A Vegetation Map

of the

Borderlands Ecosystem Management Area

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Final Report

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SUMMARY

A map of current vegetation of the Borderlands Ecosystem Management Area in southwest New Mexico and southeast Arizona was developed from LANDSAT Thematic Mapper satellite imagery to serve regional, ecosystem-based planning. A preliminary vegetation classification was developed based on over 500 ground samples, and served as the basis for defining 34 map units. Vegetation ranged from montane coniferous forests, woodlands and shrublands, to chaparral, grasslands, desert scrub, and riparian areas. Overall map accuracy was 79.3% with most errors associated with closely related vegetation or at ecotones between types. Brief descriptions are provided for each map unit with respect to plant community composition, environment and distribution along with representative photographs and a species list.

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INTRODUCTION

The Borderlands region of the "bootheel" of New Mexico and adjacent southeast Arizona spans an area of over 800,000 acres (325,000 ha), across a wide variety of terrains from low desert basins and lava flows to mountain tops over 8,200 ft (2,500 m). It is known for its high biological diversity with elements of the Chihuahuan Desert and Sierra Madre Occidentale of Mexico mixed with biota from the Rocky Mountains and Colorado Plateau (Bourgeron et al. 1995). It also an area with a long history of natural resources utilization, particularly livestock grazing, which provides the primary economic base and social context for the region. As an aid in ecosystem management for this diverse region, a map of current vegetation was developed using LANDSAT Thematic Mapper (TM) satellite imagery. TM imagery is relatively coarse-grained imagery (28.5- meter pixels), but cost effective for mapping large areas at scales appropriate for regional, ecosystem-based planning. In addition, because the map also comes in a computerized digital format, it is readily useable in a geographic information system (GIS) for developing management scenarios. This report details the mapping methodology, and presents an annotated legend to accompany the map along with an accuracy assessment and suggestions for appropriate applications for the map.

STUDY AREA

The study area is presented in Figure 1 and as Map Sheet 1, a false-color TM image in Bands 2, 4 and 7 (blue, infrared, and far infrared) with an overlay of the major roads and streams and features. The area is over 801,000 acres (324,000 ha) in size, and includes most of the Animas and Peloncillo Mountains south of State Highway 9, and the adjacent intermountain basins -- the western Playas Valley, southern Animas Valley, San Simon and San Bernardino Valleys east of U.S. Highway 80. The study area was primarily designed to encompass the many private and public owners that have direct interests in the Borderlands Ecosystem Management Area, e.g., members of the Malpai Borderlands Group and their neighbors.

METHODS

Overall Mapping Strategy

In order to develop a map which accurately depicts patterns of vegetation over this 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 image was processed to account for geometric and radiometric distortions of the raw imagery. A preliminary analysis was then run to determine optimal strategies for mapping and field sampling.

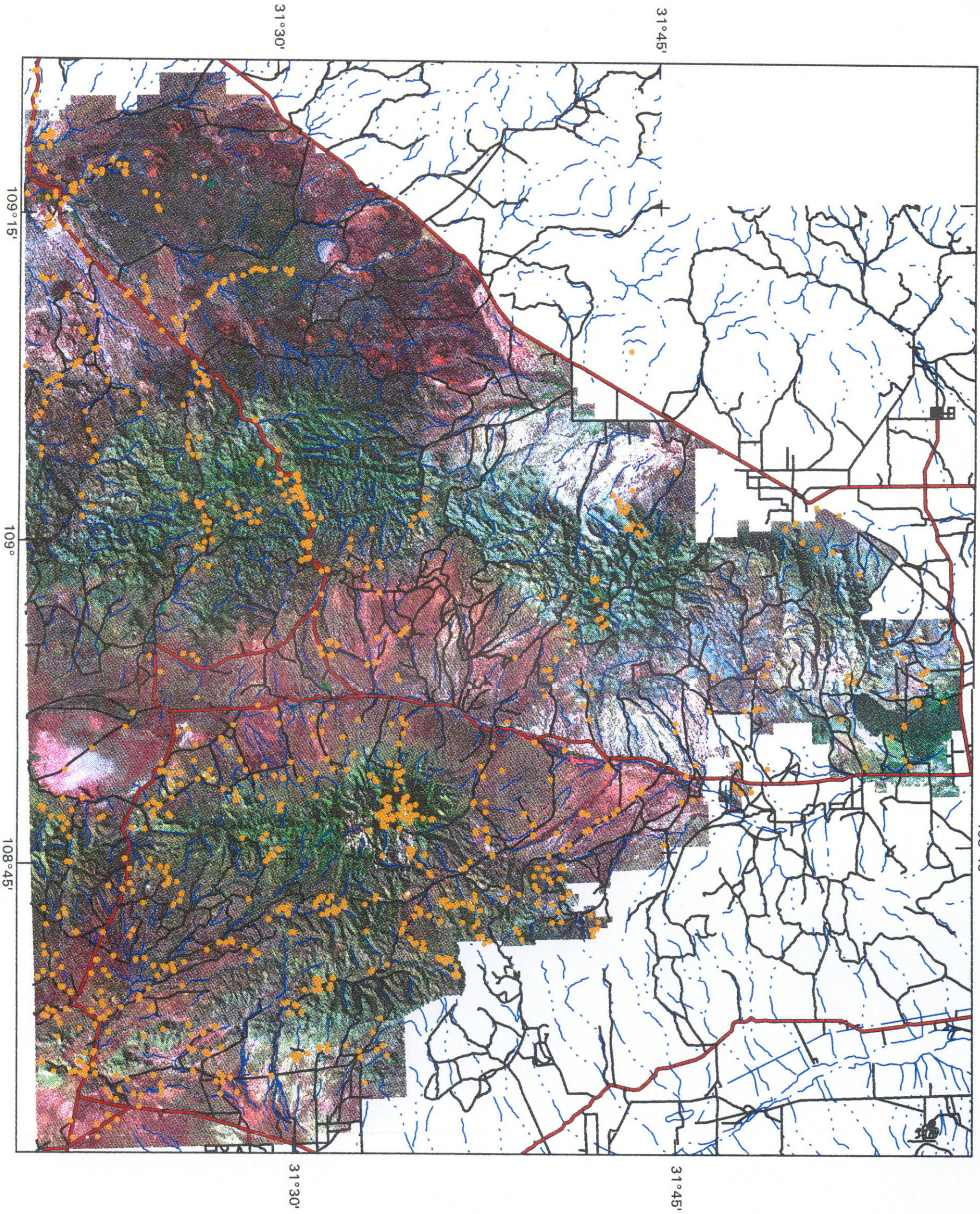

Figure 1. Borderlands Ecosystem Mangement Area showing distribution of sample points. Major roads and drainages are overlain on a false-color Thematic Mapper satellite image where red is TM band 7 (far infrared), green is TM 4 (near infrared) and blue in TM 2 is (natural green).

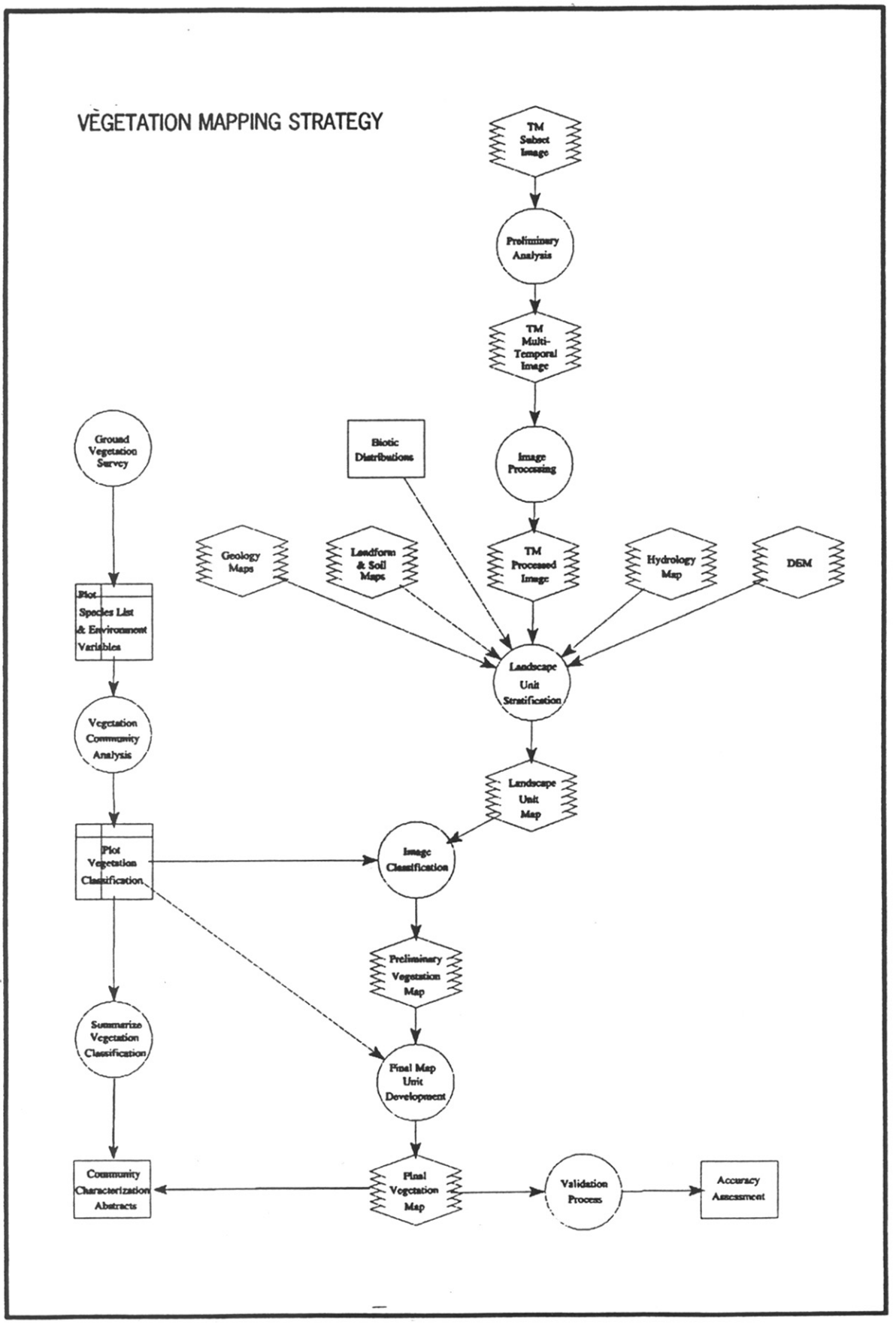

Figure 2. Flow chart of the mapping strategy used to develop the Borderlands map.

The preliminary analysis indicated a need to stratify the image analysis by broadly defined landscape level elements to overcome disparate, but localized, misclassifications that occurred across the image. This was done in two parts. First, an unsupervised classification was performed to stratify the image into blocks of similar pixels. Then, ancillary data layers such as geology maps along with anecdotal biological information were used to build landscape units from the unsupervised classification. This strategy created a landscape unit map with broad, ecologically similar areas stratified into blocks of related pixels.

Concurrently, a ground vegetation survey was conducted to gather information on vegetation community composition, environmental characteristics and location throughout the study area. Data points acquired in previous surveys of the Gray Ranch were also used (Bourgeron et al. 1996). Using this data, a provisional vegetation classification was developed to serve as a basis for defining vegetation map units. The classification hierarchy follows the structure and standards of the National Vegetation Classification (Federal Geographic Data Committee 1996) and the Gap Analysis maps (Muldavin 1996, Thompson et al. 1996).

The next step was to develop a preliminary vegetation map using a supervised image classification procedure based on the ground survey data and additional points interpreted from aerial photographs. A separate supervised image classification was performed with each landscape unit. The various landscape unit analyses were then combined into a preliminary vegetation map where each map class is represented by a particular ground point, which in turn is defined in terms of community types of the vegetation classification.

Individual map classes were then combined into final map units based on vegetation composition, spatial continuity and similar landscape structure, and the final vegetation map then generated. Map unit descriptions were developed which summarize the vegetation composition and landscape characteristics of each unit.

A separate set of vegetation data points were used to assess the accuracy of the vegetation map, and include ground survey points not used in the image analysis and additional monitoring site data provided by cooperators[2]. Each validation data point was assigned a community type according to the provisional vegetation classification and then evaluated against the composition of the map unit it fell within.

Data Sources

Satellite Imagery

An August, 1990 Landsat Thematic Mapper (TM) satellite scene, previously used for a Gray Ranch vegetation map, also provided the basis for the vegetation map of the Borderlands Ecosystem Management Area. Late summer imagery is used to catch the “green up” period for this region, when most perennial vegetation is at its peak production. TM

[2] additional monitoring site data collected by Peter Sundt was provided by the Animas Foundation, Animas NM.

satellite imagery was selected for mapping the natural vegetation cover for the study area because the cost-per-square mile for satellite data is less than that for aerial photography, both in terms of direct costs and in the ensuing map development. It takes only one full scene to cover the study area, and the imagery comes in a digital form suitable for analytical and computerized map production. 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). Also, satellite data do not have the radiometric problems of air photos, such as hot spots, dark edges, and 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 or "spectral signatures" of natural radiation of surface materials such as rocks, plants, soils, and water. These signatures provide a quantitative measure of reflectance at specific wavelengths which can then be statistically analyzed to develop a vegetation map of spectrally similar plant communities. Landsat TM has high spectral discrimination, with six spectral bands and one thermal band. Each band represents a specific range of light wavelength (Table 1). 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 in developing mapping units of the vegetation communities in sparsely vegetated areas that commonly occur in arid regions.

TM integrates the spectral characteristics of each band over the Instantaneous Field of View (IFOV) of an area of 28.5m x 28.5m; this is the smallest area resolvable by the sensor, and is represented on the computer screen by individual "pixels" (picture elements). At this resolution, individual occurrences of plants are not resolved by the sensor, but rather, 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. Topographic effects creating shadows within narrow valleys and steep scarps can also cause problems. A proper combination of field sampling and image processing techniques helps to alleviate most 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.

Table 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.

Terrain Models and Ancillary Map Coverages

United States Geological Survey (USGS) at 1:24,000 scale and Bureau of Land Management (BLM) at 1:100,000 Digital Elevation Models (DEMs) were purchased and mosaicked to provide digital elevation coverage for the study area. The DEMs were further processed to create slope and aspect images.

USGS Digital Line Graphs (DLGs) of boundary, road and drainage networks were provided from the Animas Foundation's Geographical Information System (GIS), and were compiled for use in Arc/Info and ERDAS. Partial coverage of digital orthoquads quadrangles were obtained from the USGS.

Aerial Photography

Aerial photography was acquired on loan from several sources in order to cover the entire study area. All photography was approximately at a scale of 1:24,000. Photography and sources include: 1957 black and white, and 1975 natural color covering the Gray Ranch courtesy of the Animas Foundation; black and white covering the San Bernardino and San Simon Valleys courtesy of the Natural Resources Conservation Service (NRCS), and 1976 a panchromatic ortho-photo covering the northern Peloncillos courtesy of EOSAT. The aerial

photo coverage, particularly the color, was used to both validate vegetation patterns, and to help build and verify raw TM image modeling of vegetation occurrences (seeds).

Preliminary Image Analysis

Initially, the TM image was geo-rectified using a nearest-neighbor interpolation to create a mapping base. This process makes the image planimetric so that area, direction, and distance measurements can be performed, making it useable with other map products. Then a radiometric correction was performed on all TM bands to account for the systematic signal distortion of the sensor, and an atmospheric correction was also done because reflected responses received by the satellite are attenuated due to both solar and atmospheric effects. See Appendix B for details on these analyses and the software used.

All TM bands except the thermal (TM band 6) were used for mapping. In addition a Normalized Difference Vegetation Index (NDVI) was computed as follows and added to the analysis set:

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

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 a senescent grassland.

Biological Field Data Acquisition

The basis for the image classification is the field vegetation plot data. To ensure wide coverage, potential field plot locations were identified using 1:50,000 scale maps of the raw imagery over the extent of the study area. An attempt was made to select beforehand the approximate locations of field plots according to spectral differences associated with general vegetation types, geomorphology, and soils within the boundaries of each 7.5' topographic quadrangle. 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.

Plots were generally $400m^2$ and square, but occasionally other sizes were used to fit the structure of a community, especially along drainages where vegetation stands conform to the channel shape. A list of all vascular plant species, stratified by lifeform (shrub, grass and forb layers) was compiled and cover estimated for each species using a modified Krajina Scale (Table 2). Site attributes including slope shape, grade and aspect, surface soil texture and color,

ground cover (percent rock, gravel, bare soil and litter), parent material and erosion type are recorded and detailed narrative descriptions of the site and directions to the site are also included. Plant vouchers specimens were collected as necessary and confirmed at the University of New Mexico Herbarium. Species names follow Kartesz (1994) and a species list derived from the plot data is provided in Appendix A..

Much of the field data on the Gray Ranch was from prior NMNHP surveys of 1990 and 1991, with additional field data gathered in 1995 throughout the study area of the larger Borderlands Ecosystem Management area on property of participating landowners. Highly accurate plot locations, necessary for use in the image analysis, were determined using a Global Positioning System (GPS) for all the 1995 and 1990 data. The 1991 data and low accuracy points were redone in fall of 1995 to insure proper modeling of vegetation occurrences with the imagery. 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 data resides in the NMNHP Biological and Conservation Database in a Microsoft Access format. There are 510 field plots, 236 observational and airborne videography plots derived data points in the database. The data were subjected to extensive quality control for errors following NMNHP standard protocols (raw data read-backs and computer routines).

Each plot was classified according the National Vegetation Classification (FGDCS 1996) and following national Heritage methods. In general, each plot was classified into an Alliance based on dominant or indicator species, and then to a particular community type (Plant Association) based on co-dominance or other indicator species. Phases of community types were assigned as necessary to further define the character of the plant community. Air photo interpreted data points were commonly only classified to the Alliance level. A point coverage for image analysis was developed in ERDAS and ARC-INFO and attributed by Alliance and Community Type.

Table 2. Modified Krajina cover scale used for plant cover estimates.

Scalar Symbol	Percentage Cover	Note
+0	N/A	Outside quadrat
+	<0.05	Solitary or very few
1	0.05- 0.10	very scattered
2	0.11- 0.99	scattered
3	1.0 - 4.9	
4	5.0 - 9.9	
5	10.0- 24.9	
6	25.0- 32.9	
7	33.0 - 49.9	

8	50.0 -74.9	
9	75.0 - 94.9	
10	95.0 -100.0	

Map Development

Landscape Unit Stratification

Landscape Units were 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 which increases with coverage of large, physiographically heterogeneous sites. For example, a desert grassland on a basin lava flow may have the same signature as a shadowed, pinyon woodland on a north facing hillslope. It has been shown that remotely sensed data alone has been an inadequate identifier of vegetation cover characteristics and this has led to many attempts to incorporate other ancillary data in the classification process (Niemann, 1993). To alleviate this problem, a two tiered approach was used to delineate smaller subset areas (landscape units) within the larger Borderlands image.

