wavelength and the concentration of the gasses. The absorption of these gasses was modeled by LOWTRAN 6. The absorption of the different gasses were then added together to give total absorption which is then used to calculate transmittance (Table A-4).

These factors are used to derive the actual reflectance $\boldsymbol{\rho}$ on the ground using the generalized formula as:

$$L_s = (1/\pi)\rho\tau_\upsilon(\varepsilon\tau_o\cos\Theta + E) + L_p$$

where $\mathbf{L_s}$ is the light received at the sensor, $\boldsymbol{\tau_\upsilon}$ is the atmospheric transmittance along the ray path from the surface to the sensor, $\boldsymbol{\varepsilon}$ is the solar gain, $\boldsymbol{\tau_o}$ is the atmospheric transmittance along the ray path from the sun to the surface, $\mathbf{E}$ is the sky irradiance, and $\mathbf{L_p}$ is the scattering along the ray path. The image file was transformed using this equation to model atmospheric effects.

Topographic Normalization and Surface (Terrain)

The surface reflectance can be attenuated by differential illumination due to topography; slopes facing the sun will have a brighter reflectance and slopes facing the other direction will be shadowed. The high topographic relief of the mountainous areas of WSMR required topographic normalization using a terrain (surface) model described above for WSMR. The topographic normalization was computed on the TM image using the terrain model as:

$$L_h = L_s(\cos\Theta)/(\cos\iota)$$

where $\mathbf{L_h}$ is the topographically corrected image value, and $\boldsymbol{\iota}$ is the solar incidence angle in relation to the perpendicular of the slope at that pixel.

Normalized Difference Vegetation Index

The Normalized Difference Vegetation Index (NDVI) was created using the equation below and added to the file.

$$NDVI = (TM4 - TM3) / (TM4 + TM3)$$

Where TM4=near infrared band, TM3=green band.

The NDVI enhances green vegetation over other major surface features. It was believed that the NDVI would help emphasize vegetation response patterns in the classification over soil responses. The NDVI also allows quick assessment of class signatures; for example, a riparian area should have a higher NDVI response than senescent grassland.

Table A-2. Gains and offsets used to radiometrically calibrate the image data.

	TM 1	TM 2	TM 3	TM 4	TM 5	TM 7
OFFSET	-0.15	-0.280487	-0.119403	-0.15	-0.014999	-0.014999
GAIN	0.0602436	0.1175036	0.0805971	0.0815399	0.0108074	0.0056984

Table A-3. Solar gain for the TM bands used in the study.

	TM 1	TM 2	TM 3	TM 4	TM 5	TM 7
SOLAR GAIN	189.0	168.0	144.0	101.63	21.6	7.6133

Table A-4. Atmospheric gas absorption and total atmospheric transmission coefficients used in the atmospheric modeling.

	TM1	TM 2	TM 3	TM 4	TM 5	TM 7
Molecular Absorption	0.1459	0.0811	0.0406	0.0199	0.001	0.00003
Ozone Absorption	0.00756	0.0298	0.01996	0.0002	0.0	0.0
Water Vapor Absorption	0.0	0.0	0.0	0.0183	0.0455	0.0702
Carbon Dioxide Absorption	0.0	0.0	0.0	0.06545	0.0012	0.01603
Total Trans-mission	0.875	0.8945	0.9399	0.899	0.9431	0.9049

Eco-area Landscape Unit Stratification

A polygon coverage of "eco-area" Landscape Units was created to aid spectral discriminations between different vegetation classes in production of the vegetation map. Different vegetation classes can have similar spectral signatures due to confounding effects of environmental features, a problem that increases with coverage of large, physiographically heterogeneous sites. It has been shown that remotely sensed data alone has been inadequate as a sole identifier of vegetation cover characteristics, and this has led to many attempts to incorporate other ancillary data in the classification process (Niemann, 1993). Earlier attempts at classifying the whole range at one time proved to be unsatisfactory. Even adding more class signatures to the classification only added to the heterogeneity of the resulting vegetation map without improving the accuracy. To alleviate this problem to some degree, smaller subset eco-area landscape units were delineated within the larger WSMR image on the basis of relatively homogeneous topography, elevation, slope, aspect, geologic surface substrate, and known biotic distributions.

Ground Survey Data and Image Analysis

The basis for the image classification is the field vegetation plot data. To ensure wide coverage over the entire study area, potential field plot locations were identified using the GIS. In the first year of sampling (1993), allocation was based on an initial unsupervised image classification (see below); large polygons of uniform spectral characteristics were identified for sampling. Field crews implemented the design within the constraints of scheduling and the NMNHP sampling protocol calling for plots to be located within large stands of more or less uniform vegetation (minimum of 1 ha in size). Field sampling in 1994 and 1995 was directed by the results of the Preliminary Vegetation Map, developed from a supervised classification of 1991-1993 data points. In particular, areas were targeted which were not spectrally or spatially covered in the previous data set.

A Global Positioning System (GPS) was used to record the highly accurate plot locations necessary for use in the image analysis. GPS positions were post-processed to +/- 10 m accuracy using base station data. The 1991 data was corrected with temporary base stations on various WSMR benchmarks. Subsequent years used base station files from the USFS Lincoln National Forest in Alamogordo, New Mexico State University in Las Cruces, and the NPS Southwest Geographic Information Center in Albuquerque, NM.

Image Classification

The image classification procedure synthesizes satellite image data with field plot data and ancillary data derived principally from Geographic Information System (GIS) coverages. The underlying concept of the mapping procedure is the digital integration of multiple, spatially related data sets. Initially, various digital data layers are created, followed by an interactive process of deriving statistical signatures from the image data, and finally an iterative process is used to create a preliminary vegetation classification.

Two principal data sets were used, the satellite image and the database information containing field plot data. These were converted into a spatially related data layer in the GIS along with DEMs, slopes, aspects, roads, hydrology, and elevation contours. These coverages were used interactively throughout the classification process to verify field plot distributions, accuracy check, and ultimately to characterize mapping units.

Unsupervised Strategy

Initially, an unsupervised image classification was used to identify non-vegetated areas in the imagery. An unsupervised classification classifies an image into a predesignated number of mutually exclusive and more or less arbitrary spectral classes. A Feature Oriented Principal Components Analysis (FOPCA) in ERDAS Imagine was computed to enhance detection of these non-vegetated areas, and the resulting components were used to replace the TM bands in the subsequent unsupervised image classification. Classes that corresponded to clouds, cloud shadows, water, gypsum dunes, and lava were identified and then masked in the original image before further processing. The unsupervised classification was also used in the stratification of field sampling in 1993.

Supervised Strategy and Seeding

A supervised classification strategy was then adopted to create a preliminary vegetation map based on vegetation plant associations of WSMR (Vol. 1). In contrast to an unsupervised classification, a supervised strategy develops spectral classes based on precise ground locations with known characteristics such as vegetation composition, rock type, and landscape context.

In a supervised classification strategy, the field data is applied to the TM image through an interactive process called "seeding." In the seeding process, a pixel at the field plot location was selected in the imagery, and its spectral characteristics were used to gather other similar contiguous pixels to create a statistical model or "seed" of the field plot. The seeding algorithm searches around that point within user-defined parameters which contain a seed within: 1) a certain distance, 2) a certain area, and 3) a certain spectral distance defined as:

$$SD = \sqrt{\Sigma (\mu - X)^2}$$

where **SD** is the spectral distance between a new pixel and the mean of the current seed group pixels across all bands, **μ** is the mean of the seed pixel group for each TM band, and **X** is the spectral value of the new pixel for each TM band.

In an iterative process, the best seed models were constructed by adjusting the parameters and comparing the resulting pixel distributions against the terrain models and the original imagery. A seed was developed for each field plot using the plot GPS location and associated field information. The seed's maximum area was initially defined by the size of the vegetation community occurrence as determined in the field. The actual seed was then defined by increasing the spectral distance iteratively until the spectral signature collected within the seed generated a covariance matrix which could be inverted, a requirement for the maximum likelihood decision rule used later in the actual classification.