The landscape units were constructed by stratifying the image into spectrally similar groups and then further dividing them ecologically using geology maps and outlined areas of homogenous topography (eco-areas). Spectral groups were defined using an unsupervised classification with 20 classes. Classes were lumped according to their relationship to topography, elevation, slope, aspect, geology, surface substrate and known biotic distribution. The broadly defined basin/range eco-areas and geological maps refined the spectral groups further to these environmental variables resulting in 48 landscape units. For each landscape unit, a supervised classification was performed using only appropriate field plot seeds from within that unit.

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 digital elevation models (DEM's), digital orthoquads derived from USGS 7.5 minute topography maps where available, roads and hydrology. The DEM's were used to

construct additional layers of slope, aspect and elevation contours. These coverages were used interactively throughout the classification process, in order to verify field plot distributions, check accuracy, and ultimately to characterize mapping units.

A supervised classification strategy was adopted to create a preliminary vegetation map based on community types according to NMNHP community classification. In contrast to an unsupervised classification which simply classifies an image into a pre-designated number of mutually exclusive and more or less arbitrary spectral classes, 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 for similar pixels within user-defined parameters that contain seed pixels 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. Then the actual seed was 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, maps and aerial photos, 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 on the basis of 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 color aerial photography, but only in cases when there was high confidence in the vegetation type designation and location.

For each landscape unit a supervised classification was performed using the statistics gathered in the seeding process, and based on a maximum likelihood decision rule. The maximum likelihood decision rule also contains a Bayesian classifier which 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, cov_c is the covariance matrix for a particular class, X is the measurement vector of the pixel, M_c is the mean vector of the class and ^{T} is the matrix transpose function (ERDAS, 1994). Each pixel is then assigned to the class with the lowest weighted distance. This technique assumes that 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.

Each 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. Seed selection for a given landscape unit was based on their potential quality of modeling vegetation occurrences and proximity within the landscape unit area. With each run of the classification, informal accuracy checking was done to locate problems 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. Statistical analysis on the seed spectral means using average linkage cluster and principal components techniques were also applied to locate seeds with distribution problems. For example, a seed modeling an oak occurrence may be classifying over a grassland region. By removing the confusing oak seed and running a new classification, the grassland seeds are free to classify the problem area.

Upon completion of image analysis, landscape units 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 Units and Vegetation Map Development

The spectral map classes generated from the seeds were aggregated into a limited number of Mapping Units (MU's) based on floristic composition, landscape position, spatial contiguity, and spectral similarity, e.g. floristically similar classes which had similar

landscape positions and that were spatially near each other, were grouped into a mapping unit. This was an iterative process based once again 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.

To create the final map, a filtering process was applied to create a minimum mapping unit size of 0.5 hectares. The procedure eliminates the "speckle" created by spatially solitary mapping units which have less than six contiguous pixels. The eliminated areas were 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 which covered less than 0.5 hectares.

RESULTS

Provisional Vegetation Classification

A provisional hierarchical vegetation classification of Borderlands Ecosystem Management Area was developed which identifies 42 Alliances (cover types) containing 135 Plant Associations (Community types). The classification is outlined in Table 3 and follows national vegetation classification structure from forests and woodlands down through shrublands and grasslands. The classification is based on over 500 field vegetation samples and provides the basis for defining map units. Copies of the raw data and the digital Microsoft Access database that the classification is based on have been provided in a separate binder with accompanying disk.

The classification status of each association, e.g. Established, Provisional or New was determined from NMNHP state and Heritage Network western U.S. databases. There were 48 Established (E) associations that were either well-documented with data or well-described in the literature. Some 29 associations were Provisional (P) with only moderate documentation and in need of additional information on distribution, composition and environment. Finally, there were 58 New or *de nova* (N) associations with limited documentation (commonly represented by one or two plots) and in need of corroboration with additional data or literature references, but which were still used provisionally in the defining of map units. The map units that each association is found in are also shown in Table 3 with an indication as to whether the association is a major component of the unit (>10% of the area) or a minor inclusion (<10%).

Table 3. Provisional Vegetation Classification for the Borderlands Ecosystem Management Area. Hierarchy follows the US National Vegetation Classification system (Federal Geographic Data Committee, 1996). Hierarchical levels are as follows: I= Class, II=Subclass, III= Group, IV=Formation, V. Regional Biome Type, VI= Alliance with implied level VII Plant Associations (PA's). Regional Biome Type is not a formal part of the National Classification, but is a part of the New Mexico GAP classification and map (Thompson et al. 1986). The classification status of each plant association is indicated: E=established, well-documented (>5 standard plots) and described type in the US; P=Provisional association with moderate documentation (<5 standard plots) ; N=New (*de Nova)* association limited documentation requiring corroboration. The map units each association can be found in are also indicated map unit number (see Table 6), and by whether they are major a component of the unit or an inclusions (<10% of the map unit). Inclusions in parentheses are incidental and account for < 1% of the map unit. Some associations were not directly mapped.

Vegetation Class Level and Name	Class Status	Map Units Major	Inclu.
I. Forest			
II. Evergreen forest			
III. Temperate or subpolar needle-leaved evergreen forest			
IV. Conical-crowned temperate or subpolar needle-leaved evergreen forest			
V. Rocky Mountain Upper Montane Conifer Forest			
VI. Douglas-fir (*Psuedotsuga menziesii)* Alliance			
Douglasfir-Gambel's Oak (*Pseudotsuga menziesii-Quercus gambelii*; PSEMEN/QUEGAM)	E	1	-
I. Woodland			
II. Evergreen woodland			
III. Temperate or subpolar needle-leaved evergreen woodland			
IV. Rounded-crown temperate or subpolar needle-leaved evergreen woodland			
V. Rocky Mountain/Great Basin Lower Montane and Foothill Conifer Woodland			
VI. Ponderosa Pine (*Pinus ponderosa*) Woodland Alliance			
Ponderosa Pine/Gambel's Oak (*Pinus ponderosa-Quercus gambelii*; PINPON/QUEGAM)	E	1	-
VI. Juniperus monosperma Alliance			
Oneseed Juniper/Black Grama (*Juniperus monosperma/Bouteloua eriopoda*; JUNMON/BOUERI)	E	-	4
Oneseed Juniper/Blue Grama (*Juniperus monosperma/Bouteloua gracilis*; JUNMON/BOUGRA)	E	-	-
Oneseed Juniper/Hairy Grama (*Juniperus erythrocarpa/Bouteloua hirsuta*; JUNMON/BOUHIR)	E	4	-
Oneseed Juniper/Sideoats Grama (*Juniperus erythrocarpa/Bouteloua curtipendula*; JUNMON/BOUCUR)	E	4	-
V. Madrean Lower Montane and Foothill Conifer Woodlland			
VI. Apache Pine (*Pinus engelmannii*) Alliance			
Apache Pine/Gambel's Oak (*Pinus engelmannii/Quercus gambelii*; PINENG/QUEGAM)	N	-	1
VI. Chihuahua Pine (*Pinus leiophylla*) Alliance			
Chihuahua Pine-Arizona White Oak (*Pinus leiophylla/Quercus arizonica*; PINLEI/QUEARI)	E	-	1
Chihuahua Pine/Pointleaf Manzanita (*Pinus leiophylla/Arctostaphylos pungens*; PINLEI/ARCPUN)	E	-	-
Chihuahua Pine-Silverleaf Oak (*Pinus leiophylla/Quercus hypoleucoides*; PINLEI/QUEHYP)	E	1	-
VI. Mexican Pinyon Pine (*Pinus cembroides*) Woodland Alliance			
Mexican Pinyon-Arizona White Oak (*Pinus cembroides-Quercus arizonica*; PINCEM-QUEARI)	P	2	-
Mexican Pinyon/Gambel's Oak (*Pinus cembroides/Quercus gambelii;* PINCEM/QUEGAM)	N	-	-

Table 3. Provisional Vegetation Classification for the Borderlands Ecosystem Management Area (continued)

Vegetation Class Level and Name	Class Status	Map Units Major	Inclu.
Mexican Pinyon/Netleaf Oak (*Pinus cembroides/Quercus rugosa*; PINCEM/QERUG)	N	2	-
Mexican Pinyon/Pinyon Ricegrass (*Pinus cembroides/Piptochaetium fimbriatum*; PINCEM/PIPFIM)	P	-	-
Mexican Pinyon/Pointleaf Manzanita (*Pinus cembroides/Arctostaphylos pungens*; PINCEM/ARCPUN)	N	-	14
Mexican Pinyon/Silverleaf Oak (*Pinus cembroides/Quercus hypoleucoides*; PINCEM/QUEHYP	N	2	-
Mexican Pinyon-Toumey Oak (*Pinus cembroides/Quercus toumeyi*; PINCEM/QUETOU)	P	2	5
VI. Alligator Juniper (*Juniperus deppeana*) Woodland Alliance			
Alligator Juniper/Hairy Grama (*Juniperus deppeana/Bouteloua hirsuta*; JUNDEP/BOUHIR)	P	4	-
Alligator Juniper/Sideoats Grama (*Juniperus deppeana/Bouteloua curtipendula*; JUNDEP/BOUCUR)	P	4	13
Alligator Juniper/Texas Bluestem (*Juniperus deppeana/Schizachyrium cirratum*; JUNDEP/SCHCIR)	P	4	-
III. Temperate broad-leaved evergreen woodland			
IV. Temperate broad-leaved evergreen woodland			
V. Madrean Broadleaf Evergreen Woodland			
VI. Arizona White Oak (*Quercus arizonica*) Alliance [includes Gray Oak; *Q. grisea*]			
Arizona White Oak/Bullgrass (*Quercus arizonica/Muhlenbergia emersleyi;* QUEARI/MUHEME)	E	3	14
Arizona White Oak/Hairy Grama (*Quercus arizonica/Bouteloua hirsuta;* QUEARI/BOUHIR)	P	3	-
Arizona White Oak/Pointleaf Manzanita (*Quercus arizonica/Arctostaphylos pungens*; QUEARI/ARCPUN)	P	-	-
Arizona White Oak/Sideoats Grama (*Quercus arizonica/Bouteloua curtipendula*; QUEARI/BOUCUR)	P	-	3, 29
VI. Emory Oak (*Quercus* emoryi) Alliance			
Emory Oak/Blue Grama (*Quercus emoryi/Bouteloua gracilis*; QUEEMO/BOUGRA)	N	3	-
Emory Oak/Bullgrass (*Quercus emoryi/Muhlenbergia emersleyi*; QUEEMO/MUHEME)	P	3	-
Emory Oak/Hairy Grama (*Quercus emoryi/Bouteloua hirsuta*; QUEEMO/BOUHIR)	N	-	3
Emory Oak/Mesa Dropseed (*Quercus emoryi/Sporobolus flexuosus*; QUEEMO/SPOFLE)	N	-	3
Emory Oak/Pinyon Ricegrass (*Quercus emoryi/Piptochaetium fimbriatum*; QUEEMO/PIPFIM)	P	3	-
Emory Oak/Pointleaf Manzanita (*Quercus emoryi-Arctostaphylos pungens*; QUEEMO/ARCPUN)	N	3	5
Emory Oak/Sideoats Grama (*Quercus emoryi/Bouteloua curtipendula*; QUEEMO/BOUCUR)	P	-	3
Emory Oak/Texas Bluestem (*Quercus emoryi/Schizachyrium cirratum*; QUEEMO/SCHCIR)	P	-	3
II. Deciduous Woodland			
III. Cold-deciduous woodland			
IV. Seasonally/temporarily flooded cold-deciduous woodland			
V. Lowland Broad-leaved Deciduous Forested Wetland, Temporarily Flooded			
VI. Arizona Sycamore (*Platanus wrightii*) Woodland Alliance			
Arizona Sycamore/Sideoats Grama (*Platanus wrightii/Bouteloua curtipendula*) PLAWRI/BOUCUR	P	29	-
VI. Fremont Cottonwood (*Populus fremontii*) Woodland Alliance			
Fremont Cottonwood/Sparse Undergrowth (*Populus fremontii*/Sparse; POPFRE/SPARSE)	P	29	-

Table 3. Provisional Vegetation Classification for the Borderlands Ecosystem Management Area (continued)

Vegetation Class Level and Name	Class Status	Map Units Major	Inclu.
I. Shrubland			
II. Deciduous shrubland (scrub)			
III. Cold-deciduous shrubland			
IV. Temperate cold-deciduous shrubland			
V. Rocky Mountain Montane Scrub			
VI. Mountain Mahogany (*Cercocarpus montanus*) Shrubland Alliance			
Mountain Mahogany/Bullgrass (*Cercocarpus montanus/Muhlenbergia emersleyi*; CERMON/MUHEME)	P	4	-
Mountain Mahogany/Sideoats Grama*Cercocarpus montanus/Bouteloua curtipendula*; CERMON/BOUCUR)	E	-	(4)
IV. Seasonallt/temporarily flooded cold-deciduous shrubland			
V. Southwest Arroyo Cold-Deciduous Riparian/Wetland Shrublands			
VI. Apacheplume (*Fallugia paradoxa)* Shrubland Alliance			
Apacheplume/Blue Grama (*Fallugia paradoxa/Bouteloua gracilis*; FALPAR/BOUGRA)	P	31	29
III. Extremely xeromorphic deciduous shrubland (subdesert)			
IV. Extremely xeromorphic deciduous subdesert shrubland with succulents			
V. Chihuahuan Deciduous Desert Scrub			
VI. Honey Mesquite (*Prosopis glandulosa*) Shrubland Alliance			
Honey Mesquite/Black Grama (*Prosopis glandulosa/Bouteloua eriopoda*; PROGLA/BOUERI)	E	10	-
Honey Mesquite/Blue Grama (*Prosopis glandulosa/Bouteloua gracilis*; PROGLA/BOUGRA)	E	10	-
Honey Mesquite-Broom Snakeweed (*Prosopis glandulosa-Gutierrezia sarothrae*; PROGLA/GUTSAR)	E	10	24
Honey Mesquite-Burroweed (*Prosopis glandulosa/Isocoma tenuisecta;* PROGLA/ISOTEN)	N	-	(10)
Honey Mesquite/Bush Muhly (*Prosopis glandulosa/Muhlenbergia porteri*; PROGLA/MUHPOR)	E	10	-
Honey Mesquite/Giant Sacaton (*Prosopis glandulosa/Sporobolus wrighti;* PROGLA/SPOWRI)	N	30	10, 11,24, 31
Honey Mesquite/Hairy Grama (*Prosopis glandulosa/Bouteloua hirsuta*; PROGLA/BOUHIR)	N	10	-
Honey Mesquite/Monotypic Stand (*Prosopis glandulosa/Monotypic*; PROGLA/MONTYP)	N	30	11, 33, 34
Honey Mesquite/Obtuse Panicgrass (*Prosopis glandulosa/Panicum obtusum;* PROGLA/PANOBT)	N	11	-
Honey Mesquite/Purple Threeawn (*Prosopis glandulosa/Aristida purpurea*; PROGLA/ARIPUR)	P	10	16
Honey Mesquite/Sideoats Grama (*Prosopis glandulosa/Bouteloua curtipendula*; PROGLA/BOUCUR)	N	-	(10)
Honey Mesquite/Tobosagrass (*Prosopis glandulosa/Hilaria mutica*; PROGLA/HILMUT)	E	11	10, 22,25
VI. Tarbush (*Flourensia cernua*) Alliance			
Tarbush/Bush Muhly (*Flourensia cernua/Muhlenbergia porteri*; FLOCER/MUHPOR)	E	-	(9)
VI. Viscid Acacia (*Acacia constricta, A. neovernicosa)* Shrubland Alliance			
Viscid Acacia/Black Grama (*Acacia neovernicosa/Bouteloua eriopoda*; ACANEO/BOUERI)	E	-	8
Viscid Acacia/Bush Muhly (*Acacia neovernicosa/Muhlenbergia porteri;* ACANEO/MUHPOR)	E	-	9
Viscid Acacia-Mariola (*Acacia neovernicosa-Parthenium incanum*; ACANEO/PARINC)	E	7	-
Viscid Acacia-Ocotillo (*Acacia neovernicosa-Fouquieria splendens*; ACANEO/FOUSPL)	N	9	-
Viscid Acacia/Sideoats Grama (*Acacia neovernicosa/Bouteloua curtipendula*; ACANEO/BOUCUR)	E	8	10
Viscid Acacia/Tobosagrass (*Acacia neovernicosa/Hilaria mutica*; ACANEO/HILMUT)	N	-	7, 23, 30

Table 3. Provisional Vegetation Classification for the Borderlands Ecosystem Management Area (continued)

Vegetation Class Level and Name	Class Status	Map Units Major	Map Units Inclu.
VI. Catclaw Mimosa (*Mimosa aculeaticarpa)* Alliance			
Catclaw Mimosa/Black Grama (*Mimosa aculeaticarpa/Bouteloua eriopoda*; MIMACUB/BOUERI)	E		(19)
Catclaw Mimosa/Purple Threeawn (*Mimosa aculeaticarpa/Aristida purpurea*; MIMACUB/ARIPUR)	P	-	(9)
VI. Velvetpod Mimosa (*Mimosa dysocarpa*) Shrubland Alliance			
Velvetpod Mimosa-Sacahuista (*Mimosa dysocarpa-Nolina microcarpa*; MIMDYS/NOLMIC)	N	-	-
Velvetpod Mimosa/Tobosagrass (*Mimosa dysocarpa/Hilaria mutica*; MIMDYS/HILMUT)	N	31	(8)
VI. Littleleaf Sumac (*Rhus microphylla*) Shrubalnd Alliance			
Littleleaf Sumac/Sideoats Grama (*Rhus microphylla/Bouteloua curtipendula*; RHUMIC/BOUCUR)	P	-	-
VI. Beebrush (*Aloysia wrightii*) Shrubland Alliance			
Wright's Beebrush/Marioloa (*Aloysia wrightii/Parthenium incanum;* ALOWRI/PARINC)	N	8	-
Wright's Beebrush/Sideoats Grama (*Aloysia wrightii/Bouteloua curtipendula;* ALOWRI/BOUCUR)	N		
II. Evergreen Shrubland			
III. Temperate broad-leaved evergreen shrubland			
IV. Sclerophyllous temperate broad-leaved evergreen shrubland			
V. Interior Chaparral			
VI. Toumey Oak (*Quercus toumeyi*) Shrubland Alliance			
Toumey Oak/Bullgrass (*Quercus toumeyi/Muhlenbergia emersleyi*; QUETOU/MUHEME)	P	5	-
Toumey Oak/Hairy Grama (*Quercus toumeyi/Bouteloua hirsuta;* QUETOU/BOUHIR)	N	-	(5)
Toumey Oak-Pointleaf Manzanita (*Quercus toumeyi/Arctostaphylos pungens;* QUETOU/ARCPUN)	P	5	-
Toumey Oak/Sideoats Grama (*Quercus toumeyi/Bouteloua curtipendula*; QUETOU/BOUCUR)	P	-	-
VI. Pointleaf Manzanita (*Arctostaphylos pungens*) Shrubland Alliance			
Pointleaf Manzanita/Sideoats Grama (*Arctostaphylos pungens/Bouteloua curtipendula*; ARCPUN/BOUCUR)	N	5	-
III. Extremely xeromorphic			
IV. Broad-leaved and Microphyllous-leaved evergreen extremely xeromorphic subdesert shrubland			
V. Chihuahuan Evergreen Desert Scrub			
VI. Creosotebush (*Larrea tridentata*) Shrubland Alliance			
Creosotebush-Mariola (*Larrea tridentata-Parthenium incanum*; LARTRI/PARINC)	E	9	7
Creosotebush/Fluffgrass (*Larrea tridentata/Erioneuron pulchellum*; LARTRI/ERIPUL)	E	-	-
Creosotebush/Bush Muhly (*Larrea tridentata/Muhlenbergia porteri*; LARTRI/MUHPOR)	E	9	-
Creosotebush/Giant Sacaton (*Larrea tridentata/Sporobolus wrightii*;LARTRI/SPOWRI)	N	-	(9, 11)
Creosotebush-Tarbush/Sparse Undergrowth (*Larrea tridentata-Florencia cernua*/Sparse; LARTRI-FLORCER/SPARSE)	E	-	(9)
VI. Sandpaperbush (*Mortonia sempervirens ssp. scabrella*) Shrubland Alliance			
Sandpaperbush -Mariola (*Mortonia sempervirens ssp. scabrella-Parthenium incanum*; MORSEMS/PARINC)	N	6	-
Sandpaperbush -Viscid Acacia-Mariola (*Mortonia sempervirens ssp. scabrella-Acacia neovernicosa -Parthenium icanum ;* MORSEMS-ACANEO-PARINC)	N	6	7