The seed shape and location was checked against field notes and maps, and by direct interpretation of the seed in the TM image on the screen in conjunction with the terrain models. Each seed is saved in a signature file with its field plot number, mean values for each image band, variance, number of pixels that were used to create the seed, and minimum and maximum values.

This process was repeated for all of the potential seed plots. The seed potential of each field plot was assessed based on occurrence size indicated in the field and classification confidence in terms of vegetation type. Those plots from small and/or ill-defined stands were rejected in the seeding process. Small stand plots were kept for later map validation routines. Additionally, seeds were developed from photo-interpretation of the color-infrared aerial photography, but only in cases when there was high confidence in the vegetation type designation and location.

Supervised Classification

A supervised classification was performed using the statistics gathered in the seeding process and is based on a maximum likelihood decision rule. The maximum likelihood decision rule also contains a Bayesian classifier that uses probabilities to weight the classification towards particular classes. In this study, the probabilities were unknown, so the maximum likelihood equation for each of the classes is given as:

$$D = -[0.5\ln(cov_c)]-[0.5(X-M_c)^T*(cov_c^{-1})*(X-M_c)]$$

where **D** is the weighted distance, $\mathbf{cov_c}$ is the covariance matrix for a particular class, **X** is the measurement vector of the pixel, $\mathbf{M_c}$ is the mean vector of the class, and $^{\mathbf{T}}$ is the matrix transpose function (ERDAS, 1994). Each pixel is then assigned to the class with the lowest weighted distance. This technique assumes the statistical signatures have a normal distribution.

This decision rule is considered the most accurate because it not only uses a spectral distance (as the minimum distance decision rule), but it also takes into account the variance of each of the signatures. The variance is important when comparing a pixel to a signature representing, for example, a Chihuahuan scrub community which might be fairly heterogeneous, to a water class which is more homogeneous.

The classification was stratified by eco-area landscape units, and the results were analyzed and compared to proximal eco-areas. To locate problems, informal accuracy checking was used based on independent field data, air photos, personal knowledge of a site, and other ancillary data. If a distribution problem with a seed was detected, the seed was re-checked to insure it was properly modeling the vegetation type and landscape. Each eco-area landscape unit was iteratively classified and re-checked in order to insure that the vegetation types were adequately mapped with a goal of attaining 80% accuracy at the series (dominance cover type) level.

Upon completion of image analysis, eco-areas were mosaicked together to create the preliminary vegetation map of the entire study area. This preliminary map had as many map classes as seeds used to develop it.

Final Map Unit Development

For the final map, the seed map classes were aggregated into a limited number of Mapping Units (MU's). These were based on floristic composition, landscape position, spatial contiguity, and spectral similarity, e.g., floristically similar seed classes which had similar landscape positions and were spatially near each other were grouped into a mapping unit. This was an iterative process based on informal accuracy checking that was continued until all seed classes were grouped into the most consistent and accurate mapping units. Using an average linkage clustering method, Mapping Units were also checked for the degree of spectral homogeneity within a unit and to detect any outliers or potential groupings not previously recognized. The cluster analysis was performed on the spectral means of the individual classes from the preliminary vegetation map.

The map units are hierarchically structured into two levels . There are the Major Map units that represent relatively broad vegetation and landscape types. Nested with each upper major unit are subunits that are more refined . Each sub-unit is defined with respect to specific vegetation communities in the vegetation classification of Volume I. Sub-units were formulated first and then aggregated into Major Units. Hence, the Major Units can be easily decomposed in a GIS into the sub-units and then re-defined as necessary to meet specific management purposes.

Final Vegetation Map

To create the final map, a filtering process was applied to create a minimum mapping unit size of 0.5 ha. The procedure eliminates the "speckle" created by spatially solitary mapping units that have less than six contiguous pixels. The eliminated areas are then filled in by the majority of surrounding pixels using a 3 pixel x 3 pixel majority filter (a majority filter replaces the middle pixel of a 3 x 3 kernel with the class which is the majority within that kernel). The filtered file was substituted into the map wherever there were clusters of pixels of a particular class that covered less than 0.5 ha.

Roads, military cantonments, and other highly disturbed areas were digitized and masked out (these areas were not sampled and therefore had no spectral class representing their distribution). Contiguous pixels are affected by the diffuse reflection (Lambertian reflection) from these areas; therefore, a buffer area was also assigned to compensate for these errors. However, some military disturbance sites and barren areas were sampled in the field, and those were included in the classification process. The buffered road coverage was used to create a road-disturbance class.

For the area of White Sands National Monument, the map developed for the National Park Service by Muldavin et al. (1994) was directly inserted as a sub-site within the Lake Lucero-White Sands Landscape Unit. The national monument map units and delineations were not altered, except for being filtered to the same 0.5 ha level as the rest of the map. Selected seeds from the Monument were used in the remainder of the surrounding eco-areas to ensure continuity between units from WSNM to WSMR (and Holloman).

Software and Hardware Used

ERDAS Imagine, version 8.2 was the principal software used throughout the mapping process. All digital imagery and GIS coverages were processed, manipulated, or used as overlays for analysis within the Imagine environment. The ERDAS Imagine software was loaded on a SUN workstation using a SUNOS Unix Operating System.

Arc/Info, version 7.03 was used to create, import, and manipulate vector coverages and Microsoft Access database ASCII files.

PC-based Microsoft Access, version 2.0 was used to store and manipulate all field data as well as to integrate ancillary data from other software sources.

Trimble's Pfinder, version 2.0 PC software was used to differentially correct GPS data collected in the field to account for position errors due to Selective Ability (SA).

The Statistical Applications Software (SAS), Statgraphics, and Systat for Windows statistical packages were used to manipulate image statistics and field data. The SAS program resides on the University of New Mexico network, and Statgraphics and Systat were loaded into a PC network environment.

Digital Map Files

Nine digital files used in the development and creation of the vegetation map for White Sands Missile Range and San Andres National Wildlife Refuge were downloaded to 8mm tape for delivery to the WSMR geographical information system. Brief descriptions of each file follow:

ERDAS Imagine Files

em.img.z a -- A compressed file of the 1:24,000 scale digital elevation models acquired from the U.S. Geological Survey.

L1class.img -- Vegetation map of the entire study area using Level 1 mapping units.

L2class.img -- Vegetation map of the entire study area using Level 2 mapping units.

tm.img -- Atmospheric, radiometric, and geometrically original Thematic Mapper image of the study area from August 13, 1991.

tmmasked.img -- modified TM image where clouds and cloud shadows have been replaced by August 15, 1992 imagery and a topographic correction applied to overcome slope shadows. This was the image used for the development of the vegetation map.

Arc/Info (Version 7.02) Files

gpspts.e00 -- coverage with associated attribute table of all field points used for the development of the map.

lakes.e00 -- waterbody coverage from U.S.G.S. 1:100,000 digital line graphs.

streams.e00 -- coverage of major water courses from U.S.G.S. 1:100,000 digital line graphs.

roads.e00 -- coverage of major roads from U.S.G.S 1:100,000 digital line graphs.

APPENDIX B

White Sands Missile Range Vegetation Map

Accuracy Assessment Data Listing

Listings of map unit Land Condition Trend Analysis (LCTA) validation points used to evaluate the accuracy of the White Sands Missile Range Vegetation Map (WSMR). See text for details on methods. Points are presented in tables by accuracy classes: a) correctly classified, b) marginally incorrectly classified points that are still closely related to the correct classes, and c) grossly incorrectly classified points that are unrelated to their mapped category. Table 1 refers to the major map units and Table 2 to the subunits. LCTA species codes are structured with the first two letters representing the genus and the third and fourth the specific epithet.

Appendix B. Table 1(a). Major map unit validation correct classifications. The 137 correctly mapped Land condition Trend Analysis (LCTA) vegetation transects ordered by major map unit name. The LCTA transect number and general classification is given followed by the dominant species using LCTA data and codes.

MU No.	Major Map Unit Name	LCTA Transect	LCTA General Vegetation Class	LCTA Dominant Species	Validation Comments
1	Ponderosa Pine Forest	81	PINE	PIPO-RONE-POFE	
2	Pinyon Pine Woodland	5	PINYON-JUNIPER ECO	PIED-JUMO-QUUN-CEMO	
3	Juniper Woodland	104	JUNIPER-PINYON-GRA	JUMO-PIED-YUEL-BOHI	
3	Juniper Woodland	191	P-J GRASS ECO	PIED-JUMO-ARGL-CEMO-QUTO	Transitional?
4	Montane Scrub	83	OAK-MAHOGANY ECO	QUTU-CEMO-AGNE-OPIM-YUBA	
5	Interior Chaparral	52	OAK ECO	QUTU-GAWR-CEMO-ALWR	
6	Sandsage Shrubland	9	SANDSAGE-MESQUITE	ARFI-PRGLT-YUEL	
6	Sandsage Shrubland	46	THREEAWN-YUCCA	ARFI-BOER-YUEL	
6	Sandsage Shrubland	33	SANDSAGE-MIXED GRA	ARFI-BOER-SPFL-EPTO	
6	Sandsage Shrubland	31	SANDSAGE-GRASS	ARFI-SPFL-BOER-EPTO	
6	Sandsage Shrubland	20	SANDSAGE-DROPSEED	ARFI-SPCO-YUEL	
6	Sandsage Shrubland	8	SANDSAGE-GRASS	ARFI-SPFL	
6	Sandsage Shrubland	4	SANDSAGE-GRASS	ARFI-ARPA-YUEL	
6	Sandsage Shrubland	29	SANDSAGE-MIXEDGRAS	ARFI-ARPA-SPFL-YUEL	
7	Fourwing Saltbush Shrubland	103	SALTBUSH	ATCA-PRGLT	
7	Fourwing Saltbush Shrubland	71	SALTBUSH-PLAYA	ATCA-SUNI	
7	Fourwing Saltbush Shrubland	120	SALTBUSH	ATCA-EPTO-LYBE	
7	Fourwing Saltbush Shrubland	114	SALTBUSH	ATCA-PRGLT	
7	Fourwing Saltbush Shrubland	98	SACATON-SCRUB	SPAI-ATCA	
7	Fourwing Saltbush Shrubland	68	SACATON-SALTBUSH	SPAI-ATCA	
7	Fourwing Saltbush Shrubland	99	TOBOSA-MIXED SCRUB	SPAI-ATCA	
8	Creosotebush Shrubland	79	MIXED SCRUB	LATR-PRGLT	
8	Creosotebush Shrubland	63	MIXED SCRUB	LATR-FLCE	
8	Creosotebush Shrubland	197	MIXED SCRUB	FLCE-LATR-PRGLT	
8	Creosotebush Shrubland	196	CREOSOTE	LATR-SPOR	
8	Creosotebush Shrubland	195	GRAMA-SCRUB	BOCU-DAFO-PAIN-VIST	
8	Creosotebush Shrubland	187	CREOSOTE	LATR-PRGLT	
8	Creosotebush Shrubland	186	MIXED SCRUB-GRASS	LATR-PRGLT-MUPO	
8	Creosotebush Shrubland	180	MIXED SCRUB	LATR-GUSA-PRGLT	
8	Creosotebush Shrubland	179	MIXED SCRUB	LATR-PAIN-DAFO	
8	Creosotebush Shrubland	163	GRAMA-SCRUB	BOER-LATR ROCK	
8	Creosotebush Shrubland	156	MIXED SCRUB	ACCO-LATR	

Appendix B. Table 1(a). Major map unit validation correct classifications (continued).					
MU No.	Major Map Unit Name	LCTA Transect	LCTA General Vegetation Class	LCTA Dominant Species	Validation Comments
8	Creosotebush Shrubland	16	MIXED SCRUB	LATR-FLCE	
8	Creosotebush Shrubland	118	CREOSOTE	LATR-EPTO-SPOR	
8	Creosotebush Shrubland	59	MIXED SCRUB	FLCE-LATR-PRGLT	
8	Creosotebush Shrubland	15	MIXED SCRUB	FLCE-LATR-ATCA	
8	Creosotebush Shrubland	23	TARBUSH	FLCE-LATR	
8	Creosotebush Shrubland	30	CREOSOTE-GRASS	LATR	
8	Creosotebush Shrubland	35	CREOSOTE	LATR-PRGLT	
8	Creosotebush Shrubland	42	MIXED SCRUB	LATR-FLCE-PAIN	
8	Creosotebush Shrubland	44	MIXED SCRUB	LATR-PRGLT-FLCE-PAIN	
8	Creosotebush Shrubland	47	MIXED SCRUB	LATR-FLCE-PRGLT	
8	Creosotebush Shrubland	49	TARBUSH	FLCE-LATR	
8	Creosotebush Shrubland	58	MIXED SCRUB	LATR-PRGLT-PAIN	Inclusion
8	Creosotebush Shrubland	2	MIXED SCRUB-GRASS	LATR-FLCE-PAIN-DAFO-BOCU	
10	Acacia Shrubland	159	MIXED SCRUB	FOSP-ACCO	
11	Mesquite Shrubland	155	MESQUITE	PRGLT DUNE-ATCA	
11	Mesquite Shrubland	178	CREOSOTE	LATR-PRGLT	Inclusion
11	Mesquite Shrubland	204	MESQUITE	PRGLT DUNE	
11	Mesquite Shrubland	194	MESQUITE	PRGLT-ATCA	
11	Mesquite Shrubland	190	MESQUITE	PRGLT DUNE	
11	Mesquite Shrubland	188	MESQUITE	PRGLT DUNE	
11	Mesquite Shrubland	205	MESQUITE	PRGLT DUNE	
11	Mesquite Shrubland	184	MESQUITE	PRGLT DUNE	
11	Mesquite Shrubland	170	MIXED SCRUB	ATCA-MIBI-PRGLT	
11	Mesquite Shrubland	169	MESQUITE	PRGLT DUNE-ATCA-LYBE-EPT	
11	Mesquite Shrubland	168	MESQUITE	PRGLT DUNE-ATCA-YUEL	
11	Mesquite Shrubland	162	MESQUITE	PRGLT-ATCA	
11	Mesquite Shrubland	117	MESQUITE	PRGLT DUNE-ATCA	
11	Mesquite Shrubland	111	SALTBUSH	ATCA-PSSC-SPFL	Inclusion
11	Mesquite Shrubland	95	MESQUITE	PRGLT DUNE-ATCA-SPAI	
11	Mesquite Shrubland	164	MESQUITE	PRGLT-ATCA	
12	Mixed Foothill-Piedmont Desert Grasslands	125	GRAMA-SCRUB	BOER-DAFO-AGNE	Best fit
12	Mixed Foothill-Piedmont Desert Grasslands	18	GRAMA-SCRUB	BOER-YUBA-LATR	
12	Mixed Foothill-Piedmont Desert Grasslands	24	GRAMA-SCRUB	BOER-LATR-FOSP	
12	Mixed Foothill-Piedmont Desert Grasslands	90	WOLFTAIL-SCRUB	LYPH-PAIN-VIST	Best fit1
12	Mixed Foothill-Piedmont Desert Grasslands	100	GRAMA-SOTOL	BOER-DAWH-ROCK	