Table 3. Provisional Vegetation Classification for the Borderlands Ecosystem Management Area (continued)

Vegetation Class Level and Name	Class Status	Map Units Major	Map Units Inclu.
I. Dwarf-shrubland			
II. Evergreen shrubland			
III. Extremely xeromorphic evergreen shrubland			
IV. Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert dwarf shrubland			
V. Chihuahuan Evergreen Desert Dwarf Shrubland			
VI. Burroweed (*Isocoma tenuisecta*) Dwarf Shrubland Alliance			
Burroweed/Purple Threeawn (*Isocoma tenuisecta/Aristida purpurea*; ISOTEN/ARIPUR)	N	12	-
I. Herbaceous vegetation			
II. Perennial graminoid (grasslands)			
III. Temperate or subpolar grassland (without a significant tree or shrub layer)			
IV. Tall bunch temperate grassland			
V. Lowland/Swale Tall Desert Grassland			
VI. Giant Sacaton (*Sporobolus wrightii*) Herbaceous Alliance			
Giant Sacaton/Monotypic Stand (*Sporobolus wrightii/Monotypic;* SPOWRI/MONTYP)	P	27	
Giant Sacaton-Tobosagrass (*Sporobolus wrightii-Hilaria mutica*; SPOWRI-HILMUT)	N	-	24
Giant Sacaton-Vine Mesquite (*Sporobolus wrightii-Panicum obtusum*; SPOWRI-PANOBT)	P	27	24
VI. This Paspalim (*Paspalum setaceum*) Alliance			
Thin Paspalum-Mesa Dropseed (*Paspalum setaceum-Sporobolus flexuosus*; PASSET-SPOFLE)	N	26	
IV. Medium-tall bunch temperate grassland			
V. Plains-Mesa-Foothill Mid-grass Grassland			
VI. Sideoats Grama (*Bouteloua curtipendula*) Herbaceous Alliance			
Sideoats Grama-Curlymesquite (*Bouteloua curtipendula-Hilaria belangeri*; BOUCUR-HILBEL)	N	-	-
Sideoats Grama-Plains Lovegrass (*Bouteloua curtipendula-Eragrostis intermedia*; BOUCUR-ERAINT)	N	13	-
Sideoats Grama-Purple Grama (*Bouteloua curtipendula-Bouteloua radicosa*; BOUCUR-BOURAD)	N	-	5
Sideoats Grama-Purple Threeawn (*Bouteloua curtipendula-Aristida purpurea*; BOUCUR-ARIPUR)	P	-	-
Sideoats Grama-Tanglehead (*Bouteloua curtipendula-Heteropogon contortus*; BOUCUR-HETCON)	N	-	-
Sideoats Grama-Texas Bluestem (*Bouteloua curtipendula-Schizachyrium cirratum*; BOUCUR-SCHCIR)	N	13	-
V. Madrean Foothill Grassland			
VI. Bullgrass (*Muhlenbergia emersleyi*) Herbaceous Alliance			
Bullgrass-Hairy Grama (*Muhlenbergia emersleyi-Bouteloua hirsuta*; MUHEME-BOUHIR)	N	-	-
Bullgrass-Sideoats Grama (*Muhlenbergia emersleyi-Bouteloua curtipendula*; MUHEME-BOUCUR)	N	-	-
V. Lowland/Swale Medium-tall Desert Grassland			
VI. Alkali Sacaton (*Sporobolus airoides*) Herbaceous Alliance			
Alkali Sacaton/Monotypic Stand (*Sporobolus airoides/Monotypic*; SPOAIR-MONTYP)	E	27	-

Table 3. Provisional Vegetation Classification for the Borderlands Ecosystem Management Area (continued)

Vegetation Class Level and Name	Class Status	Map Units Major	Inclu.
VI. Toboasgrass (*Hilaria mutica*) Herbaceous Alliance			
Tobosagrass-Blue Grama (*Hilaria mutica-Bouteloua gracilis*l; HILMUT-BOUGRA)	E	22,24,25	17
Tobosagrass-Burrograss (*Hilaria mutica-Scleropogon brevifolius*; HILMUT-SCLBRE)	E	23	-
Tobosagrass/Monotypic Stand (*Hilaria mutica/Monotypic*; HILMUT/MONTYP)	E	23	24
Tobosagrass-Needle Grama (*Hilaria mutica-Bouteloua aristidoides*; HILMUT-BOUARI)	N	23	-
Tobosagrass-Purple Threeawn (*Hilaria mutica-Aristida purpurea*; HILMUT-ARIPUR)	N	22,24	21
Tobosagrass-Sideoats Grama (*Hilaria mutica-Bouteloua curtipendula*; HILMUT- BOUCUR)	N	-	(17, 24)
Tobosagrass-Vine Mesquite (*Hilaria mutica-Panicum obtusum*; HILMUT-PANOBT)	E	-	(10)
IV. Short sod temperate or subpolar grasslands (including sod or mixed sod and bunch graminoids)			
V. Plains-Mesa-Foothill Short-grass Grassland			
VI. Blue Grama (*Bouteloua gracilis*) Herbaceous Alliance			
Blue Grama-Alkali Sacaton (*Bouteloua gracilis-Sporobolus airoides*; BOUGRA-SPOAIR)	E	27	-
Blue Grama-Buffalograss (*Bouteloua gracilis-Buchloe dactyloides*; BOUGRA-BUCDAC)	E	17	18
Blue Grama-Curlymesquite (*Bouteloua gracilis-Hilaria belangeri*; BOUGRA-HILBEL)	N	-	(17)
Blue Grama-Mesa Dropseed (*Bouteloua gracilis-Sporobolus flexuosus*; BOUGRA-SPOFLE)	N	26	-
Blue Grama-Plains Lovegrass (*Bouteloua gracilis-Eragrostis intermedia*; BOUGRA-ERAINT)	N	-	(17, 18)
Blue Grama-Purple Threeawn (*Bouteloua gracilis-Aristida purpurea*; BOUGRA-ARIPUR)	P	17, 18	16
Blue Grama-Sideoats Grama (*Bouteloua gracilis-Bouteloua curtipendula*; BOUGRA-BOUCUR)	E	-	(17, 18)
Blue Grama-Vine Mesquite (*Bouteloua gracilis-Panicum obtusum*; BOUGRA-PANOBT)	P	16	27
VI. Hairy Grama (*Bouteloua hirsuta*) Herbaceous Alliance			
Hairy Grama-Black Grama (*Bouteloua hirsuta-Bouteloua eriopoda*; BOUHIR-BOUERI)	E	-	16
Hairy Grama-Blue Grama (*Bouteloua hirsuta-Bouteloua gracilis*; BOUHIR- BOUGRA)	E	13,16,17	-
Hairy Grama-Curlymesquite (*Bouteloua hirsuta-Hilaria belangeri*; BOUHIR-HILBEL)	N	13,17	-
Hairy Grama-Purple Grama (*Bouteloua hirsuta-Bouteloua radicosa*; BOUHIR-BOURAD)	N	13	-
Hairy Grama-Sideoats Grama (*Bouteloua hirsuta-Bouteloua curtipendula*; BOUHIR-BOUCUR)	E	17	14, 15
VI. Purple Threeawn Aristida purpurea Herbaceous Alliance			
Purple Threeawn-Fluffgrass (*Aristida purpurea-Erioneuron pulchellum*; ARIPUR-ERIPUL)	N	21	-
Purple Threeawn-Sixweeks Threeawn (*Aristida purpurea-Aristida adscensiones*; ARIPUR-ARIADS)	N	21	-
VI. Black Grama (*Bouteloua eriopoda*) Herbaceous Alliance			
Black Grama-Sideoats Grama (*Bouteloua eriopoda-Bouteloua curtipendula*; BOUERI-BOUCUR)	E	-	-
Black Grama-Blue Grama (*Bouteloua eriopoda-Bouteloua gracilis*; BOUERI-BOUGRA)	E	19,25	17
Black Grama-Curly Mesquite Grass (*Bouteloua eriopoda-Hilaria belangerii*; BOUERI-HILBEL)	N	-	(13)
Black Grama-Purple Threeawn (*Bouteloua eriopoda-Aristida purpurea*; BOUERI-ARIPUR)	E	-	(13)

Table 3. Provisional Vegetation Classification for the Borderlands Ecosystem Management Area (continued)

Vegetation Class Level and Name	Class Status	Map Units Major	Inclu.
IV. Seasonally/temporarily flooded temperate grassland			
V. Montane Seasonally/Temporarily Flooded Grassland			
VI. Shortawn Foxtail (*Alopecurus aequalis*) Herbaceous Alliance			
Shortawn Foxtail/Bulb Panicgrass (*Alopecurus aequalis-Panicum bulbosum*; ALOAEQ-PANBUL)	N	-	-
V. Lowland Seasonally/Temporarily Flooded Grassland			
VI. Creeping Muhly (*Muhlenbergia repens*) Herbaceous Alliance			
Creeping Muhly-Bottlebrush Squirreltail (*Muhlenbergia repens-Elymus elymoides*; MUHREP-ELYELY)	N	28	-
VI. Vine Mesquite (*Panicum obtusum*) Herbaceous Alliance			
Vine Mesquite-Buffalograss (*Panicum obtusum-Buchloe dactyloides*; PANOBT-BUCDAC)	N	28	-
Vine Mesquite Grass/Monotypic Stand (*Panicum obtusum/Monotypic*; PANOBT/MONTYP)	N	-	(11)
III. Temperate or subpolar grassland with a shrub layer (generally 10-25%)			
IV. Medium-tall sod temperate or subpolar grasslands (including sod or mixed sod and bunch graminoids) with sparse, broad-leaved evergreen or semi-evergreen shrubs			
V. Plains-Mesa-Foothill Shrub/Medium-tall Grassland			
VI. Sideoats Grama (Bouteloua curtipendula) Shrub/Herbaceous Alliance			
Sideoats Grama/Common Sotol (*Bouteloua curtipendula/Dasylirion wheeleri*; BOUCUR/DASWHE)	E	-	(9)
Sideoats Grama/Ocotillo (*Bouteloua curtipendula/Fouquieria splendens*; BOUCUR/FOUSPL)	E	-	(8)
Sideoats Grama/Sacahuista (*Bouteloua curtipendula/Nolina microcarpa*; BOUCUR/NOLMIC)	E	-	-
IV. Short temperate or subpolar grasslands with xeromorphic (evergreen or deciduous) shrubs			
V. Foothill-Piedmont Xermorphic Shrub-Grassland			
VI. Blue Grama (*Bouteloua gracilis*) Shrub/Herbaceous Alliance			
Blue Grama/Sacahuista (*Bouteloua gracilis/Nolina microcarpa*; BOUGRA/NOLMIC)	N	14	-
VI. Hairy Grama (*Bouteloua hirsuta*) Desert Shrub/Herbaceous Alliance			
Hairy Grama/Ocotillo (*Bouteloua hirsuta/Fouquieria splendens*; BOUHIR/FOUSPL)	N	-	8 (9)
Hairy Grama/Sacahuista (*Bouteloua hirsuta/Nolina microcarpa*; BOUHIR/NOLMIC)	E	14	13, 17, 22(19)
Hairy Grama/Soaptree Yucca (*Bouteloua hirsuta/Yucca elata*; BOUHIR/YUCELA)	E	-	(17)
Hairy Grama/Sotol (*Bouteloua hirsuta/Dasylirion wheeleri*; BOUHIR/DASWHE)	E	13	-
VI. Black Grama (*Bouteloua eriopoda*) Shrub/Herbaceous Alliance			
Black Grama/Apacheplume (*Bouteloua eriopoda/Fallugia paradoxa*; BOUERI/FALPAR)	P	-	-
Black Grama/Longleaf Jointfir (*Bouteloua eriopoda/Ephedra trifurca*; BOUERI/EPHTRI)	E	-	(19, 20)
IV. Short temperate or subpolar grasslands with needle-leaved or microphyllous evergreen dwarf-shrubs			
V. Plains-Mesa-Foothill Short-grass Grassland with Dwarf-Shrubs			
VI. Blue Grama (*Bouteloua gracilis*) Dwarf-shrub/Herbaceous Alliance			
Blue Grama/Broom Snakeweed (*Bouteloua gracilis/Gutierrezia sarothrae*; BOUGRA/GUTSAR)	P	-	-

Table 3. Provisional Vegetation Classification for the Borderlands Ecosystem Management Area (continued)

Vegetation Class Level and Name	Class Status	Map Units Major	Inclu.
VI. Hairy Grama (*Bouteloua hirsuta*) Dwarf-shrub/Herbaceous Alliance			
Hairy Grama/Featherplume (*Bouteloua hirsuta/Dalea formosa*; BOUHIR/DALFOR)	E	18	-
V. Foothill-Piedmont Dwarf-shrub/Grassland			
VI. Black Grama (*Bouteloua eriopoda*) Dwarf-shrub/Herbaceous Alliance			
Black Grama/Broom Snakeweed (*Bouteloua eriopoda/Gutierrezia sarothrae*; BOUERI/GUTSAR)	N	20	(16)
Black Grama/Turpentine Bush (*Bouteloua eriopoda/Ericameria laricifolia*; BOUERI/ERILAR)	N	25	-
VI. Sideoats Grama (Bouteloua curtipendula) Dwarf-shrub/Herbaceous Alliance			
Sideoats Grama/Turpentine Bush (*Bouteloua curtipendula/Ericameria laricifolia*; BOUCUR/ERILAR)	N	15	13
II. Annual Graminoids and Forbs			
III. Temperate or subpolar annual grasslands or forb vegetation			
IV. Seasonally/temporarily flooded temperate annual grassland or forb vegetation			
V. Lowland Seasonally/Temporarily Flooded Annual Grassland			
VI. Hall's Panicgrass (*Panicum hallii*) Herbaceous Alliance			
Hall's Panicgrass-Feather Fingergrass (*Panicum hallii-Chloris virgata*; PANHAL-CHLVIR)	N	28	

The wide variety of plant associations is a reflection of the high biodiversity of the study area. The mountainous area lies in a broad transition zone between the floristically distinct provinces of the Sierra Madre of Mexico to the south, and the Rocky Mountains and Great Basin to the north. The mountains are in turn separated by wide basins and valleys dominated by vegetation characteristic of the Chihuahuan Desert.

The lowest elevations (4,800-5,600 ft) of the study area support Chihuahuan Desert Scrub and Desert Grasslands communities. They occur on valley floors, enclosed basin bottoms and lower piedmont slopes (bajadas) of the Animas, Playas, San Simon, and San Bernadino Valleys. On the valley floors with little or no slopes, extensive "flats" dominated by tobosagrass (*Hilaria mutica* Alliance) occur. Here, soils tend to be composed of depositional fine textured silts and clays. Tobosa grasslands also dominate the extensive lava flows (malpai) in the bottoms of the of the San Bernadino and San Simon Valleys. Intermixed with the lowland grasslands are shrubands dominated by honey mesquite (*Prosopis glandulosa* Alliance) or acacia (*Acacia neomexicanaI* or *A. constricta* Alliance) with grassy understories such as the Honey Mesquite/Tobosagrass, or Viscid Acacia/tobosagrass.

At the lowest position, commonly adjacent to stream channels or in swales where moisture is adequate, extensive tall grasslands dominated by giant sacaton (*Sporobolus wrightii* Alliance) occur. The occurrence along Animas Creek in the northern end of the study area is one the largest contiguous stands found in the Southwest. Also of special interest are the riparian corridors that support Arizona sycamore and Fremont's cottonwood riparian forest (*Platanus wrightii* and *Populus fremontii* Alliances), scattered small isolated wetlands of the upper watersheds, and "arroyo riparian" shrublands of the ephemeral stream channels.

In addition to the riparian communities of the drainageways, there are enclosed lake basins (playas) with extensive grasslands such as those found in the southern Animas Valley (Fitzpatrick Playa). At this site blue grama/buffalo grass community is found encircling the playas on the coarser sediments. Moving downslope toward the playa bottoms, on the finer textured soils, the blue grama/buffalo grass community is replaced by the transitional vine mesquite grass/buffalo grass community (*Panicum obtusum* Alliance). On the playa bottom the soils are heavy clays and are commonly waterlogged during the rainy season. Here, species that are tolerant of repeated annual inundation such as alkali sacaton (*Sporobolus airoides*), vine mesquite (*Panicum obtusum*), Hall's panicgrass (*Panicum hallii*), feather fingergrass (*Chloris virgata*) and creeping muhly (*Muhlenbergia repens*) prevail. Also, within these playas are the very sandy deposits which support the unusual Emory oak/sand dropseed cienega and sand dropseed/paspalum setaceum grassland.

Alluvial fans or piedmonts (bajadas) ring the basins and extend to the base of the mountains. The soils become more coarse textured than the basins, and the tobosagrass communities are commonly replaced by communities dominated by mesquite, with grassy understories of black, hairy and blue grama (*Bouteloua eriopoda, B. hirsuta*, and *B. gracilis),* or purple threeawn (*Aristida purpurea* and its relatives). In these communities, mesquite has probably encroached as a function of past grazing and fire management in combination with climatic downturns.