Appendix B. Table 1(a). Major map unit validation correct classifications (continued).					
MU No.	**Major Map Unit Name**	**LCTA Transect**	**LCTA General Vegetation Class**	**LCTA Dominant Species**	**Validation Comments**
12	Mixed Foothill-Piedmont Desert Grasslands	105	GRAMA-SCRUB	BOHI-BOER	
12	Mixed Foothill-Piedmont Desert Grasslands	110	GRAMA-SCRUB	BOER-VIST-DAFO	Inclusion
12	Mixed Foothill-Piedmont Desert Grasslands	136	MIXED SCRUB-GRAMA	LATR-PRGLT-BOER	
12	Mixed Foothill-Piedmont Desert Grasslands	109	MIXED SCRUB-GRASS	LATR-FOSP-BOER-ROCK	Inclusion
13	Mixed Lowland Desert Scrub	60	TARBUSH	FLCE-SCBR	
13	Mixed Lowland Desert Scrub	192	MIXED SCRUB	LATR-PRGLT-FLCE	
13	Mixed Lowland Desert Scrub	112	CREOSOTE	LATR-GUSA	
13	Mixed Lowland Desert Scrub	97	CREOSOTE-GRASS	LATR-SPFL	
13	Mixed Lowland Desert Scrub	69	TARBUSH-GRASS	FLCE-SPAI	
13	Mixed Lowland Desert Scrub	67	MIXED SCRUB	LATR-FLCE	
13	Mixed Lowland Desert Scrub	61	CREOSOTE	LATR-FLCE	
13	Mixed Lowland Desert Scrub	57	CREOSOTE	LATR-FLCE	
13	Mixed Lowland Desert Scrub	55	CREOSOTE	LATR-FLCE	
13	Mixed Lowland Desert Scrub	51	TARBUSH	FLCE-SPAI	
13	Mixed Lowland Desert Scrub	43	MIXED-SCRUB	LATR-FAPA-RHMI	Best fit
13	Mixed Lowland Desert Scrub	22	TARBUSH	FLCE-EPTO-SPAI	
13	Mixed Lowland Desert Scrub	65	MIXED SCRUB	LATR-FLCE	
15	Foothill-Montane Temperate Grasslands	133	GRAMA-SCRUB	BOCU-ERER-DAFO-EULA-YUEL	
16	Piedmont Desert Grasslands	84	SACATON	SPAI-BOGR	
16	Piedmont Desert Grasslands	11	GRAMA	BOGR-BOER	Inclusion
16	Piedmont Desert Grasslands	12	GRAMA-YUCCA	BOER-BOGR-YUEL-YUBA	
18	Desert Plains Grasslands	7	DROPSEED-YUCCA	SPFL-YUEL-ARFI	
18	Desert Plains Grasslands	32	TOBOSA-SCRUB	HIMU-YUEL-SPCO	
18	Desert Plains Grasslands	36	THREEAWN-YUCCA	ARPA-BOER-YUEL	
18	Desert Plains Grasslands	38	GRAMA-TOBOSA	BOER-HIMU-EPTO	
18	Desert Plains Grasslands	50	GRAMA-SCRUB	BOER-EPTR-YUEL	
19	Lowland Basin Grasslands	183	MIXED SCRUB-GRASS	SPOR-ATCA-FLCE-LATR	
19	Lowland Basin Grasslands	189	SALTBUSH	ATCA-FLCE-LYBE	
19	Lowland Basin Grasslands	119	SACATON-SCRUB	SPAI-ATCA	
19	Lowland Basin Grasslands	124	MESQUITE	PRGLT-SPOR	
19	Lowland Basin Grasslands	126	SALTBUSH	ATCA-LYBE-SPAI	
19	Lowland Basin Grasslands	127	SACATON-SCRUB	SPAI-PRGLT-ATCA	
19	Lowland Basin Grasslands	129	SALTBUSH	ATCA-EPTO-SPAI-GYP DOME	Transitionalt?
19	Lowland Basin Grasslands	166	SALTBUSH	ATCA-LYBE-SCBR	
19	Lowland Basin Grasslands	108	SALTBUSH	ATCA-LYBE-SPAI	

Appendix B. Table 1(a). Major map unit validation correct classifications (continued).					
MU No.	Major Map Unit Name	LCTA Transect	LCTA General Vegetation Class	LCTA Dominant Species	Validation Comments
19	Lowland Basin Grasslands	131	SACATON-SCRUB	SPAI-PRGLT	
19	Lowland Basin Grasslands	3	SACATON	SPAI-MUER-YUEL	
19	Lowland Basin Grasslands	102	SALTBUSH	ATCA-LYBE-SPAI	
19	Lowland Basin Grasslands	101	MESQUITE	PRGLT DUNE-ATCA-LYBE	Inclusion
19	Lowland Basin Grasslands	66	SALTBUSH	ATCA-PRGLT-SPAI	
19	Lowland Basin Grasslands	56	SACATON-TOBOSA	SPAI-HIMU	
19	Lowland Basin Grasslands	41	SALTBUSH	ATCA-SPNE	
19	Lowland Basin Grasslands	40	SALTBUSH	ATCA-SPAI	
19	Lowland Basin Grasslands	39	SALTBUSH	ATCA-SPAI	
19	Lowland Basin Grasslands	115	SACATON-SCRUB	SPAI-ATCA	
19	Lowland Basin Grasslands	116	SACATON-SCRUB	SPAI-ATCA	
22	Gypsum Duneland -- Vegetated	128	YUCCA-MINT	YUEL-POIN-GYP DUNE	
23	Gypsum Duneland -- Barren	158	ALKALI PLAYA-DUNES	BARREN	
27	Pickleweed Shrubland	78	MIXED SCRUB	ATCA-ALOC-FRJA	
27	Pickleweed Shrubland	134	ALKALI PLAYA	ALOC	
27	Pickleweed Shrubland	142	ALKALI PLAYA	ALOC	
27	Pickleweed Shrubland	145	ALKALI PLAYA	ALOC	
28	Malpais Lava Scrub	64	MIXED SCRUB	ALWR-ATCA-LAVA	
28	Malpais Lava Scrub	92	MIXED SCRUB	ATCA-LYBE-LAVA	
28	Malpais Lava Scrub	89	MIXED SCRUB	ALOC-ATCA-SPAI-LAVA	
28	Malpais Lava Scrub	72	MIXED SCRUB	ALWR-ATCA-LATR-LAVA	
30	Vegetated Gypsum Outcrop	174	SALTBUSH-GRASS	ATCA-SPNE-LYBE	
30	Vegetated Gypsum Outcrop	182	DROPSEED-SCRUB	SPNE-ATCA-MICRO	
30	Vegetated Gypsum Outcrop	175	MIXED SCRUB	ATCA-EPTO-COHI-SPNE-GYP	
30	Vegetated Gypsum Outcrop	173	MIXED SCRUB-GRASS	GYP DOME	
30	Vegetated Gypsum Outcrop	167	SALTBUSH	ATCA-SPNE	
30	Vegetated Gypsum Outcrop	165	SALTBUSH-WOLFBERRY	ATCA-LYBE-GYP DOME	
30	Vegetated Gypsum Outcrop	130	SALTBUSH	ATCA-SPNE-GYP DOME	
30	Vegetated Gypsum Outcrop	54	DROPSEED-GYPBORAGE	SPNE-COHI-GYP DOME	
30	Vegetated Gypsum Outcrop	177	SALTBUSH-GRASS	ATCA-SPNE-LYBE	
33	Gypsum Interdune Swale Grassland	157	GYPSUM DUNES	ORHY	Best fit
34	Mimosa Shrubland	206	CATCLAW	ACGR-ERLA	Best fit
35	Playa	152	ALKALI PLAYA	BARREN	
35	Playa	143	ALKALI PLAYA	BARREN	
35	Playa	151	ALKALI PLAYA	BARREN	

Appendix B. Table 1(b). Marginal, closely related miss-classifications among major map units. The 24 incorrectly mapped but closely related Land condition Trend Analysis (LCTA) vegetation transects ordered by major map unit name. The LCTA transect number and general classification is given followed by the dominant species using LCTA data and codes.

MU No.	Major Map Unit Name	LCTA Transect	LCTA General Vegetation Class	LCTA Dominant Species	Validation Comments
2	Pinyon Pine Woodland	10	JUNIPER-GRASS	JUMO-BOGR-SIHI	
3	Juniper Woodland	88	GRAMA	BOHI-BOER	Juniper savana
8	Creosotebush Shrubland	21	GRAMA-SCRUB	BOER-EPTO-YUEL	Mapped as Creosote/Black Grama
8	Creosotebush Shrubland	34	MIXED SCRUB-GRASS	LATR-ATCA-PRGLT-SPAI	Transitional
11	Mesquite Shrubland	86	SALTBUSH	ATCA-LYBE	MU 7?
11	Mesquite Shrubland	85	SALTBUSH	ATCA-LYBE	MU 7?
11	Mesquite Shrubland	87	SALTBUSH	ATCA-GUSA	MU 7?
11	Mesquite Shrubland	113	SALTBUSH	ATCA-EPTO-SPFL	
12	Mixed Foothill-Piedmont Desert Grasslands	62	CREOSOTE-GRASS	LATR-DAFO-PAIN-BOER	Missed the creosote
12	Mixed Foothill-Piedmont Desert Grasslands	82	SALTBUSH-GRASS	ATCA-BOGR	BOGR ok, but no saltbrush in mu
12	Mixed Foothill-Piedmont Desert Grasslands	153	CREOSOTE	LATR-PAIN	piedmont
15	Foothill-Montane Temperate Grasslands	25	MAHOGANY-OAK-GRAMA	CEMO-QUTU-BOER-	Lower montane
15	Foothill-Montane Temperate Grasslands	19	MAHOGANY-OAK-GRAMA	CEMO-QUTU-BOER	Lower montane
16	Piedmont Desert Grasslands	201	MIXED SCRUB	LATR-OPVI-BOUT	Missed the creosote
16	Piedmont Desert Grasslands	27	MIXED SCRUB-GRASS	DAFO-PAIN-BOGR	Transitional to MU 12
16	Piedmont Desert Grasslands	26	SANDSAGE-GRAMA	ARFI-BOER-BOGR	Missed the ARTTRI
19	Lowland Basin Grasslands	94	MESQUITE	PRGLT DUNE-ATCA	Ok at series level-PROGLA
19	Lowland Basin Grasslands	28	SANDSAGE-MIXED GRAMA	ARFI-HIJA-ATCA-YUEL	ATRCAN ok transitional to MU 6
19	Lowland Basin Grasslands	53	ALKALI PLAYA	BARREN	
23	Gypsum Duneland -- Barren	135	ALKALI PLAYA	BARREN	
27	Pickleweed Shrubland	141	ALKALI PLAYA	BARREN	
27	Pickleweed Shrubland	150	ALKALI PLAYA	BARREN	
34	Mimosa Shrubland	199	MIXED SCRUB	PRGLT-ACCO	
35	Playa	132	ALKALI PLAYA	ALOC	

Appendix B. Table 1(c). Gross, unrelated miss-classifications among major map units. The 7 incorrectly mapped and unrelated Land condition Trend Analysis (LCTA) vegetation transects ordered by major map unit name. The LCTA transect number and general classification is given followed by the dominant species using LCTA data and codes.

MU No.	Major Map Unit Name	LCTA Transect	LCTA General Vegetation Class	LCTA Dominant Species	Validation Comments
4	Montane Scrub	74	SANDSAGE-MIXED GRASS	ARFI-DAWH-BOER-	ARTFIL crosses w/ CERMON
8	Creosotebush Shrubland	96	MESQUITE	PRGLT DUNE-ATCA	Mesquite vs Creosote
12	Mixed Foothill-Piedmont Desert Grasslands	17	STIPA-WOODLAND	STNE-CEMO-FLCE	
13	Mixed Lowland Desert Scrub	172	MESQUITE	PRGLT DUNE-ATCA-	Coppice vs non-coppice scrub
17	Piedmont Temperate Grasslands	70	MIXED SCRUB-GRASS	FLCE-ATCA-SPAI	Basin bottom versus slope
22	Gypsum Duneland – Vegetated	121	SALTBUSH	ATCA-SPAI	in the duneland ?
30	Vegetated Gypsum Outcrop	176	BURROGRASS-SCRUB	SCBR-LYBE-PRGLT	

Appendix B. Table 2(a). Subunit map validation correct classifications. The 131 correctly mapped Land condition Trend Analysis (LCTA) vegetation transects ordered by map subunit name. The LCTA transect number and general classification is given followed by the dominant species using LCTA data and codes.

MU No.	Sub Unit	Major Map Unit Name	LCTA Transect	LCTA General Vegetation Class	LCTA Dominant Species	Validation Comments
1	166	Ponderosa Pine/Arizona Fescue Forest and Gambel's Oak-Whortleleaf Snowberry or Prairie Junegrass Montane Shrubland	81	PINE	PIPO-RONE-POFE	
2	130	Pinyon Pine/Wavyleaf Oak, Scribner's Needlegrass, or Sacahuista Montane Woodlands	54	DROPSEED-GYPBORAGE	SPNE-COHI-GYP DOME	
2	130	Pinyon Pine/Wavyleaf Oak, Scribner's Needlegrass, or Sacahuista Montane Woodlands	5	PINYON-JUNIPER ECO	PIED-JUMO-QUUN-CEMO	
3	115	One-Seed Juniper/Sideoats Grama or Hairy Grama Montane Woodlands	104	JUNIPER-PINYON-GRASS	JUMO-PIED-YUEL-BOHI	
3	146	Oneseed Juniper/Blue Grama, New Mexico Muhly or New Mexico Needlegrass Montane Woodlands	191	P-J GRASS ECO	PIED-JUMO-ARGL-CEMO-QUTO	Transitional
4	113	Mountain Mahogany/Sideoats Grama or Curlyleaf Muhly Montane Shrubland	83	OAK-MAHOGANY ECO	QUTU-CEMO-AGNE-OPIM-YUBA	Transitional
5	123	Shrub Live Oak/Black, Blue, or Sideoats Grama Montane Shrublands	52	OAK ECO	QUTU-GAWR-CEMO-ALWR	
6	2	Sandsage/Dropseed Low Dune Shrublands	31	SANDSAGE-GRASS	ARFI-SPFL-BOER-EPTO	
6	2	Sandsage/Dropseed Low Dune Shrublands	33	SANDSAGE-MIXED GRASS	ARFI-BOER-SPFL-EPTO	
6	2	Sandsage/Dropseed Low Dune Shrublands	29	SANDSAGE-MIXEDGRAS	ARFI-ARPA-SPFL-YUEL	
6	2	Sandsage/Dropseed Low Dune Shrublands	9	SANDSAGE-MESQUITE	ARFI-PRGLT-YUEL	
6	2	Sandsage/Dropseed Low Dune Shrublands	8	SANDSAGE-GRASS	ARFI-SPFL	
6	2	Sandsage/Dropseed Low Dune Shrublands	4	SANDSAGE-GRASS	ARFI-ARPA-YUEL	
6	8	Sand Sagebrush/Black Grama, Galleta or Indian Ricegrass Sandy Plains Shrublands	46	THREEAWN-YUCCA	ARFI-BOER-YUEL	
7	109	Fourwing Saltbush/Alkali Sacaton or Mesa Dropseed Basin Shrublands and Alkali Sacaton Basin Grasslands	120	SALTBUSH	ATCA-EPTO-LYBE	
7	109	Fourwing Saltbush/Alkali Sacaton or Mesa Dropseed Basin Shrublands and Alkali Sacaton Basin Grasslands	68	SACATON-SALTBUSH	SPAI-ATCA	
7	109	Fourwing Saltbush/Alkali Sacaton or Mesa Dropseed Basin Shrublands and Alkali Sacaton Basin Grasslands	71	SALTBUSH-PLAYA	ATCA-SUNI	