Further up the piedmont slopes, mesquite becomes less prevalent as soils become coarser and perhaps temperatures cooler. The desert grasslands give way to the Plains-Mesa-Foothill Grasslands dominated by blue and hairy grama grasses (*Bouteloua gracilis* and *Bouteloua hirsuta* Alliances). Hairy Grama grasslands occur on relatively drier sites of medium textured soils (loams and gravelly loams), warmer exposures, or lower elevations. Blue grama grasslands tend towards finer textured soils and cooler sites then hairy grama. Of special note is the extensive (1000+ acres) blue grama/buffalo grass community of the southern Animas Valley which appears to one of the disjunct occurrences of this type in southwest New Mexico and northern Mexico from its main distribution in short-grass prairie of eastern New Mexico and Colorado.

The grasslands at their upper elevations usually come in contact with either the Interior Chaparral or Madrean Evergreen Woodlands. These communities form a wide elevation zone in the mountains at approximately 5,500 and 7,500 ft. (lower on the east side, higher on the west). Lower elevations are dominated by Emory oak and Toumey Oak communities (*Quercus emoryi* and *Q. toumeyi* Alliance). The Toumey oak communities are essentially communities endemic to the Borderlands with their distribution limited to southeastern Arizona, southwestern New Mexico and extreme northern Mexico. The southerly aspects of the mountain slopes are often dominated by grassland communities such as bull grass/hairy grama community, or point-leaf manzanita/oak chaparral communities (*Arctostaphylos pungens* Alliance). At mid elevations (6,000 ft.), grey oak, alligator bark juniper and oneseed juniper dominated woodland communities become more prevalent (*Quercus grisea, Juniperus deppeana,* and *J. monosperma* Alliances).

At the highest elevations, generally above 7,500 ft, the oak and juniper-dominated woodlands shift to southerly aspects and are replaced on cooler slopes by more mesic Mexican pinyon (*Pinus cembroides*) communities such as Mexican pinyon/net-leaf oak and Mexican pinyon silver-leaf oak1. Most of the manzanita-dominated chaparral communities also decline, although mountain mahogany and scrub oak communities are still prevalent (particularly on burned sites). Intermixed with the scrub at the top of mountains are Montane Coniferous Forests of Sierra Madrean and Rocky Mountain affinity. Stands of the Madrean Chihuahuan pine/silver-leaf oak community occur here on southerly aspects (*Pinus leiophylla* Alliance) and in the canyons. The Apache pine (*Pinus engelmannii* Series) is known in the study area only from the Indian Creek of the Animas Mountains, although it is common in northern Mexico. In contrast, their are also small stands of aspens (*Populus tremuloides*) in Indian Creek that are perhaps relicts of a once wider distribution of this common species from the north. At the highest elevations there are stands of ponderosa pine (both *Pinus ponderosa* var, *scopulorum* and var. a*rizonica*) and Douglas-fir (*Pseudotsuga menziesii*) that have both Madrean and Rocky Mountain floristic affinities.

The wide variety of vegetation communities from the tops of the mountains to basin bottoms makes poses a complex problem for mapping. Many of the montane communities form small patches on hillslopes and are often hidden in the shadows in the imagery; the wide variety of grassland communities often have very similar reflectances, and because they may be low in cover, the color of the soils may overwhelm the spectral signatures making it even more difficult to map individual alliances. In the mapping process we have attempted

to resolve the vegetation communities as finely as possible within these types of spatial and spectral constraints resulting in a large set of mapping units representing the most detailed delineation of vegetation for the study area to date.

Vegetation Map

A small scale map of the vegetation of the Borderlands Ecosystem Management Area is presented in Figure 3, and a larger scale map sheet is provided separately. The legend to the map is presented in Table 4 ordered by map unit number with unit labels representing the dominant vegetation characteristics along with the unit sizes in acres and hectares as determined from the GIS. A total of 33 map units have been defined for the map based on the vegetation classification. Detailed descriptions of the vegetation associations and habitats found in each map unit along with a photograph are provided in the Addendum.

Map Accuracy

The accuracy of the map was assessed using 322 independent data points gathered from the ground and through aerial photo and videography interpretation. Field points are represented by plots that were rejected as seed models in map development, and from those gathered in independent ground surveys (particularly Animas Foundation Monitoring plots of Peter Sundt). Thus, the validation data set is effectively independent from the data set used to develop the map. Each validation point was assigned to a community type (CT) according to the preliminary vegetation classification hierarchy (Table 3) .

The points were compiled in the GIS and overlaid onto the final vegetation map, with the target map units identified and evaluated as follows:

1. Correct Classification-- Major agreement. Validation point corresponded to a major community type (CT) of a map unit within 100 meters (range of geocorrection error).

2. Correct Classification -- Inclusion agreement. Validation point corresponded to an inclusion of a map unit within 100 meters.

3. Moderate Misclassification -- Formation agreement only. Validation point did not match a major or inclusion, but did correspond to a CT or Alliance within a formation (Woodland, Shrubland or Grassland).

4. Poor Agreement -- Ecotonal Misclassification - Validation point missed the target Formation, but an ecotone is known to occur between the validation point formation and the target formation e.g. Woodland to Montane Shrubland.

5. Poor Agreement -- Gross Misclassification. Validation point neither directly nor spatially related to the target map unit.

6. Rejected Point. Validation point had a suspect location accuracy, vegetation classification, or was below the minimum map unit size of 0.5 ha.

Figure 3. A vegetation Map of the Borderlands Ecosystem Management Area.

Table 4. Brief legend for the vegetation map of the Borderlands Ecosystem Management Area ordered by major formations and map unit number, with unit sizes. See Map Unit descriptions for details.

		Hectares	Acres
FORESTS and WOODLANDS			
1	Chihuahuan Pine, Ponderosa Pine and Douglas-fir Montane Forest	524	1,296
2	Mexican Pinyon Montane Woodland	5,235	12,937
3	Emory and Arizona White Oak Foothill Woodlands	27,065	66,880
4	Alligator and Oneseed Juniper Foothill Woodlands	12,832	31,710
SHRUBLANDS			
5	Toumey Oak, Pointleaf Manzanita and Mountain Mahogany Shrublands	13,780	34,053
6	Sandpaper Bush Foothill Desert Shrubland	1,105	2,732
7	Viscid Acacia Foothill Desert Shrubland	2,083	5,148
8	Viscid Acacia or Ocotillo Foothill Shrublands with Black or Sideoats Grama Grasses	1,468	3,628
9	Creosote Bush Piedmont Desert Shrubland	6,241	1,5421
10	Honey Mesquite Desert Shrubland with Grama Grasses	55,736	1,37727
11	Honey Mesquite or Viscid Acacia Basin Shrubland with Tobosagrass	20,711	51,178
12	Burroweed-Purple Threeawn Basin Shrubland	10,113	24,990
GRASSLANDS			
13	Hairy Grama and Sideoats Grama Foothill Grasslands	32,660	80,704
14	Hairy Grama or Blue Grama Piedmont-Foothill Grasslands with Sacahuista	12,704	31,394
15	Rock Outcrop or Sparse Grama Foothill Grasslands	5,919	14,626
16	Blue Grama or Hairy Grama Piedmont Grasslands with Honey Mesquite	5,497	13,585
17	Blue Grama or Hairy Grama Piedmont Grasslands	32,526	80,373
18	Blue Grama-Purple Threeawn or Hairy Grama/Featherplume Piedmont Sparse Grasslands	13,121	32,424
19	Black Grama-Blue Grama Piedmont Grassland	2,646	6,540
20	Black Grama Piedmont Grassland	1,632	4,034
21	Purple Threeawn Basin and Piedmont Grassland	7,763	19,182
22	Tobosagrass Foothill Lava Grassland	1,269	3,136
23	Tobosagrass Lava Grasslands	28,204	69,694
24	Tobosagrass or Tobosagrass-Blue Grama Basin Grassland	4,840	11,961
25	Black Grama or Tobosagrass Basin Grasslands	4,578	11,314
26	Mesa Dropseed-Blue Grama Basin Grassland	1,047	2,587
27	Giant Sacaton or Alkali Sacaton Basin-Swale Grasslands	1,570	3,880
28	Creeping Muhly, Annual Grasses, or Vine Mesquitegrass Grasslands	3,073	7,593
RIPARIAN WOODLANDS AND SHRUBLANDS			
29	Freemont's Cottonwood and Arizona Sycamore Riparian Woodlands	640	1,583
30	Honey Mesquite Semi-Riparian Woodlands	670	1,656
31	Apacheplume and Desert Willow Arroyo Riparian Shrublands	3,216	7,947
MISCELLANEOUS			
32	Rock Outcrop and Talus	932	2,303
33	Barren Alluvial Flats	2,920	7,217
34	Water Tanks/Disturbed Areas	10	26

A summary table of the results is provided in Table 5. Twenty-two points related to riparian vegetation are excluded from the table and discussed separately. Of the 300 upland points, 238 or 79.3% are classified correctly as major community types or inclusions. In addition, 44 or 14.6% were correct at the Formation level, with 16 or 5.3% being correct at the Alliance level but missing the CT. Chihuahuan pine types, in particular, cross-classified with oak woodlands without pines (seven points). The separation of pine-type woodlands that have oak co-dominants from woodlands with only oaks remains problematic.

Taken together, the map was accurate 93.9% of the time with respect to woodland, shrubland, and grassland formations as defined in the map units. Where Formations were incorrect, 4.7% were "ecotonal" misclassifications, such as the difference between desert grasslands and desert shrublands. A small percentage, 1.3%, were even further apart, or "gross" miscalculations, e.g., desert shrubland versus woodland.

Riparian validation points were set aside because of the problematic nature of mapping riparian areas with TM imagery with its 28.5-meter pixel size. Often, narrow riparian areas are masked within other units. In this case 10 out of 22 riparian validation points were misclassified into such things as oak woodlands or desert shrublands. Effective riparian mapping should be done with high resolution imagery and at finer scales (1:6,000 is most appropriate).

DISCUSSION

Because the validation data set represents a more or less random sample of the study area, less common map units may not be tested. This is particularly the case for upper elevation woodland and forest types. In addition, the validation data set has a bias against the map because it includes field plots that were rejected for developing the map, and hence may have some unknown spectral characteristic that is anomalous, not representing the general character of the map. We would encourage further testing of the map with additional independent data sets.

These issues aside, we believe the test gives an initial sense of the quality of the overall map. It represents the highest detailed and accurate vegetation map produced to date for the Borderlands area. Although a map such as this can be produced at any scale, it is intended to be used at 1:100,000. Site-level planning scales such as 1:24,000 and below can be problematic because of the minimum map unit size of 0.5, geo-reference limits, and the generalized definition of map units. At these scales, higher resolution imagery is more appropriate. Of course higher resolution mapping brings with it significant increases in costs -- between $1.25 and $2.50 per acre. This map was produced at an approximate cost of $0.07 per acre. Thus, the map with its generalized map units represents an economical, yet effective approach for the development of a useful tool for regional ecosystem based planning.

Table 5. Accuracy assessment summary based on 300 independent field and aerial interpreted sample points (for uplands only).

Accuracy Condition	Count	%	Count	%
Correct Map Unit Classification			**238**	**79.3**
Major Community Types	205	68.3		
Inclusions	33	11.0		
Moderate Misclassification (Correct Formation)			**44**	**14.6**
Alliance Cross-classification	28	9.3		
Community Type Cross-classification	16	5.3		
Poor Misclassification (Incorrect Formation)				
Ecotonal Misclassifications			**14**	**4.7**
Montane Shrubland vs Foothill Grassland	2	0.7		
Montane Shrubland vs Woodland	5	1.7		
Desert Shrubland vs Desert Grassland	7	2.3		
Gross Misclassifications			**4**	**1.3**
Desert Shrub vs Montane Shrubland	1	0.3		
Desert Shrub vs Woodland	1	0.3		
Plains Grass vs Desert Shrubland	1	0.3		
Woodland vs Desert Grass	1	0.3		
TOTAL	300	100%	**300**	**100%**

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ADDENDUM

Map Unit Descriptions

for the

Borderlands Ecosystem Management Area Vegetation Map

This addendum provides descriptions of each map unit defined for the Borderlands Ecosystem Management Area Vegetation Map. Descriptions are ordered numerically and generally follow the major formations from Forests and Woodlands, to Shrublands, Grasslands, Riparian Woodlands and various Miscellaneous units. Information is provided on vegetation community composition, distribution and environment for each map unit along with their sizes in acres and hectares as determined from the GIS. The major community types are indicated (those communities estimated to comprise at least 10% of the area of the unit) along with significant inclusions (less than 10% coverage).

Figure 4. An open-canopied Chihuahuan pine stand typical of Map Unit 1 in the Peloncillo Mountains. A mixture of woodland species can occur in the sub-canopy such as alligator bark juniper, gray oak and Mexican pinyon.

FORESTS and WOODLANDS

Map Unit: 1
Chihuahuan Pine, Ponderosa Pine and Douglas-fir Montane Forest and Woodlands

Montane forests and woodlands of higher elevations of the Animas and Peloncillo Mountains and extending down slope in cool drainages. Open stands of Chihuahuan pine (*Pinus leiophylla*) are the most common element, particular at the lower elevations (Figure 4). Stands of ponderosa pine (*Pinus ponderosa*) occur on higher open slopes and mix with Douglas-fir (*Pseudotsuga menziesi*) in more protected north-facing slopes or in deep drainages. Small stands of Apache pine (*Pinus engelmannii*) and quaking aspen (*Populus temuloides*) occur in the Animas Mountains (Indian Creek).

Major Community Types:	
Ponderosa Pine/Gambel Oak	*Pinus ponderosa/Quercus gambelii*
Douglas-fir/Gambel Oak	*Pseudotsuga menziesi-Quercus gambelii*
Chihuahuan Pine/Silverleaf Oak	*Pinus leiophylla/Quercus hypoleucoides*
Inclusions:	
Apache Pine/Gambel Oak	*Pinus engelmannii/Quercus gambelii*
Chihuahuan Pine/Arizona White Oak	*Pinus leiophylla/Quercus arizonica*

Hectares: 525 Acres: 1296

Map Unit: 2
Mexican Pinyon Montane Woodland

Moderately open to closed woodlands dominated by Mexican pinyon (*Pinus cembroides*) with alligator juniper (*Juniperus deppeana*) often as a co-dominant canopy associate (Figure 5). Extensive stands occur on upper rhyolitic slopes of both the Peloncillo and Animas Mountains (5,300 to 8,000 ft; 1,600 to 2,400 m). These woodlands commonly intergrade with montane shrublands and chaparral on open warmer slopes that have been burned, and stands often have chaparral indicators such as pointleaf manzanita (*Arctostaphylos pungens*) or scrub live oaks such as Toumey oak (*Quercus toumeyi*) or gray oak (*Q. grisea*) in the understory. These woodlands are also often co-dominated by evergreen oak trees such as silverleaf oak (*Q. hypoleucoides*), net leaf oak (*Q. rugosa*) or Arizona white oak (*Q. arizonica*) and can grade at lower elevations into Emory oak, silverleaf oak, or white oak woodlands. Chihuahuan pine (*Pinus leiophylla*) may occasionally occur within stands.

Major Community Types	
Mexican Pinyon-Silverleaf Oak	*Pinus cembroides-Quercus hypoleucoides*
Mexican Pinyon-Netleaf Oak	*Pinus cembroides-Quercus rugosa*
Mexican Pinyon/Toumey Oak	*Pinus cembroides/Quercus toumeyi*
Mexican Pinyon/Arizona White Oak	*Pinus cembroides/Quercus arizonica*
Inclusions	
Mountain Mahogany/Bullgrass	*Cercocarpus montanus/Muhlenbergia emersleyi*
Emory Oak/Bullgrass	*Quercus emoryi/Muhlenbergia emersleyi*

Hectares: 5236 Acres: 12938

Figure 5. Dense woodland dominated by Mexican pinyon in association with evergreen oaks and junipers; typical of Map Unit 2 in the Peloncillo Mountains.

Map Unit: 3
Emory and Arizona White Oak Foothill Woodland

This oak (encinal) woodland is an extensive unit of mid elevations (4,800 to 5,800 ft; 1,500 to 1,760 m) of the Animas and Peloncillo Mountains (Figure 6). Emory oak (*Quercus emoryi*) and Arizona white oak (*Q. arizonica*) are the canopy dominants with alligator or oneseed junipers (*Juniperus deppeana* and *J. monosperma*) as common associates (Mexican pinyon is uncommon). Understories are usually grassy with robust muhly grasses (*Muhlenbergia emersleyi* or *M. longiligula*) or grama grasses (*Bouteloua curtipendula, B. hirsuta or B. gracilis*) the most prevalent species. There is an overall high diversity of both grasses and forbs, many of which are of Sierra Madrean affinity. At lower elevations stands tend to be open and stretch along the lower foothills and extend onto the piedmonts where they grade into open savannas dominated by junipers (No. 4). Dense, semi-riparian stands can also occur in drainage bottoms where pinyon rice grass (*Piptochaetium fimbriatum*) is often abundant beneath the shady canopies. At higher elevations, the unit grades to montane shrublands and chaparral (No. 5) on warmer rocky hill slopes that have been burned (occasionally manzanita is an understory shrub dominant in the woodlands). Inclusions of open grassland with bullgrass, mixed grama grasses and sacahuista can occur on the warmer hillslopes or in areas of recent burns. Towards cooler slopes and in higher elevations it inter-fingers with Mexican Pinyon Woodlands (No. 2) forming a complex matrix across the landscape. A unique and distinct occurrence of Emory oak and Arizona white oak with mesa dropseed and blue grama is found on sandy soils of playas in the lower Animas Valley.

Major Community Types	
Arizona White Oak/Bull Muhly	*Quercus arizonica/Muhlenbergia emersleyi*
Arizona White Oak/Hairy Grama	*Quercus arizonica/Bouteloua hirsuta*
Emory Oak/Pointleaf Manzanita	*Quercus emoryi/Arctostaphylos pungens*
Emory Oak/Pinyon Ricegrass	*Quercus emoryi/Piptochaetium fimbriatum*
Emory Oak/Bullgrass	*Quercus emoryi/Muhlenbergia emersleyi*
Emory Oak/Blue Grama	*Quercus emoryi/Bouteloua gracilis*
Inclusions	
Bullgrass-Hairy Grama	*Muhlenbergia emersleyi-Bouteloua hirsuta*
Emory Oak/Mesa Dropseed	*Quercus emoryi/Sporobolus crytandra*
Emory Oak/Sideoats Grama	*Quercus emoryi/Bouteloua cutipendula*

Hectares: 27066 Acres: 66881

Figure 6. Open Emory oak woodlands (Encinal) typical Map Unit 3 on the western flank of the Animas Mountains

Map Unit: 4
Alligator and Oneseed Juniper Foothill Woodlands

Open, savanna-like woodlands dominated by either oneseed juniper (*Juniperus monosperma*) or alligator juniper (*J. deppeana*) (Figure 7). They occur along the gentle to moderate slopes of the lower elevation foothills of the Animas and Peloncillo Mountains (4,300 to 6,000 ft; 1,300 to 1,850 m). Inter-tree spaces are dominated primarily by grama grasses (*Bouteloua gracilis, B. hirsuta, B. curtipendula*) or Texas bluestem (*Schizachyrium ciratum*). Oneseed juniper stands are particularly prevalent on open slopes of the Peloncillo Mountains. Alligator juniper stands tend to occur at higher elevations and on rockier slopes throughout both the Animas and Peloncillo Mountains. Inclusions of Toumey oak (*Quercus toumeyi*) and other scrub oak shrublands can occur along with open grasslands that follow along the fringe of the woodlands. Some stands can have a significant shrub component of honey mesquite (*Prosopis glandulosa*) or sacahuista (*Nolina microcarpa*).