Appendix B. Table 2(a). Subunit map validation correct classifications (continued).						
MU No.	Sub Unit	Major Map Unit Name	LCTA Transect	LCTA General Vegetation Class	LCTA Dominant Species	Validation Comments
7	109	Fourwing Saltbush/Alkali Sacaton or Mesa Dropseed Basin Shrublands and Alkali Sacaton Basin Grasslands	98	SACATON-SCRUB	SPAI-ATCA	
7	109	Fourwing Saltbush/Alkali Sacaton or Mesa Dropseed Basin Shrublands and Alkali Sacaton Basin Grasslands	99	TOBOSA-MIXED SCRUB	SPAI-ATCA	
7	109	Fourwing Saltbush/Alkali Sacaton or Mesa Dropseed Basin Shrublands and Alkali Sacaton Basin Grasslands	103	SALTBUSH	ATCA-PRGLT	
7	109	Fourwing Saltbush/Alkali Sacaton or Mesa Dropseed Basin Shrublands and Alkali Sacaton Basin Grasslands	114	SALTBUSH	ATCA-PRGLT	
8	31	Creosotebush/Black Grama, Fluff Grass or Bush Muhly Piedmont Shrublands	63	MIXED SCRUB	LATR-FLCE	
8	31	Creosotebush/Black Grama, Fluff Grass or Bush Muhly Piedmont Shrublands	47	MIXED SCRUB	LATR-FLCE-PRGLT	
8	31	Creosotebush/Black Grama, Fluff Grass or Bush Muhly Piedmont Shrublands	15	MIXED SCRUB	FLCE-LATR-ATCA	
8	31	Creosotebush/Black Grama, Fluff Grass or Bush Muhly Piedmont Shrublands	16	MIXED SCRUB	LATR-FLCE	
8	104	Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed Piedmont Shrubland	156	MIXED SCRUB	ACCO-LATR	
8	104	Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed Piedmont Shrubland	44	MIXED SCRUB	LATR-PRGLT-FLCE-PAIN	
8	104	Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed Piedmont Shrubland	195	GRAMA-SCRUB	BOCU-DAFO-PAIN-VIST	
8	104	Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed Piedmont Shrubland	163	GRAMA-SCRUB	BOER-LATR ROCK	
8	104	Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed Piedmont Shrubland	79	MIXED SCRUB	LATR-PRGLT	
8	104	Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed Piedmont Shrubland	179	MIXED SCRUB	LATR-PAIN-DAFO	
8	104	Creosotebush-Mariola and Mariola-Pricklyleaf Dogweed Piedmont Shrubland	2	MIXED SCRUB-GRASS	LATR-FLCE-PAIN-DAFO-BOCU	
8	105	Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands	180	MIXED SCRUB	LATR-GUSA-PRGLT	

Appendix B. Table 2(a). Subunit map validation correct classifications (continued).						
MU No.	**Sub Unit**	**Major Map Unit Name**	**LCTA Transect**	**LCTA General Vegetation Class**	**LCTA Dominant Species**	**Validation Comments**
8	105	Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands	35	CREOSOTE	LATR-PRGLT	
8	105	Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands	187	CREOSOTE	LATR-PRGLT	
8	105	Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands	59	MIXED SCRUB	FLCE-LATR-PRGLT	
8	105	Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands	30	CREOSOTE-GRASS	LATR	
8	105	Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands	49	TARBUSH	FLCE-LATR	
8	136	Ocotillo or Creosotebush-Mariola, or Mariola-Pricklyleaf Dogweed Foothill Shrublands	42	MIXED SCRUB	LATR-FLCE-PAIN	
8	137	Creosotebush/Black Grama or Alkali Sacaton, and Tarbush/Black Grama Piedmont Shrublands	23	TARBUSH	FLCE-LATR	
8	142	Creosotebush/Fluffgrass or Sparse Piedmont Shrublands	58	MIXED SCRUB	LATR-PRGLT-PAIN	Inclusion
8	149	Creosotebush-Mariola or Bush Muhly or Fluffgrass Piedmont Shrublands	197	MIXED SCRUB	FLCE-LATR-PRGLT	
8	149	Creosotebush-Mariola or Bush Muhly or Fluffgrass Piedmont Shrublands	186	MIXED SCRUB-GRASS	LATR-PRGLT-MUPO	
8	159	Creosotebush/Alkali Sacaton or Hairy Coldenia Basin Shrublands	118	CREOSOTE	LATR-EPTO-SPOR	
10	121	Viscid Acacia/Southwestern Needlegrass, Mariola, or Tarbush Foothill Shrublands	159	MIXED SCRUB	FOSP-ACCO	
11	4	Littleleaf Sumac/Dropseed Coppice Dune Shrublands	20	SANDSAGE-DROPSEED	ARFI-SPCO-YUEL	
11	101	Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands	205	MESQUITE	PRGLT DUNE	
11	101	Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands	169	MESQUITE	PRGLT DUNE-ATCA-LYBE-EPT	
11	101	Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands	168	MESQUITE	PRGLT DUNE-ATCA-YUEL	
11	101	Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands	194	MESQUITE	PRGLT-ATCA	

Appendix B. Table 2(a). Subunit map validation correct classifications (continued).						
MU No.	**Sub Unit**	**Major Map Unit Name**	**LCTA Transect**	**LCTA General Vegetation Class**	**LCTA Dominant Species**	**Validation Comments**
11	101	Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands	184	MESQUITE	PRGLT DUNE	
11	101	Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands	188	MESQUITE	PRGLT DUNE	
11	101	Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands	190	MESQUITE	PRGLT DUNE	
11	101	Honey Mesquite-Fourwing Saltbush, Snakeweed or Mesa Dropseed Coppice Dune Shrublands	204	MESQUITE	PRGLT DUNE	
11	102	Honey Mesquite-Fourwing Saltbush or Mesa Dropseed Coppice Dune Shrublands	117	MESQUITE	PRGLT DUNE-ATCA	
11	102	Honey Mesquite-Fourwing Saltbush or Mesa Dropseed Coppice Dune Shrublands	111	SALTBUSH	ATCA-PSSC-SPFL	Inclusion
11	110	Honey Mesquite-Fourwing Saltbush or Snakeweed Basin Shrubland	164	MESQUITE	PRGLT-ATCA	
11	110	Honey Mesquite-Fourwing Saltbush or Snakeweed Basin Shrubland	162	MESQUITE	PRGLT-ATCA	
11	110	Honey Mesquite-Fourwing Saltbush or Snakeweed Basin Shrubland	178	CREOSOTE	LATR-PRGLT	Inclusion
11	150	Honey Mesquite/Fourwing Saltbush or Snakeweed Coppice Dune Shrublands	155	MESQUITE	PRGLT DUNE-ATCA	
11	150	Honey Mesquite/Fourwing Saltbush or Snakeweed Coppice Dune Shrublands	170	MIXED SCRUB	ATCA-MIBI-PRGLT	
12	103	Black Grama/Mariola or Sideoats Grama Foothill Grasslands and Ocotillo/Mariola Shrublands	90	WOLFTAIL-SCRUB	LYPH-PAIN-VIST	Best fit
12	103	Black Grama/Mariola or Sideoats Grama Foothill Grasslands and Ocotillo/Mariola Shrublands	125	GRAMA-SCRUB	BOER-DAFO-AGNE	Best fit
12	103	Black Grama/Mariola or Sideoats Grama Foothill Grasslands and Ocotillo/Mariola Shrublands	110	GRAMA-SCRUB	BOER-VIST-DAFO	Inclusion
12	103	Black Grama/Mariola or Sideoats Grama Foothill Grasslands and Ocotillo/Mariola Shrublands	136	MIXED SCRUB-GRAMA	LATR-PRGLT-BOER	
12	103	Black Grama/Mariola or Sideoats Grama Foothill Grasslands and Ocotillo/Mariola Shrublands	109	MIXED SCRUB-GRASS	LATR-FOSP-BOER-ROCK	Inclusion
12	138	Black Grama-Blue Grama or Sideoats Grama and Blue Grama/Banana Yucca Foothill Grasslands	18	GRAMA-SCRUB	BOER-YUBA-LATR	

Appendix B. Table 2(a). Subunit map validation correct classifications (continued).						
MU No.	**Sub Unit**	**Major Map Unit Name**	**LCTA Transect**	**LCTA General Vegetation Class**	**LCTA Dominant Species**	**Validation Comments**
12	145	Sideoats, Black or Hairy Grama/Sotol Foothill Grasslands	100	GRAMA-SOTOL	BOER-DAWH-ROCK	
13	107	Creosotebush/Alkali Sacaton or Sparse, and Tarbush/Alkali Sacaton Basin Shrublands	43	MIXED-SCRUB	LATR-FAPA-RHMI	Best fit
13	107	Creosotebush/Alkali Sacaton or Sparse, and Tarbush/Alkali Sacaton Basin Shrublands	55	CREOSOTE	LATR-FLCE	
13	107	Creosotebush/Alkali Sacaton or Sparse, and Tarbush/Alkali Sacaton Basin Shrublands	97	CREOSOTE-GRASS	LATR-SPFL	
13	107	Creosotebush/Alkali Sacaton or Sparse, and Tarbush/Alkali Sacaton Basin Shrublands	57	CREOSOTE	LATR-FLCE	
13	107	Creosotebush/Alkali Sacaton or Sparse, and Tarbush/Alkali Sacaton Basin Shrublands	112	CREOSOTE	LATR-GUSA	
13	135	Creosotebush-Tarbush/Sparse or Alkali Sacaton, and Tarbush/Alkali Sacaton Basin Shrublands	65	MIXED SCRUB	LATR-FLCE	
13	135	Creosotebush-Tarbush/Sparse or Alkali Sacaton, and Tarbush/Alkali Sacaton Basin Shrublands	51	TARBUSH	FLCE-SPAI	
13	135	Creosotebush-Tarbush/Sparse or Alkali Sacaton, and Tarbush/Alkali Sacaton Basin Shrublands	22	TARBUSH	FLCE-EPTO-SPAI	
13	135	Creosotebush-Tarbush/Sparse or Alkali Sacaton, and Tarbush/Alkali Sacaton Basin Shrublands	61	CREOSOTE	LATR-FLCE	
13	135	Creosotebush-Tarbush/Sparse or Alkali Sacaton, and Tarbush/Alkali Sacaton Basin Shrublands	69	TARBUSH-GRASS	FLCE-SPAI	
13	135	Creosotebush-Tarbush/Sparse or Alkali Sacaton, and Tarbush/Alkali Sacaton Basin Shrublands	60	TARBUSH	FLCE-SCBR	
13	135	Creosotebush-Tarbush/Sparse or Alkali Sacaton, and Tarbush/Alkali Sacaton Basin Shrublands	67	MIXED SCRUB	LATR-FLCE	
13	151	Creosotebush-Tarbush or Creosote/Sparse Basin Shrublands	192	MIXED SCRUB	LATR-PRGLT-FLCE	
16	17	Black Grama and Blue Grama/Yucca Piedmont Grasslands	12	GRAMA-YUCCA	BOER-BOGR-YUEL-YUBA	
16	156	Blue Grama-Alkali Sacaton Grassland	84	SACATON	SPAI-BOGR	
18	5	Black Grama, Galleta or Mesa Dropseed/Soaptree Yucca Sandy Plains Grassland	38	GRAMA-TOBOSA	BOER-HIMU-EPTO	Inclusion

Appendix B. Table 2(a). Subunit map validation correct classifications (continued).						
MU No.	**Sub Unit**	**Major Map Unit Name**	**LCTA Transect**	**LCTA General Vegetation Class**	**LCTA Dominant Species**	**Validation Comments**
18	5	Black Grama, Galleta or Mesa Dropseed/Soaptree Yucca Sandy Plains Grassland	50	GRAMA-SCRUB	BOER-EPTR-YUEL	
18	5	Black Grama, Galleta or Mesa Dropseed/Soaptree Yucca Sandy Plains Grassland	36	THREEAWN-YUCCA	ARPA-BOER-YUEL	
18	5	Black Grama, Galleta or Mesa Dropseed/Soaptree Yucca Sandy Plains Grassland	32	TOBOSA-SCRUB	HIMU-YUEL-SPCO	
18	5	Black Grama, Galleta or Mesa Dropseed/Soaptree Yucca Sandy Plains Grassland	7	DROPSEED-YUCCA	SPFL-YUEL-ARFI	
19	6	Alkali Sacaton-Burrograss or Tobosagrass Basin Grasslands, and Fourwing Saltbush/Alkali Sacaton Basin Shrubland	39	SALTBUSH	ATCA-SPAI	
19	6	Alkali Sacaton-Burrograss or Tobosagrass Basin Grasslands, and Fourwing Saltbush/Alkali Sacaton Basin Shrubland	40	SALTBUSH	ATCA-SPAI	
19	6	Alkali Sacaton-Burrograss or Tobosagrass Basin Grasslands, and Fourwing Saltbush/Alkali Sacaton Basin Shrubland	56	SACATON-TOBOSA	SPAI-HIMU	
19	6	Alkali Sacaton-Burrograss or Tobosagrass Basin Grasslands, and Fourwing Saltbush/Alkali Sacaton Basin Shrubland	3	SACATON	SPAI-MUER-YUEL	
19	6	Alkali Sacaton-Burrograss or Tobosagrass Basin Grasslands, and Fourwing Saltbush/Alkali Sacaton Basin Shrubland	41	SALTBUSH	ATCA-SPNE	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	129	SALTBUSH	ATCA-EPTO-SPAI-GYP DOME	transitional ?
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	189	SALTBUSH	ATCA-FLCE-LYBE	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	166	SALTBUSH	ATCA-LYBE-SCBR	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	131	SACATON-SCRUB	SPAI-PRGLT	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	127	SACATON-SCRUB	SPAI-PRGLT-ATCA	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	126	SALTBUSH	ATCA-LYBE-SPAI	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	124	MESQUITE	PRGLT-SPOR	

Appendix B. Table 2(a). Subunit map validation correct classifications (continued).						
MU No.	**Sub Unit**	**Major Map Unit Name**	**LCTA Transect**	**LCTA General Vegetation Class**	**LCTA Dominant Species**	**Validation Comments**
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	108	SALTBUSH	ATCA-LYBE-SPAI	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	116	SACATON-SCRUB	SPAI-ATCA	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	115	SACATON-SCRUB	SPAI-ATCA	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	101	MESQUITE	PRGLT DUNE-ATCA-LYBE	Inclusion
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	66	SALTBUSH	ATCA-PRGLT-SPAI	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	102	SALTBUSH	ATCA-LYBE-SPAI	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	119	SACATON-SCRUB	SPAI-ATCA	
19	185	Tobosagrass-Burrograss or Alkali Sacaton Basin Grasslands	183	MIXED SCRUB-GRASS	SPOR-ATCA-FLCE-LATR	
22	160	Hoary Rosemarymint/Sandhill Muhly or Mesa Dropseed Gypsum Dune Shrubland	128	YUCCA-MINT	YUEL-POIN-GYP DUNE	
23	162	Barren Gypsum Dune	158	ALKALI PLAYA-DUNES	BARREN	
27	120	Pickleweed Alkaline Basin Shrubland	134	ALKALI PLAYA	ALOC	
27	120	Pickleweed Alkaline Basin Shrubland	145	ALKALI PLAYA	ALOC	
27	120	Pickleweed Alkaline Basin Shrubland	142	ALKALI PLAYA	ALOC	
27	120	Pickleweed Alkaline Basin Shrubland	78	MIXED SCRUB	ATCA-ALOC-FRJA	
28	126	Malpais Lava Mixed Shrublands	89	MIXED SCRUB	ALOC-ATCA-SPAI-LAVA	
28	126	Malpais Lava Mixed Shrublands	64	MIXED SCRUB	ALWR-ATCA-LAVA	
28	126	Malpais Lava Mixed Shrublands	92	MIXED SCRUB	ATCA-LYBE-LAVA	

Appendix B. Table 2(a). Subunit map validation correct classifications (continued).						
MU No.	**Sub Unit**	**Major Map Unit Name**	**LCTA Transect**	**LCTA General Vegetation Class**	**LCTA Dominant Species**	**Validation Comments**
28	126	Malpais Lava Mixed Shrublands	72	MIXED SCRUB	ALWR-ATCA-LATR-LAVA	
30	154	Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland	177	SALTBUSH-GRASS	ATCA-SPNE-LYBE	
30	154	Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland	175	MIXED SCRUB	ATCA-EPTO-COHI-SPNE-GYP	
30	154	Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland	174	SALTBUSH-GRASS	ATCA-SPNE-LYBE	
30	154	Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland	182	DROPSEED-SCRUB	SPNE-ATCA-MICRO	
30	154	Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland	173	MIXED SCRUB-GRASS	GYP DOME	
30	154	Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland	130	SALTBUSH	ATCA-SPNE-GYP DOME	
30	154	Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland	167	SALTBUSH	ATCA-SPNE	
30	154	Gyp Dropseed/Hairy Coldenia or Alkali Sacaton Basin Grasslands and Fourwing Saltbush/Gyp Dropseed Basin Shrubland	165	SALTBUSH-WOLFBERRY	ATCA-LYBE-GYP DOME	
33	164	Gypsum Grama-New Mexico Bluestem Interdune Swale Grassland	157	GYPSUM DUNES	ORHY	Best fit
34	165	Mimosa/Black Grama or Sideoats Grama Foothill Shrublands	206	CATCLAW	ACGR-ERLA	Best fit
35	173	Barren Alkaline Playa	152	ALKALI PLAYA	BARREN	
35	173	Barren Alkaline Playa	143	ALKALI PLAYA	BARREN	
35	173	Barren Alkaline Playa	151	ALKALI PLAYA	BARREN	

Appendix B. Table 2(b). Marginal, closely related miss-classifications among map subunits. The 27 incorrectly mapped but closely related Land condition Trend Analysis (LCTA) vegetation transects ordered by map subunit name. The LCTA transect number and general classification is given followed by the dominant species using LCTA data and codes.