Major Community Types	
Oneseed Juniper/Hairy Grama	*Juniperus monosperma/Bouteloua hirsuta*
Oneseed Juniper/Sideoats Grama	*Juniperus monosperma/Bouteloua curtipendula*
Alligator Juniper/Sideoats Grama	*Juniperus deppeana/Bouteloua curtipendula*
Alligator Juniper/Hairy Grama	*Juniperus deppeana/Bouteloua hirsuta*
Alligator Juniper/Texas Bluestem	*Juniperus deppeana/Schizachyrium cirratum*
Inclusions	
` Hairy Grama-Blue Grama	*Bouteloua hirsuta-Bouteloua gracilis*
Oneseed Juniper/Black Grama	*Juniperus monosperma/Bouteloua eriopoda*
Toumey Oak/Sideoats Grama	*Quercus toumeyi/Bouteloua curtipendula*

Hectares: 12833 Acres: 31711

SHRUBLANDS

Map Unit: 5
Toumey Oak, Pointleaf Manzanita and Mountain Mahogany Shrublands

This unit is dominated by interior chaparral and montane shrubland communities and is found at low to mid elevations (4,600 to 6,600 ft; 1,400 to 2,000 m) of the Animas and Peloncillo Mountains (Figure 8). The chaparral aspect is dominated by Toumey oak (*Quercus toumeyi*) and/or pointleaf manzanita (*Arctostaphylos pungens*) which can form dense stands along lower rocky slopes, usually below 5,500 ft (1,675m). At higher elevations on warm, dry slopes, dense montane shrublands occur dominated by mountain mahogany (*Cercocarpus montanus*) and shrubby live oaks (*Q. grisea, Q. Arizonica or Q. hypoleucoides*). In general undergrowths are grassy; bullgrass (*M. emersleyi*) and grama grasses (*Bouteloua curtipendula* or *B. radicosa*) are the most prevalent. At moderate elevations, near drainages and on cooler slopes, inclusions of Emory Oak and Mexican pinyon woodlands can occur. Also along the lower elevations the unit borders either on open woodlands (No.4) or foothill grasslands.

Major Community Types	
Toumey Oak/Bullgrass	*Quercus toumeyi/Muhlenbergia emersleyi*
Toumey Oak-Pointleaf Manzanita	*Quercus toumeyi-Arctostaphylos pungens*
Pointleaf Manzanita/Sideoats Grama	*Arctostaphylos pungens/Bouteloua curtipendula*
Mountain Mahogany/Bullgrass	*Cercocarpus montanus/Muhlenbergia emersleyi*
Inclusions	
Sideoats Grama-Purple Grama	*Bouteloua curtipendula-Bouteloua radicosa*
Emory Oak/Pointleaf Manzanita	*Quercus emoryi/Arctostaphylos pungens*
Mexican Pinyon/Toumey Oak	*Pinus cembroides/Quercus toumeyi*
Mountain Mahogany/Sideoats Grama	*Cercocarpus montanus/Bouteloua curtipendula*
Toumey Oak/Hairy Grama	*Quercus toumeyi/Bouteloua hirsuta*

Hectares: 13781 Acres: 34053

Figure 7. Alligator juniper woodland in the Peloncillo Mountains with a grassy understory of hairy grama; a common component of Map Unit 4.

Figure 8. Toumey oak shrublands typical of Map unit 5 in the southern Animas Mountains.

Map Unit: 6
Sandpaperbush Foothill Desert Shrubland

Chihuahuan desert shrubland dominated by sandpaperbush (*Mortonia sempervirens*) along with a wide variety of shrub and sub-shrub associates including viscid acacia (*Acacia neovernicosa*), mariola (*Parthenium incanum*) and creosote bush (*Larrea tridentata*). It occurs at low elevations (4,300 to 4,800 ft; 1,300 to 1,400 m) primarily on limestone alluvium of upper piedmonts and on lower hillslopes in the eastern portion of the San Bernadino Valley (Figure 9).

Major Community Types	
Sandpaperbush-Viscid Acacia	*Mortonia sempervirens-Acacia neovernicosa*
Sandpaperbush-Mariola	*Mortonia sempervirens-Parthenium incanum*

Hectares: 1106 Acres: 2732

Map Unit: 7
Viscid Acacia Foothill Desert Shrubland

Viscid Acacia (Whitethorn) shrubland that occurs on limestone at the east end of the San Bernadino Valley (Figure 10). This community has a high diversity of shrubs with inclusions of creosote bush (*Larrea tridentata*) and Rio Grande saddlebush (sandpaper bush). Generally, herbaceous cover is low, but tobosagrass can be abundant in swales or near basin bottoms.

Major Community Types	
Viscid Acacia-Mariola	*Acacia neovernicosa-Parthenium incanum*
Inclusions	
Viscid Acacia/Tobosagrass	*Acacia neovernicosa/Hilaria mutica*
Sandpaperbush-Viscid Acacia	*Mortonia sempervirens-Acacia neovernicosa*
Creosotebush-Mariola	*Larrea tridentata-Parthenium incanum*

Hectares: 2084 Acres: 5149

Map Unit: 8
Viscid Acacia or Ocotillo Foothill Shrublands with Grama Grasses

A diverse desert shrubland found on steep hillslopes in the northern Peloncillo Mountains and on piedmont alluvium in the San Bernadino Valley (Figure 11). Viscid acacia (*Acacia neovernicosa*) is usually the dominant with high diversity of other shrubs and sub-shrubs such as mariola (*Parthenium incanum*), Wright's beebrush (*Aloysia wrightii*) and ocotillo (*Fouquieria splendens).* Inclusions of hairy grama grasslands with ocotillo can occur on steep, sparse rock outcrops.

Major Community Types	
Viscid Acacia/Sideoats Grama	*Acacia neovernicosa/Bouteloua curtipendula*
Viscid Acacia-Ocotillo	*Acacia neovernicosa-Fouquieria splendens*
Wright’s Beebrush-Mariola	*Aloysia wrightii-Parthenium incanum*
Inclusions	
Hairy Grama/Ocotillo	*Bouteloua hirsuta/Fouquieria splendens*
Sideoats Grama/Ocotillo	*Bouteloua curitpendula-Fouquieria splendens*
Velvetpod Mimosa/Tobosagrass	*Mimosa dysocarpa/Hilaria mutica*
Viscid Acacia/Black Grama	*Acacia neovernicosa/Bouteloua eriopoda*

Hectares: 1468 Acres: 3629

Figure 9. Sandpaper bush and viscid acacia shrubland typical of Map Unit 6 in the limestone foothills of the western San Bernadino Valley and southern Peloncillo Mountains.

Figure 10. Viscid acacia shrublands are abundant in the western foothills and bajadas of the southern Peloncillo Mountains, and are the major component of Map Unit 7.

Map Unit: 9
Creosotebush Piedmont Desert Shrubland

A Chihuahuan Desert shrubland dominated by creosotebush (*Larrea tridentata*) that occurs on piedmont (bajada) slopes or limestone foothills of the San Bernadino Valley and northern end of the Animas Valley (Figure 12). Along lower slopes and alluvial plains, creosotebush occurs in homogenous stands with a grassy understory dominated by bush muhly (*Muhlenbergia porteri*). Further up the piedmont stands tend to become more shrubby and are highly diverse. Inclusions of viscid acacia (*Acacia neovernicosa*) and Rio Grande saddlebush (*Mortonia sempervirens*) shrublands can also occur. Honey mesquite (*Prosopis glandulosa*) can be a well-represented associate in drainages and swales.

Major Community Types	
Creosotebush/Bush Muhly	*Larrea tridentata/Muhlenbergia porteri*
Creosotebush-Mariola	*Larrea tridentata-Parthenium incanum*
Inclusions	
Viscid Acacia/Bush Muhly	*Acacia neovernicosa/Muhlenbergia porteri*
Tarbush/Bush Muhly	*Flourensia cernua/Muhlenbergia porteri*
Sideoats Grama/Ocotillo	*Bouteloua curtipendula/Fouquieria splendens*

Hectares: 6241 Acres: 15422

Map Unit: 10
Honey Mesquite Desert Shrubland with Grama Grasses

This map unit is characterized by a wide variety of honey mesquite (*Prosopis glandulosa*) shrubland communities (Figure 13). It is widely distributed in the study area where it can occur on lower foothills, piedmonts (bajadas) and in basin bottoms and drainages at elevations of 3,850 to 5,300 ft (1,175 to 1,600m). Undergrowths range from grassy to very sparse and dominated by sub-shrubs. Hairy and blue grama (*Bouteloua hirsuta* and *B. gracilis*) tend to occur on higher elevation piedmonts. Black grama or tobosagrass becomes more common on lower piedmonts, low elevation foothills extending towards the basin bottoms. In the basin bottoms of the San Simon, San Bernadino, Playas Valleys and on the piedmonts of the northern Animas Valley where soils are very shallow or sandy, grass cover declines and gramas are replaced by bush muhly (*Muhlenbergia porteri*), threeawns (*Aristida purpurea* and others) and broom snakeweed (*Gutierrezia sarothrae*). Inclusions of Honey Mesquite/Giant Sacaton and Honey Mesquite/Tobosagrass occur in riparian areas and wide floodplains such as in the Walnut Creek drainage in the Playas Valley. There are also occasional inclusions of viscid acacia with sideoats grama along deeply cut drainages and lower foothills.

Major Community Types	
Honey Mesquite/Blue Grama	*Prosopis glandulosa/Bouteloua gracilis*
Honey Mesquite/Hairy Grama	*Prosopis glandulosa/Bouteloua hirsuta*
Honey Mesquite/Black Grama	*Prosopis glandulosa/Bouteloua eriopoda*
Honey Mesquite/Bush Muhly	*Prosopis glandulosa/Muhlenbergia porteri*
Honey Mesquite/Purple Threeawn	*Prosopis glandulosa/Aristida purpurea*
Honey Mesquite-Broom Snakeweed	*Prosopis glandulosa-Gutierrezia sarothrae*
Inclusions	
Catclaw Mimosa/Purple Threeawn	*Mimosa aculeaticarpa/Aristida purpurea*
Honey Mesquite/Giant Sacaton	*Prosopis glandulosa/Sporobolus wrightii*
Honey Mesquite/Tobosagrass	*Prosopis glandulosa/Hilaria mutica*
Viscid Acacia/Sideoats Grama	*Acacia neovernicosa/Bouteloua curtipendula*

Hectares: 55737 Acres: 137728

Figure 11. Viscid acacia and/or Ocotillo shrublands are common in the western foothills and bajadas of the southern Peloncillo Mountains, and are the major component of Map Unit 8.

Figure 12. Creosotebush Shrubland typical of Map Unit 9 in the western foothills and bajadas of the southern Peloncillo Mountains.

Map Unit: 11
Honey Mesquite or Viscid Acacia Basin Shrublands with Tobosagrass and Vine Mesquitegrass

This is a sparse desert shrubland dominated by either honey mesquite (*Prosopis* glandulosa) or viscid acacia (*Acacia neovernicosa*) with a grassy understories of scattered tobosagrass (*Hilaria mutica*). It occurs on lava flows and cinder cones in the northern Animas Valley, San Bernadino Valley, and southern San Simon Valley where it borders tobosa grasslands (Figure 14). Honey mesquite with vine mesquitegrass occurs to a lesser extent in swales. Inclusions of honey mesquite with giant sacaton and monotypic honey mesquite stands occur along major drainages and sandy floodplains. Minor inclusions of creosotebush with bush muhly occur on alluvial plains bordering the basins.

Major Community Types	
Viscid Acacia/Tobosagrass	*Acacia neovernicosa/Hilaria mutica*
Honey Mesquite/Tobosagrass	*Prosopis glandulosa/Hilaria mutica*
Honey Mesquite/Vine Mesquitegrass	*Prosopis glandulosa/Panicum obtusum*
Inclusions	
Honey Mesquite/Monotypic Stand	*Prosopis glandulosa/Monotypic*
Honey Mesquite/Giant Sacaton	*Prosopis glandulosa/Sporobolus wrightii*
Creosotebush/Bush Muhly	*Larrea tridentata/Muhlenbergia porteri*

Hectares: 20711 Acres: 51178

Map Unit: 12
Burroweed-Purple Threeawn Basin Shrubland

A desert shrubland dominated by the sub-shrubs burroweed (*Isocoma tenuisecta*) and threeawn grasses (*Aristida purpurea* and others) and annual grasses (Figure15). It occurs at low elevations (4,300 to 4,800 ft;1,300 to 1,400m) on basin bottom alluvial flats in the southern San Simon Valley and northern Animas Valley.

Major Community Types	
Burroweed/Purple Threeawn	*Isocoma tenuisecta/Aristida purpurea*

Hectares: 10113 Acres: 24991

Figure 13. Low and open-canopied honey mesquite shrubland with scattered grasses (mostly threeawns) representing the more sparsely vegetated aspect of Map Unit 10. Mesquite cover can range from 10 to 25% along these alluvial fans of the northern Animas Valley.

Figure 14. Moderately dense viscid acacia (or honey mesquite) stands with grassy understories of tobosagrass like these in swales of San Bernadino Valley characterize Map Unit 10.

GRASSLANDS

Map Unit: 13
Blue, Hairy and Sideoats Grama Foothill Grasslands

Grasslands of moderate elevations (4,700 to 6,100 ft; 1,400 to 1,850m) and moderate, rhyolitic slopes (<45%) of the Peloncillo and Animas Mountains (Figure16), occasionally extending down onto the piedmonts (bajadas). They are dominated by either blue, hairy or sideoats grama (*Bouteloua gracilis*, *B. Hirsuta*, or *B. curtipendula*), grasses that have their center of distribution in the Great Plains. Blue and hairy grama occur throughout the range of the unit, while sideoats-dominated communities tend towards steeper, rocky slopes. These grasslands are often co-dominated by grasses with more limited Southwestern distribution such Texas bluestem (*Schizachyrium ciratum*), purple grama (*B. radicosa*) and curly mesquite grass (*Hilaria belangeri*). On more disturbed sites, plains lovegrass becomes more common. Shrubs are generally low in cover, but sotol (*Dasylirion wheeleri*) can be well-represented in some stands. Inclusions include alligator juniper woodlands in drainages (see No. 4), and shrubby hairy grama/sacahuista and turpentine bush/sideoats on open slopes (see No. 14).

Major Community Types	
Hairy Grama-Blue Grama	*Bouteloua hirsuta-Bouteloua gracilis*
Hairy Grama-Curly Mesquite Grass	*Bouteloua hirsuta-Hilaria belangeri*
Hairy Grama/Common Sotol	*Bouteloua hirsuta/Dasylirion wheeleri*
Hairy Grama-Purple Grama	*Bouteloua hirsuta-Bouteloua radicosa*
Sideoats Grama-Texas Bluestem	*Bouteloua curtipendula-Schizachyrium cirratum*
Sideoats Grama-Plains Lovegrass	*Bouteloua curtipendula-Eragrostis intermedia*
Inclusions	
Alligator Juniper/Sideoats Grama	*Juniperus deppeana/Bouteloua curtipendula*
Hairy Grama/Sacahuista	*Bouteloua hirsuta/Nolina microcarpa*
Sideoats Grama/Turpentine Bush	*Bouteloua curtipendula/Ericameria laricifolia*

Hectares: 32660 Acres: 80705

Map Unit: 14
Hairy or Blue Grama Piedmont-Foothill Grasslands with Sacahuista

A grassland unit dominated by hairy and blue grama (*Bouteloua hirsuta* and *B. gracilis*) with conspicuous and sometimes dense sacahuista (*Nolina microcarpa*). It is found primarily on upper piedmonts (bajadas) of the Animas Valley and lower Deer Creek drainage, and to a lesser extent on lower foothill slopes throughout the study area (Figure 17). Elevations range from 4,850 to 6,250 ft (1,475 to 1,900m). On isolated sand sheets that extend up the piedmont in the southern Animas Valley sacahuista forms a dense shrubland with a low grass cover. Occasional inclusions include Mexican Pinyon woodlands and Pointleaf Manzanita chaparral in the foothills (see No. 2 and 5) and oak woodland communities in drainages and on cooler slopes (see No. 3).

Major Community Types	
Blue Grama/Sacahuista	*Bouteloua gracilis/Nolina microcarpa*
Hairy Grama/Sacahuista	*Bouteloua hirsuta/Nolina microcarpa*
Inclusions	
Arizona White Oak/Bullgrass	*Quercus arizonica/Muhlenbergia emersleyi*
Hairy Grama-Sideoats Grama	*Bouteloua hirsuta-Bouteloua curtipendula*
Mexican Pinyon/Pointleaf Manzanita	*Pinus cembroides/Arctostaphylos pungens*

Hectares: 12705 Acres: 31395

Figure 15. Sparse shrubland of burroweed and scattered grasses (mostly threeawns) in the San Simon Valley.

Figure 16. Hairy and Sideoats Grama Foothill Grasslands typical of Map Unit 13 in the Cowboy Rim country of the eastern Animas Mountains.

Figure 17. Hairy Grama Grasslands with Sacahuista typical of Map Unit 14 are common in the Deer Creek drainage (Lynch Draw) of the southern Animas Mountains.

Figure 18. Sparse grasslands of sideoats and hairy grama with a mixture of subshrubs such as these on a rocky slope in the northern Peloncillo Mountains are typical of Map Unit 15.

Map Unit: 15
Rock Outcrop or Sparse Grama Foothill Grasslands

Sparse grasslands intermixed among barren rock (talus and cliffs) and exposed soil in the foothills and mountains (Figure 18). Hairy and sideoats grama (*Bouteloua hirsuta* and *B. curtipendula*) are usually the most prevalent species, particularly in the northern Peloncillo Mountains, while sparse Toumey oak chaparral communities (see No. 5) are common in the Animas Mountains.

Major Community Types	
Sideoats Grama/Turpentine Bush	*Bouteloua curtipendula/Ericameria laricifolia*
Sideoats Grama-Hairy Grama.	*Bouteloua curtipendula-Bouteloua hirsuta.*
Toumey Oak/Sparse	*Quercus toumeyi/Sparse*

Hectares: 5919 Acres: 14627

Map Unit: 16
Blue Grama or Hairy Grama Piedmont Grasslands with Honey Mesquite

Plains grasslands dominated by blue or hairy grama (*Bouteloua gracilis* or *B. hirsuta*) with scattered honey mesquite (*Prosopis glandulosa*) that occur on piedmonts (bajadas) in the lower Deer Creek watershed and in the foothills of the Animas Mountains (Figure 19). Vine mesquitegrass (*Panicum obtusum*) is an occasional co-dominant in swales. Hairy and black grama (*B. eriopoda*) grasslands are minor inclusions on gravelly soils along the lower piedmonts and bordering basin alluvial flats. There are also inclusions of honey mesquite shrublands along drainages and on lower slopes (see No.'s 13 and 14). In more disturbed areas such as around tanks and in floodplains, purple threeawn (*Aristida purpurea*) increases.

Major Community Types	
Hairy Grama-Blue Grama	*Bouteloua hirsuta-Bouteloua gracilis*
Blue Grama-Vine Mesquite	*Bouteloua gracilis-Panicum obtusum*
Inclusions	
Hairy Grama-Black Grama	*Bouteloua hirsuta-Bouteloua eriopoda*
Blue Grama/Purple Threeawn	*Bouteloua gracilis/Aristida purpurea*
Honey Mesquite/Hairy Grama	*Prosopis glandulosa/Bouteloua hirsuta*

Hectares: 5498 Acres: 13586

Figure 19. Blue grama grasslands with scattered mesquite are typical of Map Unit 16 along the upper bajadas and lower foothills of the southern Animas Mountains.

Figure 20. Blue Grama - Buffalo Grass grasslands along a piedmont slope in the lower Animas Valley near Cloverdale are representative of Map Unit 17.

Map Unit: 17
Blue Grama or Hairy Grama Piedmont Grasslands

Grasslands of piedmonts (bajadas) in the southern Animas Valley (Figure 20). Hairy and blue grama (*Bouteloua hirsuta* and *B. gracilis*) are the dominants in association with other common Great Plains species such as buffalograss (*Buchloe dactyloides*), sideoats grama (*B. curtipendula*) and plains lovegrass (*Eragrostis intermedia*). Hairy grama with sideoats grama tends to occur in the upper portions of the piedmonts, while blue grama and buffalograss occur in the lower positions. Small inclusions of black grama (*B. eriopoda*) and hairy grama/sacahuista grasslands can occur on the piedmont slopes, plus minor amounts of tobosagrass (*Hilaria mutica*) grasslands in swales within the piedmonts and in basin bottoms.

Major Community Types	
Hairy Grama-Blue Grama	*Bouteloua hirsuta-Bouteloua gracilis*
Hairy Grama-Sideoats Grama	*Bouteloua hirsuta-Bouteloua curtipendula*
Hairy Grama-Curlymesquite	*Bouteloua hirsuta-Hilaria belangeri*
Blue Grama/Purple Threeawn	*Bouteloua gracilis/Aristida purpurea*
Blue Grama-Buffalograss	*Bouteloua gracilis-Buchloe dactyloides*
Blue Grama-Sideoats Grama	*Bouteloua gracilis-Bouteloua curtipendula*
Inclusions	
Black Grama-Blue Grama	*Bouteloua eriopoda-Bouteloua gracilis*
Tobosagrass-Blue Grama	*Hilaria mutica-Bouteloua gracilis*
Hairy Grama/Sacahuista	*Bouteloua hirsuta/Nolina microcarpa*

Hectares: 32526 Acres: 80374

Map Unit: 18
Blue Grama-Purple Threeawn or Hairy Grama/Featherplume Piedmont Sparse Grasslands

Sparse grasslands co-dominated by blue grama (*Bouteloua gracilis*) and purple threeawn (*Aristida purpurea*) and an assortment of annual grasses, or hairy grama (*B. hirsuta*) with the subshrub featherplume (*Dalea formosa*). They occur at low to mid elevations (4,850 to 5,600 ft; 1,475 to 1,700m) along piedmonts (bajadas) of the Animas Valley and in lower Deer Creek of the Animas Mountains (Figure 21). Sites appear relatively more disturbed, and the unit includes some honey mesquite treatment areas. There are inclusions of blue grama/buffalograss grasslands in the southern Animas Valley.

Major Community Types	
Hairy Grama/Featherplume	*Bouteloua hirsuta/Dalea formosa*
Blue Grama-Purple Threeawn	*Bouteloua gracilis-Aristida purpurea*
Inclusions	
Blue Grama-Buffalograss	*Bouteloua gracilis-Buchloe dactyloides*

Hectares: 13122 Acres: 32424

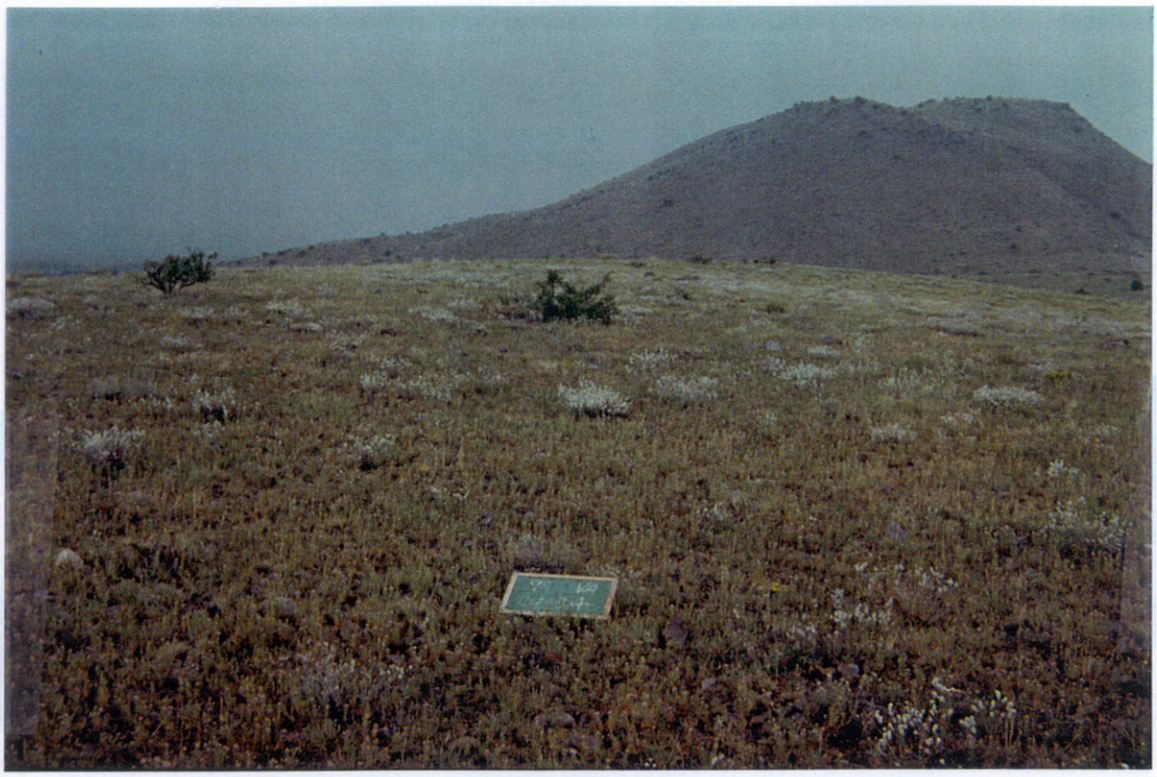

Figure 21. Hairy grama grasslands with a mixture of low-lying subshrubs (featherplume and buckwheat) typical of Map Unit 18 in the Whitewater Mountains

Figure 22. Black and blue grama piedmont grassland in the southern Animas Valley representative of Map Unit 19.

Map Unit: 19
Black Grama-Blue Grama Piedmont Grassland

Desert grasslands dominated by black and blue grama (*Bouteloua eriopoda* and *B. gracilis*) that occur on piedmonts (bajadas) in lower Deer Creek watershed, San Bernadino and Animas Valleys, and on cindercones of the San Bernadino Malpai (Figure 22). This Black Grama-Blue Grama community is found in small occurrences at low to mid elevations (4,900 to 5,300 ft; 1,500 to 1,600m), and often inter-grading with other hairy grama and blue grama communities (see No.'s 14, 16 and 17). The largest occurrences are found near Red Hill in the Animas Valley and along the Mexican border in the Deer Creek watershed.

Major Community Types	
Black Grama-Blue Grama	*Bouteloua eriopoda-Bouteloua gracilis*
Inclusions	
Black Grama/Longleaf Jointfir	*Bouteloua eriopoda-Ephedra trifurca*

Hectares: 2647 Acres: 6540

Map Unit: 20
Black Grama Piedmont Grassland

This is a sparse black grama grassland that occurs on lower elevation (4,300 to 5,000 ft; 1,300m to 1,500m) piedmonts (bajadas) in the San Bernadino, San Simon and northern Animas Valleys (Figure 23). Invasive shrubs such as broom snakeweed, honey mesquite, sacahuista and catclaw mimosa (*Mimosa aculeaticarpa* var. *biuncifera*) are common but scattered. The unit inter-grades with threeawn grasslands (No. 21) and various desert shrublands.

Major Community Types	
Black Grama/Broom Snakeweed	*Bouteloua eriopoda/Gutierrezia sarothrae*
Inclusions	
Catclaw Mimosa/Black Grama	*Mimosa aculaeticarpa/Bouteloua eriopoda*

Hectares: 1633 Acres: 4034

Map Unit: 21
Purple Threeawn Basin and Piedmont Grasslands

Very sparse grasslands dominated by purple threeawn and annual grasses such as sixweeks threeawn (*Aristida adscensiones*) that are commonly found on lower piedmonts (bajadas) throughout the study area (Figure 24). Elevations range from 4,500 to 4,700 ft (1,375 to 1,450m). Inclusions of the sparse Tobosagrass/Purple Threeawn community type are found near basin bottoms.

Major Community Types	
Purple Threeawn/Fluffgrass	*Aristida purpurea/Erioneuron pulchellum*
Purple Threeawn-Sixweeks Threeawn	*Aristida purpurea-Aristida adscensiones*
Inclusions	
Tobosagrass-Purple Threeawn	*Hilaria mutica-Aristida purpurea*

Hectares: 7763 Acres: 19183

Figure 23. Black grama grasslands of Map Unit 20 in the lower Deer Creek drainage.

Figure 24. Threeawn grasslands like these in the northern Animas Valley are the primary component of Map Unit 21.

Map Unit: 22
Tobosagrass Foothill Lava Grassland

Tobosa grassland on lava flow intrusions in the San Luis pass region in the southern Animas Mountains. Shrubs such as tree cholla (*Opuntia imbricata*) are abundant. There are small inclusions of hairy grama grassland with sacahuista along the higher elevation piedmont alluvium and lower foothill slopes. Towards drainage bottoms inclusions of honey mesquite are possible.

Major Community Types	
Tobosagrass/Purple Threeawn	*Hilaria mutica/Aristida purpurea*
Tobosagrass-Blue Grama	*Hilaria mutica-Bouteloua gracilis*
Inclusions	
Hairy Grama/Sacahuista	*Bouteloua hirsuta/Nolina microcarpa*
Honey Mesquite/Tobosagrass	*Prosopis glandulosa/Hilaria mutica*

Hectares: 1269 Acres: 3136

Map Unit: 23
Tobosagrass Lava Grasslands

This tobosagrass grassland is found on lava flows (malpai) in the southern Animas Mountains, the San Bernadino and northern Animas Valleys (Figure 25). Stands are commonly strongly dominated by tabosagrass (monotypic) or they sometimes co-dominated by annual grasses such as needle grama (*Bouteloua aristidoides*), or burrograss (*Scleropogon brevifolius*). The Viscid Acacia/Tobosagrass CT can occur as an inclusion along inset drainages and the lower part of hillslopes. On the lava flows in the San Bernadino and northern Animas Valley regions, Tobosagrass-Needle Grama and Tobosagrass-Burrograss are the primary communities.

Major Community Types	
Tobosagrass/Monotypic Stand	*Hilaria mutica/Monotypic*
Tobosagrass-Needle Grama	*Hilaria mutica-Bouteloua aristidoides*
Tobosagrass-Burrograss	*Hilaria mutica-Scleropogon brevifolius*
Inclusions	
Viscid Acacia/Tobosagrass	*Acacia neovernicosa/Hilaria mutica*

Hectares: 28204 Acres: 69694

Figure 25. Tobosagrass grassland of Map Unit 23 forms extensive and relatively uniform stands across the lava flows (malpai) of the San Simon and San Bernadino Valleys.

Figure 26. Basin bottom grasslands strongly dominated by tobosagrass are typical of Map Unit 24.

Map Unit: 24
Tobosagrass or Tobosagrass-Blue Grama Basin Grassland

This map unit includes various tobosagrass communities of lower piedmont slopes, basin bottoms and drainages. Moderately dense monotypic stands of tobosagrass are found throughout, but are particularly evident on floodplains in the Playas Valley along with scattered occurrences of the Giant Sacaton-Vine Mesquitegrass CT. Tobosagrass stands occur with blue grama on the piedmont alluvium in the Animas Valley and lower Deer Creek watershed (Figure 26). Some sites are more sparsely vegetated and Honey Mesquite/Broom Snakeweed and Tobosagrass-Purple Threeawn CTs are the dominant communities. In the lower elevation basins along drainages inclusions of Giant Sacaton-Tobosagrass and Honey Mesquite/Giant Sacaton CTs can occur.

Major Community Types	
Tobosagrass-Purple Threeawn	*Hilaria mutica-Aristida purpurea*
Tobosagrass-Blue Grama	*Hilaria mutica-Bouteloua gracilis*
Inclusions	
Tobosagrass/Monotypic Stand	*Hilaria mutica/Monotypic*
Giant Sacaton-Tobosagrass	*Sporobolus wrightii-Hilaria mutica*
Giant Sacaton-Vine Mesquite	*Sporobolus wrightii-Panicum obtusum*
Honey Mesquite/Giant Sacaton	*Prosopis glandulosa/Sporobolus wrightii*
Honey Mesquite/Broom Snakeweed	*Prosopis glandulosa/Gutierrezia sarothrae*

Hectares: 4840 Acres: 11961

Map Unit: 25
Black Grama or Tobosagrass Basin Grasslands

A desert grassland on the piedmont alluvium along the Animas and Playas Valley (Figure 27). Black grama with turpentine bush and blue grama is common on the lower footslopes, and forms a mosaic with tobosagrass, honey mesquite, and giant sacaton farther out into the basin. Plains species inclusions occur on the lower footslopes.

Major Community Types	
Tobosagrass-Blue Grama	*Hilaria mutica-Bouteloua gracilis*
Black Grama/Turpentine Bush	*Bouteloua eriopoda/Ericameria laricifolia*
Black Grama-Blue Grama	*Bouteloua eriopoda-Bouteloua gracilis*
Inclusions	
Honey Mesquite/Tobosagrass	*Prosopis glandulosa/Hilaria mutica*

Hectares: 4579 Acres: 11315

Map Unit: 26
Mesa Dropseed, Blue Grama or Thin Paspalum Grassland

This Plains grassland has a limited distribution on sands that have accumulated in playa bottoms of the southern Animas Valley. Blue grama (*Bouteloua gracilis*) or thin paspalum (*Paspalum setaceum*) are the dominants is association with mesa dropseed (*Sporobolus cryptandrus*). These grasslands also have a high production of annual grasses and forbs.

Major Community Types	
Thin Paspalum-Mesa Dropseed	*Paspalum setaceum-Sporobolus flexuosus*
Blue Grama- Mesa Dropseed	*Bouteloua gracilis- Sporobolus flexuosus*

Hectares: 1047 Acres: 2588

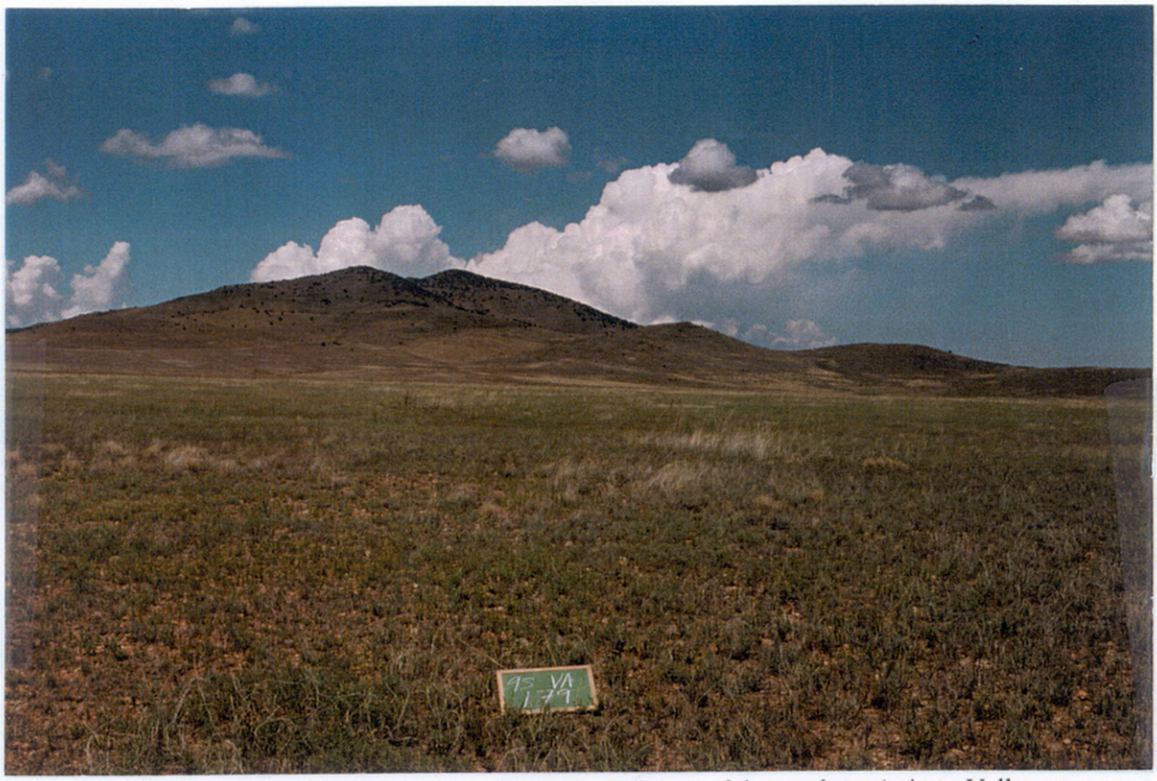

Figure 27. Tobosa grasslands with blue grama along the lower piedmont of the southern Animas Valley are a common component of Map Unit 25.