MU No.	Sub Unit	Major Map Unit Name	LCTA Transect	LCTA General Vegetation Class	LCTA Dominant Species	Validation Comments
2	130	Pinyon Pine/Wavyleaf Oak, Scribner's Needlegrass, or Sacahuista Montane Woodlands	10	JUNIPER-GRASS	JUMO-BOGR-SIHI	
3	115	One-Seed Juniper/Sideoats Grama or Hairy Grama Montane Woodlands	88	GRAMA	BOHI-BOER	Possible within juniper savana
8	137	Creosotebush/Black Grama or Alkali Sacaton, and Tarbush/Black Grama Piedmont Shrublands	21	GRAMA-SCRUB	BOER-EPTO-YUEL	Missed scrub element
8	105	Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands	196	CREOSOTE	LATR-SPOR	Missed grass element
8	105	Creosotebush/Sparse, Bush Muhly or Fluffgrass Piedmont Shrublands	34	MIXED SCRUB-GRASS	LATR-ATCA-PRGLT-SPAI	Transitional ?
11	102	Honey Mesquite-Fourwing Saltbush or Mesa Dropseed Coppice Dune Shrublands	87	SALTBUSH	ATCA-GUSA	MU 7?
11	102	Honey Mesquite-Fourwing Saltbush or Mesa Dropseed Coppice Dune Shrublands	86	SALTBUSH	ATCA-LYBE	MU 7?
11	102	Honey Mesquite-Fourwing Saltbush or Mesa Dropseed Coppice Dune Shrublands	95	MESQUITE	PRGLT DUNE-ATCA-SPAI	Also possible as 7-109
11	102	Honey Mesquite-Fourwing Saltbush or Mesa Dropseed Coppice Dune Shrublands	85	SALTBUSH	ATCA-LYBE	MU 7?
12	184	Black grama-Blue grama, and Black grama/Torrey's Jointfir Foothill Grasslands	62	CREOSOTE-GRASS	LATR-DAFO-PAIN-BOER	Missed scrub element
12	103	Black Grama/Mariola or Sideoats Grama Foothill Grasslands and Ocotillo/Mariola Shrublands	105	GRAMA-SCRUB	BOHI-BOER	Missed secondary grass element
12	133	Curlyleaf Muhly Foothill Grasslands	24	GRAMA-SCRUB	BOER-LATR-FOSP	Still foothill grassland
13	107	Creosotebush/Alkali Sacaton or Sparse, and Tarbush/Alkali Sacaton Basin Shrublands	113	SALTBUSH	ATCA-EPTO-SPFL	Still basin scrub
15	132	New Mexico Needlegrass Montane Grasslands and Mountain Mahogany/New Mexico Needlegrass Montane Shrublands	19	MAHOGANY-OAK-GRAMA	CEMO-QUTU-BOER	Missed secondary grass element
15	132	New Mexico Needlegrass Montane Grasslands and Mountain Mahogany/New Mexico Needlegrass Montane Shrublands	25	MAHOGANY-OAK-GRAMA	CEMO-QUTU-BOER-BOGR	Missed secondary grass element

Appendix B. Table 2(b). Closely related miss-classifications among map subunits (continued).

MU No.	Sub Unit	Major Map Unit Name	LCTA Transect	LCTA General Vegetation Class	LCTA Dominant Species	Validation Comments
15	119	New Mexico Needlegrass-Grama Grass Montane Grasslands	133	GRAMA-SCRUB	BOCU-ERER-DAFO-EULA-YUEL	Missed on needlegrass
16	17	Black Grama and Blue Grama/Yucca Piedmont Grasslands	11	GRAMA	BOGR-BOER	Inclusion
16	17	Black Grama and Blue Grama/Yucca Piedmont Grasslands	27	MIXED SCRUB-GRASS	DAFO-PAIN-BOGR	BOGR ok;MU 12?
16	17	Black Grama and Blue Grama/Yucca Piedmont Grasslands	26	SANDSAGE-GRAMA	ARFI-BOER-BOGR	misses sandsage element
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	53	ALKALI PLAYA	BARREN	
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	94	MESQUITE	PRGLT DUNE-ATCA	Dune vs flat mesquite
19	6	Alkali Sacaton-Burrograss or Tobosagrass Basin Grasslands, and Fourwing Saltbush/Alkali Sacaton Basin Shrubland	28	SANDSAGE-MIXED GRA	ARFI-HIJA-ATCA-YUEL	Ok ATRCAN , MU 6?
23	162	Barren Gypsum Dune	135	ALKALI PLAYA	BARREN	barren dune vs. alluvial flats
27	120	Pickleweed Alkaline Basin Shrubland	150	ALKALI PLAYA	BARREN	Sparsely vegetated flats vs. non-vegetated flats
27	120	Pickleweed Alkaline Basin Shrubland	141	ALKALI PLAYA	BARREN	Sparsely vegetated flats vs. non-vegetated flats
34	165	Mimosa/Black Grama or Sideoats Grama Foothill Shrublands	199	MIXED SCRUB	PRGLT-ACCO	
35	173	Barren Alkaline Playa	132	ALKALI PLAYA	ALOC	Sparsely vegetated flats vs. non-vegetated flats

Appendix B. Table 2(c). Gross, unrelated miss-classifications among map subunits. The10 incorrectly mapped and closely related Land condition Trend Analysis (LCTA) vegetation transects ordered by map subunit name. The LCTA transect number and general classification is given followed by the dominant species using LCTA data and codes						
MU No.	**Sub Unit**	**Major Map Unit Name**	**LCTA Transect**	**LCTA General Vegetation Class**	**LCTA Dominant Species**	**Validation Comments**
19	108	Alkali Sacaton or Tobosagrass Basin Grasslands and Honey Mesquite/Alkali Sacaton Basin Shrubland	176	BURROGRASS-SCRUB	SCBR-LYBE-PRGLT	
12	138	Black Grama-Blue Grama or Sideoats Grama and Blue Grama/Banana Yucca Foothill Grasslands	17	STIPA-WOODLAND	STNE-CEMO-FLCE	
17	118	Blue Grama-Sideoats Grama or Winterfat, and Black Grama/Soaptree Yucca Montane Valley Grasslands	70	MIXED SCRUB-GRASS	FLCE-ATCA-SPAI	?
22	168	Broom Dalea Dune Shrublands	121	SALTBUSH	ATCA-SPAI	Near duneland or possible inclusion?
13	151	Creosotebush-Tarbush or Creosote/Sparse Basin Shrublands	172	MESQUITE	PRGLT DUNE-ATCA-YUEL	
8	100	Creosotebush/Mesa Dropseed or Sparse Piedmont and Basin Shrublands	96	MESQUITE	PRGLT DUNE-ATCA	
12	171	Curlyleaf Muhly-Hairy Grama or Blue Grama, and Black Grama-Blue Grama Foothill Grasslands	82	SALTBUSH-GRASS	ATCA-BOGR	ok for BOGR, but no saltbrush in mu 12
16	147	Hairy Grama-Black Grama, and Hairy Grama or Black Grama/Soaptree Yucca Piedmont Grasslands	201	MIXED SCRUB	LATR-OPVI-BOUT	missed creosote
4	113	Mountain Mahogany/Sideoats Grama or Curlyleaf Muhly Montane Shrubland	74	SANDSAGE-MIXED GRASS	ARFI-DAWH-BOER-BOGR	ARFI vs CEMO
12	145	Sideoats, Black or Hairy Grama/Sotol Foothill Grasslands	153	CREOSOTE	LATR-PAIN	Foothills vs. piedmont