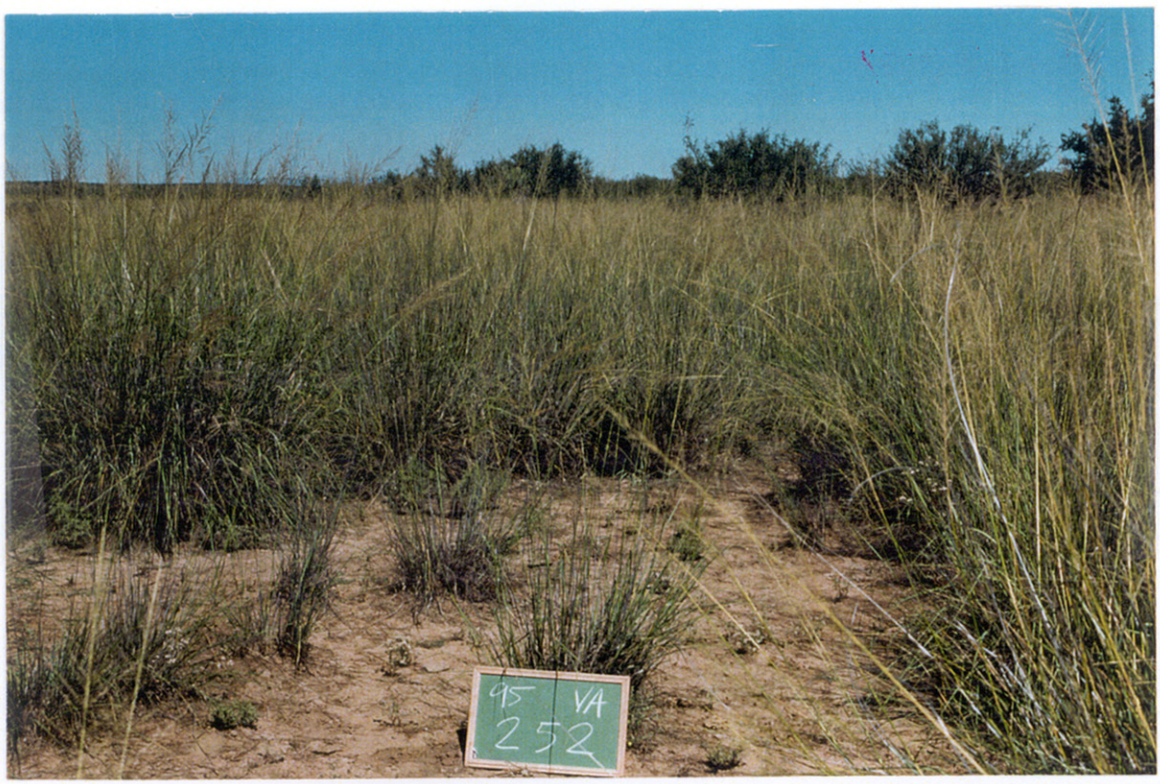

Figure 28. A typical giant sacaton grassland stand in Guadelupe Canyon of the southern Peloncillo Mountains and a major component of Map Unit 27.

Map Unit: 27
Giant Sacaton or Alkali Sacaton Basin-Swale Grasslands

Swale and riparian grasslands strongly dominated by giant sacaton (*Sporobolus wrightii*) with vine mesquitegrass (*Panicum obtusum*) or broom snakeweed (*Gutierrezia sarothrae*) as occasional associates. Very large, monotypic stands occur in drainageways and alluvial flats of the Animas, Playas and San Bernadino Valleys (Figure 28). Stands can also be dominated by the lower statured alkali sacaton (*S. airoides*), but they are limited in distribution to the San Bernadino Wildlife Refuge and the Fitzpatrick Playa of the southern Animas Valley. Minor inclusions of blue grama (*Bouteloua gracilis*) with vine mesquitegrass (*Panicum obtusum*) occur throughout the unit.

Major Community Types	
Giant Sacaton/Monotypic Stand	*Sporobolus wrightii/Monotypic*
Giant Sacaton-Vine Mesquite	*Sporobolus wrightii-Panicum obtusum*
Blue Grama-Alkali Sacaton	*Bouteloua gracilis-Sporobolus airoides*
Alkali Sacaton/Field	*Sporobolus airoides/Field*
Inclusions	
Blue Grama-Vine Mesquite	*Bouteloua gracilis-Panicum obtusum*

Hectares: 1571 Acres: 3881

Map Unit: 28
Creeping Muhly, Vine Mesquitegrass or Annual Grass Playa Grasslands

This is a lowland grassland found in playa bottoms of the Animas and Playas Valleys (Figure 29). Towards the periphery of the playas, perennial grasses such as creeping muhly (*Muhlenbergia repens*), vine mesquitegrass (*Panicum obtusum*) and bottlebrush squirreltail (*Elymus elymoides*) are dominant. Towards the center where inundation occurs more often and for longer periods of time, annual grasses such as Hall's panicgrass (*P. hallii*), sixweeks grama (*Bouteloua barbata*) and feather fingergrass (*Chloris virgata*) tend to dominate with a mixture of forbs.

Major Community Types	
Vine Mesquite-Buffalograss	*Panicum obtusum-Buchloe dactyloides*
Creeping Muhly-Bottlebrush Squirreltail	*Muhlenbergia repens-Elymus elymoides*
Hall's Panicgrass-Feather Fingergrass	*Panicum hallii-Chloris virgata*

Hectares: 3073 Acres: 7594

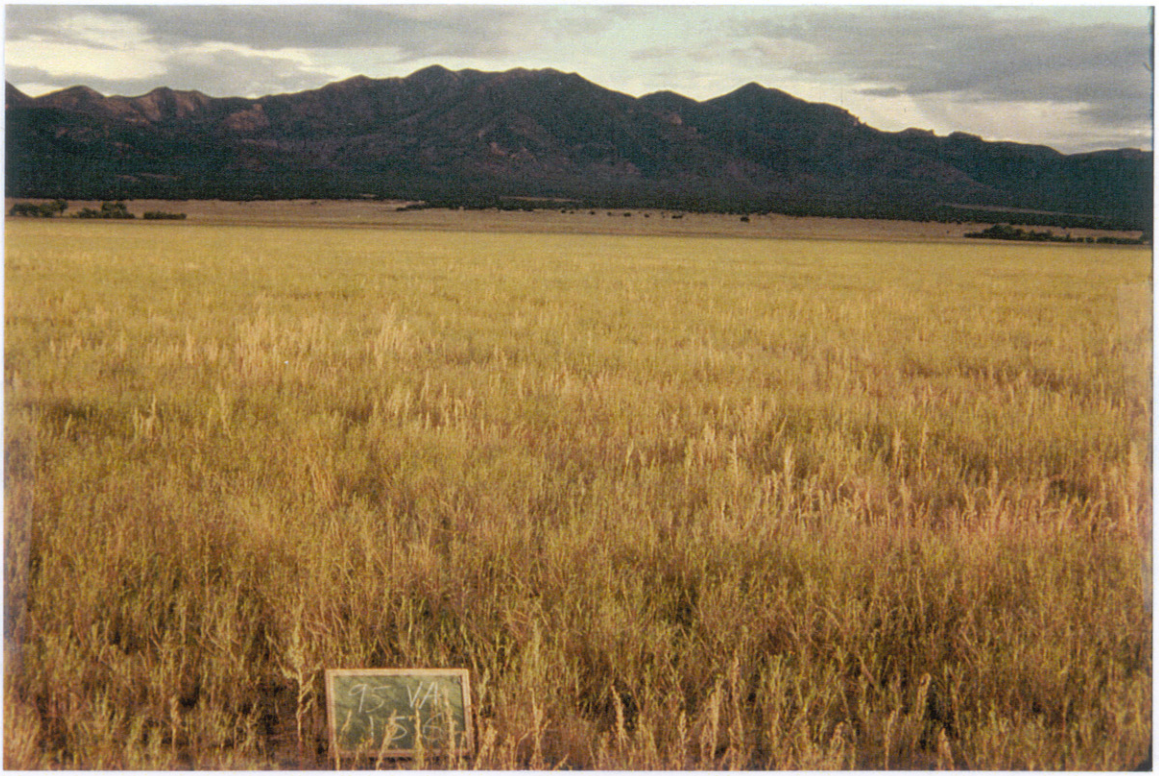

Figure 29. An extensive stand of creeping muhly and bottlebrush squirreltail grassland dominates much of the Fitzpatrick Playa in the southern Animas Valley, and is representative of Map Unit 28.

Figure 30. Riparian woodland dominated by Arizona Sycamore in the Deer Creek drainage of the Animas Mountains. This type is a major component of Map unit 29.

RIPARIAN WOODLANDS and SHRUBLANDS

Map Unit: 29
Fremont's Cottonwood and Arizona Sycamore Riparian Woodlands

This unit is composed of open deciduous riparian woodlands dominated by Arizona sycamore (*Platanus wrightii*) or Fremont cottonwood (*Populus fremontii*). These are obligate riparian species which occur in scattered stands along perennial streams or along intermittent channels where the water table is close to the surface. Large occurrences are found in Sycamore Canyon, along Animas Creek and its tributaries, and in Deer Creek of the Animas Mountains (Figure 30). The unit also has inclusions of Arizona white oak woodlands that occur along the drainage bottoms at lower elevations, and dry arroyo types dominated by Apache plume.

.

Major Community Types	
Arizona Sycamore/Sideoats Grama	*Platanus wrightii/Bouteloua curtipendula*
Fremont's Cottonwood/Sparse Undergrowth	*Populus fremontii/Sparse*
Inclusions	
Arizona White Oak/Sideoats Grama	*Quercus arizonica/Bouteloua curtipendula*
Apacheplume/Blue Grama	*Fallugia paradoxa/Bouteloua gracilis*

Hectares: 641 Acres: 1584

Map Unit: 30
Honey Mesquite Semi-Riparian Woodland

Semi-riparian woodlands dominated by tree-form honey mesquite (*Prosopis glandulosa*) that is found in the San Bernadino Valley along intermittent and ephemeral channels (Figure 31). Canopies can by very dense with little or no undergrowth. Others are more open and of lower stature, approaching shrublands with grassy undergrowth. Inclusions of viscid acacia shrublands interspersed with giant sacaton and tobosagrass grasslands can occur.

Major Community Types	
Honey Mesquite/Monotypic Stand	*Prosopis glandulosa/Monotypic*
Honey Mesquite/Giant Sacaton	*Prosopis glandulosa/Sporobolus wrightii*
Inclusions	
Viscid Acacia/Tobosagrass	*Acacia neovernicosa/Hilaria mutica*

Hectares: 670 Acres: 1656

Figure 31. Tall honey mesquite stands of Map Unit 30 such as this one in San Bernadino Valley are common along ephemeral and intermittent drainages.

Figure 32. Apache plume stands can be prominent in dry washes such Whitmire Creek and are a major component of Map Unit 31.

Map Unit: 31
Apache-plume and Desert Willow Arroyo Shrublands

Semi-riparian shrublands that occur in arroyo (dry wash) bottoms and swale areas throughout the study area (Figure 32). Most commonly they are dominated by Apache-plume (*Fallugia paradoxa*) and velvetpod mimosa (*Mimosa dysocarpa*) with smaller occurrences dominated by either desert willow (*Chilopsis linearis*) or little-leaf sumac (*Rhus microphylla*). Undergrowth ranges from scoured bare ground to grassy, somewhat stabilized sites dominated by blue grama (*Bouteloua curtipendula*) or tobosagrass (*Hilaria mutica*). There are also small inclusions of honey mesquite (*Prosopis glandulosa*) with giant sacaton (*Sporobolus wrightii*) throughout the distribution.

Major Community Types	
Velvetpod Mimosa/Tobosagrass	*Mimosa dysocarpa/Hilaria mutica*
Apache-plume/Blue Grama	*Fallugia paradoxa/Bouteloua gracilis*
Inclusions	
Desert Willow/Apache Plume	*Chilopsis linearis/Fallugia paradoxa*
Honey Mesquite/Giant Sacaton	*Prosopis glandulosa/Sporobolus wrightii*

Hectares: 3216 Acres: 7948

Map Unit: 32
Rock Outcrop and Talus

Barren areas in the Peloncillo and Animas mountains. These areas include talus fields and rock outcrops of significant area.

Hectares: 932 Acres: 2304

Map Unit: 33 & 34
Barren Alluvial Flats, Water Tanks and Disturbed Areas

Basin and piedmont alluvium areas with primarily annual grass and forb cover. These are barren areas with very sparse vegetative cover. This map unit also includes disturbed areas such as tanks and fallow fields. Some honey mesquite and tobosagrass inclusions occur in the Playas Valley.

Major Community Types	
Hall's Panicgrass-Sixweeks Grama	*Panicum hallii-Bouteloua barbata*
Inclusions	
Tobosagrass-Purple Threeawn	*Hilaria mutica-Aristida purpurea*
Honey Mesquite/Burrograss	*Prosopis glandulosa/Scleropogon brevifolius*

Hectares: 2921 Acres: 7218

Appendix A.

Borderlands Ecosystem Management Area Vegetation Map Plant Species List

Table A-1. Plant species encountered in field sample plots for the Borderlands Ecosystem Management Area Vegetation Map. Names and wetland status follow the PLANTS database and Kartez (1994). Species are alphabetically ordered scientific name by major lifeform group (trees, shrubs, graminoids and forbs).

LF	Species Name	AUTH	Family	Kartesz Symbol	NMNHP Symbol	Wetland Status	No. Obs	Common Name
TREES								
1	Chilopsis linearis	(Cav.) Sweet	Bignoniaceae	CHLI2	CHILIN	NI (FAC)	1	desert willow
1	Fraxinus velutina	Torr.	Oleaceae	FRVE2	FRAVEL	FAC+ (FACW)	1	velvet ash
1	Juglans major	(Torr.) Heller	Juglandaceae	JUMA	JUGMAJ	FACW-	2	Arizona walnut
1	Juniperus deppeana	Steud.	Cupressaceae	JUDE2	JUNDEP	NI (FACU)	6	alligator juniper
1	Juniperus monsperma	Cory	Cupressaceae	JUER	JUNERY		40	oneseed juniper
1	Pinus cemborides	Zucc.	Pinaceae		PINDIS		32	Mexican Pinyon
1	Pinus leiophylla	Schiede & Deppe	Pinaceae	PILE	PINLEI		4	Chihuahua Pine
1	Pinus ponderosa	P. & C. Lawson	Pinacea	PIPO	PIMPON		1	Ponderosa Pine
1	Platanus wrightii	S. Wats.	Platanaceae	PLWR2	PLAWRI	FACW- (FACW)	2	Arizona sycamore
1	Populus fremontii	S. Wats.	Salicaceae	POFR2	POPFRE	OBL	1	cottonwood spp.
1	Pseudotsuga menziesii	(Mirebell) Franco	Pinaceae	PSME	PSEMEN		1	Douglas-fir
1	Quercus arizonica	Sarg.	Fagaceae	QUAR	QUEARI		22	Arizona white oak
1	Quercus emoryi	Torr.	Fagaceae	QUEM	QUEEMO	FAC	6	Emory's oak
1	Quercus grisea	Liebm.	Fagaceae	QUGR3	QUEGRI	NI (FAC)	1	gray oak
1	Quercus hypoleucoides	A. Camus	Fagaceae	QUHY	QUEHYP	NI (FACU)	5	silverleaf oak
1	Quercus toumeyi	Sarg,	Fagaceae	QUTO2	QUETOU		1	Toumey oak
1	Quercus rugosa	Nee	Fagaceae	QURU4	QUERUG		1	netleaf oak
1	Salix gooddingii	Ball	Salicaceae	SAGO	SALGOO	OBL	1	Goodding's willow
1	Ulmus spp.	L.	Ulmaceae		ULMUS		1	elm spp

Table A-1. Plant species encountered in field sample plots for the Borderlands Ecosystem Management Area Vegetation Map (continued).

LF	Species Name	AUTH	Family	Kartesz Symbol	NMNHP Symbol	Wetland Status	No. Obs	Common Name
SHRUBS								
2	Acacia constricta	Benth.	Fabaceae	ACCO2	ACACON		2	mescat acacia
2	Acacia greggii	Gray	Fabaceae	ACGR	ACAGRE		4	catclaw acacia
2	Acacia neovernicosa	Isley	Fabaceae	ACNE4	ACANEO	NI (UPL)	41	viscid acacia
2	Acacia spp.	P. Mill.	Fabaceae		ACACIA		21	acacia spp.
2	Agave neomexicana	Woot. & Standl.	Agavaceae	AGNE4	AGANEO		86	New Mexico agave
2	Agave schottii	Englm.	Agavaceae	AGSC3	AGASCH		2	Schott's century plant
2	Aloysia wrightii	Heller ex Abrams	Verbenaceae	ALWR	ALOWRI		22	Wright's beebrush
2	Arctostaphylos pringlei	Parry	Ericaceae		ARCPRI		12	pringle manzanita
2	Arctostaphylos pungens	Kunth	Ericaceae	ARPU5	ARCPUN	NI (UPL)	51	pointleaf manzanita
2	Atriplex canescens	(Pursh) Nutt.	Chenopodiaceae	ATCA2	ATRCAN	NI (UPL)	19	fourwing saltbush
2	Atriplex spp.	L.	Chenopodiaceae		ATRIPL		31	saltbush
2	Brickellia californica	(Torr. & Gray) Gray	Asteraceae	BRCA3	BRICAL	FACU+	1	California brickellbush
2	Ceanothus spp.	L.	Rhamnaceae		CEANOT		1	ceanothus spp.
2	Cercocarpus montanus	Raf.	Rosaceae	CEMO2	CERMON	NI (UPL)	18	true mountain mahogany
2	Chrysothamnus nauseosus	(Pallas ex.Prush) Britt.	Asteraceae	CHNA2	CHRNAU	NI (FACU)	1	rubber rabbitbrush
2	Chrysothamnus spp.	Nutt.	Asteraceae		CHRYSO		3	rabbitbrush spp.
2	Condalia spp.	Cav.	Rhamnaceae		CONDAL		5	condalia spp.
2	Convolvulaceae Family		Convolvulaceae		CONVOL1		2	morning glory family
2	Dalea formosa	Torr.	Fabaceae	DAFO	DALFOR		20	featherplume
2	Dalea versicolor var. sessilis	(Gray) Barneby	Fabaceae		DALVERS		1	oakwoods prairieclover
2	Dasylirion wheeleri	S. Wats.	Agavaceae	DAWH2	DASWHE		46	common sotol
2	Ephedra spp.	L.	Ephedraceae		EPHEDR	NI (UPL)	1	mormontea spp.
2	Ephedra trifurca	Torr. ex S. Wats.	Ephedraceae	EPTR	EPHTRI	NI (UPL)	36	longleaf jointfir
2	Ericameria laricifolia	(Gray) Shinners	Asteraceae	ERLA12	ERILAR	FACU (UPL)	63	turpentine bush
2	Eysenhardtia polystachya	(Ortega) Sarg.	Fabaceae	EYPO	EYSPOL		1	kidneywood
2	Fallugia paradoxa	(G. Don) Endl. ex Torr.	Rosaceae	FAPA	FALPAR	NI (FAC)	4	Apacheplume
2	Ferocactus wislizeni	(Engelm.) Britt. & Rose	Cactaceae	FEWI	FERWIS		6	candy barrelcactus
2	Flourensia cernua	DC.	Asteraceae	FLCE	FLOCER		18	tarbush
2	Fouquieria splendens	Engelm.	Fouquieriaceae	FOSP2	FOUSPL	NI (UPL)	30	ocotillo
2	Garrya flavescens	S. Wats.	Garryaceae	GAFL2	GARFLA		1	ashy silktassel
2	Garrya spp.	Dougl. ex Lindl.	Garryaceae		GARRYA		1	silktassel spp.
2	Garrya wrightii	Torr.	Garryaceae	GAWR3	GARWRI		1	Wright's silktassel
2	Gutierrezia sarothrae	(Pursh) Britt. & Rusby	Asteraceae	GUSA2	GUTSAR	NI (UPL)	177	broom snakeweed

Table A-1. Plant species encountered in field sample plots for the Borderlands Ecosystem Management Area Vegetation Map (continued).

LF	Species Name	AUTH	Family	Kartesz Symbol	NMNHP Symbol	Wetland Status	No. Obs	Common Name
2	Gymnosperma glutinosum	(Spreng.) Less	Asteraceae	GYGL	GYMGLU	NI (UPL)	10	gumhead
2	Isocoma tenuisecta	Greene	Asteraceae	ISTE2	ISOTEN	NI (UPL)	26	burroweed
2	Janusia gracilis	Gray	Malpighiaceae	JAGR	JANGRA		2	slender janusia
2	Krascheninnikovia lanata	(Pursh) Guldenstaedt	Chenopodiaceae	KRLA2	KRALAN2		42	winterfat
2	Larrea tridentata	(Sesse & Moc. ex DC.) Coville	Zygophyllaceae	LATR2	LARTRI	NI (UPL)	26	creosotebush
2	Lycium pallidum	Miers	Solanaceae	LYPA	LYCPAL	NI (FAC)	2	pale wolfberry
2	Lycium spp.	L.	Solanaceae		LYCIUM		5	wolfberry spp.
2	Mimosa aculeaticarpa var. biuncifera	(Benth.) Barneby	Fabaceae	MIACB	MIMACUB		40	mimosa
2	Mimosa dysocarpa	Benth.	Fabaceae	MIDY	MIMDYS		16	Velvetpod mimosa
2	Mimosa spp.	L.	Fabaceae		MIMOSA		1	mimosa spp.
2	Mortonia sempervirens ssp. scabrella	(Gray) Prigge	Celastraceae	MOSES	MORSEMS		9	Rio Grande saddlebush
2	Nolina microcarpa	S. Wats.	Agavaceae	NOMI	NOLMIC		103	sacahuista
2	Opuntia imbricata	(Haw.) DC.	Cactaceae	OPIM	OPUIMB	NI (UPL)	92	tree cholla
2	Opuntia leptocaulis	DC.	Cactaceae	OPLE	OPULEP	NI (UPL)	8	Christmas cactus
2	Opuntia macrocentra	Engelm.	Cactaceae	OPMA8	OPUMAC	NI (UPL)	6	purple pricklypear
2	Opuntia phaeacantha	Engelm.	Cactaceae	OPPH	OPUPHA	NI (UPL)	116	tulip pricklypear
2	Opuntia spp.	P. Mill.	Cactaceae		OPUNTI	NI (UPL)	1	pricklypear spp.
2	Parthenium incanum	Kunth	Asteraceae	PAIN2	PARINC		33	mariola
2	Prosopis glandulosa	Torr.	Fabaceae	PRGL2	PROGLA	NI (FACU)	154	honey mesquite
2	Quercus spp.	L.	Fagaceae		QUERCU		2	oak spp.
2	Quercus toumeyi	Sarg.	Fagaceae	QUTO2	QUETOU		26	Toumey oak
2	Rhus aromatica	Ait.	Anacardaceae		RHUARO		1	fragrant sumac
2	Rhus microphylla	Engelm. ex Gray	Anacardiaceae	RHMI3	RHUMIC	NI (UPL)	22	littleleaf sumac
2	Rhus trilobata	Nutt.	Anacardiaceae	RHTR	RHUTRI	NI (FAC)	19	skunkbush sumac
2	Rhus virens var. choriophylla	(Woot. & Standl.) Benson	Anacardiaceae	RHVIC	RHUVIRC		3	evergreen sumac
2	Sideroxylon lanuginosum	(Michx.) Pers.	Sapotaceae		SIDLAN		2	woolly buckthorn
2	Thymophylla acerosa	(DC.) Strother	Asteraceae	THAC	THYACE		1	pricklyleaf dogweed
2	Tiquilia canescens	(DC.) A. Richards	Boraginaceae	TICA3	TIQCAN		9	woody crinklemat
2	Toxicodendron pubescens	P. Mill	Anacardiaceae		TOXPUB		1	Poison ivy
2	Vauquelinia californica ssp. pauciflora	(Standl.) Hess & Henrickson	Rosaceae	VACAP	VAUCALP		1	Arizona rosewood
2	Vitis arizonica	Engelm.	Vitaceae	VIAR2	VITARI	FAC (FACW)	4	canyon grape
2	Yucca baccata	Torr.	Agavaceae	YUBA	YUCBAC		60	banana yucca
2	Yucca elata	(Engelm.) Engelm.	Agavaceae	YUEL	YUCELA	NI (UPL)	34	soaptree yucca
2	Yucca schottii	Englm.	Agavaceae	YUSC	YUCSCH		17	Schott's yucca

Table A-1. Plant species encountered in field sample plots for the Borderlands Ecosystem Management Area Vegetation Map (continued).

LF	Species Name	AUTH	Family	Kartesz Symbol	NMNHP Symbol	Wetland Status	No. Obs	Common Name
GRAMINOIDS								
3	Aristida adscensionis	L.	Poaceae	ARAD	ARIADS		25	sixweeks threeawn
3	Aristida divaricata	Humb. & Bonpl. ex Willd.	Poaceae	ARDI5	ARIDIV		27	poverty threeawn
3	Aristida havardii	Vasey	Poaceae	ARHA3	ARIHAV		6	Havard's threeawn
3	Aristida orcuttiana	Vasey	Poaceae	AROR2	ARIORC		55	Single threeawn
3	Aristida pansa	Woot. & Standl.	Poaceae	ARPA9	ARIPAN		2	Wooton's threeawn
3	Aristida purpurea	Nutt.	Poaceae	ARPU9	ARIPUR	NI (FACU)	55	purple threeawn
3	Aristida purpurea var. longiseta	(Steud.) Vasey	Poaceae	ARPUL	ARIPURL		29	red threeawn
3	Aristida purpurea var. wrightii	(Nash) Allred	Poaceae	ARPUW	ARIPURW		2	Wright's threeawn
3	Aristida spp.	L.	Poaceae		ARISTI		42	threeawn spp.
3	Aristida ternipes	Cav.	Poaceae	ARTE3	ARITER	FAC	17	spidergrass
3	Aristida ternipes var. hamulosa	(Henr.) Trent	Poaceae	ARTEH	ARITERH	NI (UPL)	15	threeawn
3	Aristida ternipes var. ternipes	Cav.	Poaceae	ARTET	ARITERT		1	spidergrass
3	Bothriochloa barbinodis	(Lag.) Herter	Poaceae	BOBA3	BOTBAR		73	cane bluestem
3	Bouteloua aristidoides	(H.B.K.) Griseb.	Poaceae	BOAR	BOUARI		17	needle grama
3	Bouteloua barbata	Lag.	Poaceae	BOBA2	BOUBAR	NI (FACU)	5	sixweeks grama
3	Bouteloua curtipendula	(Michx.) Torr.	Poaceae	BOCU	BOUCUR	NI (FACU)	195	sideoats grama
3	Bouteloua eriopoda	(Torr.) Torr.	Poaceae	BOER4	BOUERI	NI (UPL)	64	black grama
3	Bouteloua gracilis	(Willd. ex Kunth) Lag. ex Griffiths	Poaceae	BOGR2	BOUGRA	NI (UPL)	86	blue grama
3	Bouteloua hirsuta	Lag.	Poaceae	BOHI2	BOUHIR	NI (UPL)	123	hairy grama
3	Bouteloua radicosa	(Fourn.) Griffiths	Poaceae	BORA	BOURAD		39	purple grama
3	Bouteloua rothrockii	Vasey	Poaceae	BORO2	BOUROT		3	Rothrock's grama
3	Bouteloua spp.	Lag.	Poaceae		BOUTEL		8	grama spp.
3	Brachiaria arizonica	(Scribn. & Merr.) S.T. Blake	Poaceae	BRAR7	BRAARI		1	Arizona signalgrass
3	Buchloe dactyloides	(Nutt.) Engelm.	Poaceae	BUDA	BUCDAC	FACU	9	buffalograss
3	Carex spp.	L.	Cyperaceae		CAREX		1	sedge spp.
3	Chloris virgata	Sw.	Poaceae	CHVI4	CHLVIR	NI (UPL)	11	feather fingergrass
3	Cyperus sphaerolepis	Boeckl.	Cyperaceae	CYSP7	CYPSPH		1	Rusby's flatsedge
3	Cyperus spp.	L.	Cyperaceae		CYPERU		1	flatsedge spp.
3	Digitaria californica	(Benth.) Henr.	Poaceae	DICA8	DIGCAL		16	Arizona cottontop
3	Eleocharis spp.	R. Br.	Cyperaceae		ELEOCH		1	spikerush spp.
3	Elymus elymoides	(Raf.) Swezey	Poaceae	ELEL5	ELYELY	NI (FACU)	41	bottlebrush squirreltail
3	Elyonurus barbiculmis	Hack.	Poaceae	ELBA	ELYBAR		11	woolyspike balsamscale
3	Enneapogon desvauxii	Beauv.	Poaceae	ENDE	ENNDES		2	nineawn pappusgrass
3	Eragrostis cilianensis	(All.) Lut. ex Janchen	Poaceae	ERCI	ERACIL	FACU+	5	stinkgrass
3	Eragrostis curvula var. conferta	Stapf	Poaceae		ERACURC		2	Boer lovegrass

Table A-1. Plant species encountered in field sample plots for the Borderlands Ecosystem Management Area Vegetation Map (continued).

LF	Species Name	AUTH	Family	Kartesz Symbol	NMNHP Symbol	Wetland Status	No. Obs	Common Name
3	Eragrostis intermedia	Hitchc.	Poaceae	ERIN	ERAINT	NI (UPL)	118	plains lovegrass
3	Eragrostis lehmanniana	Nees	Poaceae	ERLE	ERALEH		6	Lehmann's lovegrass
3	Eragrostis spp.	von Wolf	Poaceae		ERAGRO		2	lovegrass spp.
3	Erioneuron pulchellum	(Kunth) Tateoka	Poaceae	ERPU8	ERIPUL		29	fluffgrass
3	Heteropogon contortus	(L.) Beauv. ex Roemer & Schultes	Poaceae	HECO10	HETCON		19	tanglehead
3	Hilaria belangeri	(Steud.) Nash	Poaceae	HIBE	HILBEL		38	curlymesquite
3	Hilaria mutica	(Buckl.) Benth.	Poaceae	HIMU2	HILMUT		77	tobosagrass
3	Leptochloa dubia	(Kunth) Nees	Poaceae	LEDU	LEPDUB	NI (FACU)	10	green sprangletop
3	Leptochloa mucronata	(Michx.) Kunth	Poaceae	LEMU10	LEPMUC		2	red sprangletop
3	Lycurus phleoides	Kunth	Poaceae	LYPH	LYCPHL	NI (FACU)	57	common wolfstail
3	Muhlenbergia arenicola	Buckl.	Poaceae	MUAR2	MUHARE2		18	sand muhly
3	Muhlenbergia emersleyi	Vasey	Poaceae	MUEM	MUHEME		94	bullgrass
3	Muhlenbergia longiligula	Hitchc.	Poaceae	MULO	MUHLON		10	longtongue muhly
3	Muhlenbergia metcalfei	Jones	Poaceae	MUME	MUHMET		2	Metcalfe's muhly
3	Muhlenbergia porteri	Scribn. ex Beal	Poaceae	MUPO2	MUHPOR	NI (UPL)	47	bush muhly
3	Muhlenbergia pungens	Thurb.	Poaceae	MUPU2	MUHPUN		2	sandhill muhly
3	Muhlenbergia repens	(Presl) A.S. Hitchc.	Poaceae	MURE	MUHREP		4	creeping muhly
3	Muhlenbergia spp.	Schreb.	Poaceae		MUHLEN		9	muhly spp.
3	Panicum bulbosum	Kunth	Poaceae	PABU	PANBUL		1	bulb panicgrass
3	Panicum hallii	Vasey	Poaceae	PAHA	PANHAL	FACU	4	Hall's panicgrass
3	Panicum hirticaule	J. Presl.	Poaceae	PAHI5	PANHIR		5	Mexican panicgrass
3	Panicum obtusum	Kunth	Poaceae	PAOB	PANOBT	FAC (FACW)	39	vine mesquite
3	Panicum spp. (depauperate)	L.	Poaceae		PANICU		1	panicgrass spp.
3	Piptochaetium fimbriatum	(H.B.K.) Hitchc.	Poaceae	PIFI	PIPFIM	NI (FACU)	22	pinyon ricegrass
3	Poa fendleriana	(Steud.) Vasey	Poaceae	POFE	POAFEN	NI (FACU)	9	muttongrass
3	Poa spp.	L.	Poaceae		POA		5	bluegrass spp.
3	Schizachyrium cirratum	(Hack.) Woot. & Standl.	Poaceae	SCCI2	SCHCIR		77	Texas bluestem
3	Schizachyrium scoparium	(Michx.) Nash	Poaceae	SCSC	SCHSCO	FACU	8	little bluestem
3	Schizachyrium spp.	Nees	Poaceae		SCHIZA		2	bluestem spp.
3	Scleropogon brevifolius	Phil.	Poaceae	SCBR2	SCLBRE	NI (UPL)	7	burrograss
3	Setaria leucopila	(Scrib. & Merr.) K. Schum.	Poaceae	SELE6	SETLEU	NI (FACW)	19	streambed bristlegrass
3	Sorghum halepense	(L.)Pers.	Poaceae	SOHA	SORHAL	FACU+	4	johnsongrass
3	Sporobolus airoides	(Torr.) Torr.	Poaceae	SPAI	SPOAIR	FAC	2	alkali sacaton
3	Sporobolus contractus	Hitchc.	Poaceae	SPCO4	SPOCON	NI (UPL)	1	spike dropseed
3	Sporobolus cryptandrus	(Torr.) Gray	Poaceae	SPCR	SPOCRY	FACU- (FAC)	11	sand dropseed
3	Sporobolus spp.	R. Br.	Poaceae		SPOROB		11	dropseed spp.

Table A-1. Plant species encountered in field sample plots for the Borderlands Ecosystem Management Area Vegetation Map (continued).

LF	Species Name	AUTH	Family	Kartesz Symbol	NMNHP Symbol	Wetland Status	No. Obs	Common Name
3	Sporobolus wrightii	Munro	Poaceae	SPWR2	SPOWRI	NI (FAC)	25	giant sacaton
3	Stipa eminens	Cav.	Poaceae	STEM2	STIEMI	NI (UPL)	1	southwestern needlegrass
3	Stipa spp.	L.	Poaceae		STIPA		6	needlegrass spp.
3	Trachypogon secundus	(J. Presl) Scribn.	Asteraceae	TRSE	TRASEC		10	onesided crinkleawn
3	Tridens muticus	(Torr.) Nash	Poaceae	TRMU	TRIMUT	NI (FACU)	1	slim tridens
3	Vulpia octoflora var. octoflora	(Walt.) Rydb.	Poaceae	VUOCO	VULOCTO	NI (FACU)	67	sixweeks fescue
FORBS								
4	Allium cernuum	Roth	Liliaceae	ALCE2	ALLCER	NI (FACU)	1	nodding onion
4	Amaranthus palmeri	S. Wats.	Amaranthaceae	AMPA	AMAPAL		1	carelessweed
4	Ambrosia artemisiifolia	L.	Asteraceae	AMAR2	AMBART	FACU	7	annual ragweed
4	Ambrosia spp.	L.	Asteraceae		AMBROS		4	ragweed spp.
4	Aquilegia spp.	L.	Ranunculaceae		AQUILE		2	columbine spp.
4	Artemisia carruthii	Wood ex Carruth.	Asteraceae	ARCA14	ARTCAR	NI (FAC)	1	Carruth's sagewort
4	Artemisia dracunculus	L.	Asteraceae	ARDR4	ARTDRA	NI (FAC)	8	wormwood
4	Artemisia ludoviciana	Nutt.	Asteraceae	ARLU	ARTLUD	NI (FACU)	1	Louisiana sagewort
4	Asclepias verticillata	L.	Asclepiadaceae	ASVE	ASCVER		1	whorled milkweed
4	Aster pauciflorus	Nutt.	Asteraceae	ASPA8	ASTPAU		1	alkalimarsh aster
4	Aster spp.	L.	Asteraceae		ASTER		1	aster spp.
4	Asteraceae		Asteraceae		ASTERA		42	
4	Astragalus spp.	L.	Fabaceae		ASTRAG		13	milkvetch spp.
4	Bahia absinthifolia	Benth.	Asteraceae	BAAB	BAHABS		11	hairyseed bahia
4	Bidens bipinnata	L.	Asteraceae	BIBI7	BIDBIP	NI (FACW)	1	spanish-needles
4	Boerhaavia coccinea	P. Mill.	Nyctaginaceae		BOECOC	NI (FAC)	24	scarlet spiderling
4	Brassica spp. (depauperate)	L.	Brassicaceae		BRASSI1		1	cabbage mustard spp.
4	Brassicaceae Family		Brassicaceae		BRASSI2		1	Mustard Family
4	Cactaceae Family		Cactaceae		CACTAC		3	cactus family
4	Calliandra humilis	Benth.	Fabaceae	CAHU	CALHUM		36	dwarf stickpea
4	Calliandra humilis var. reticulata	(Gray) L. Benson	Fabaceae	CAHUR	CALHUMR		11	dwarf stickpea
4	Calliandra spp.	Benth.	Fabaceae		CALLIA		6	calliandra spp.
4	Castilleja spp.	Mutis ex L. f.	Scrophulariaceae		CASTIL		11	paintbrush spp.
4	Chaetopappa ericoides	(Torr.) Nesom	Asteraceae	CHER2	CHAERI		1	rose heath
4	Chamaesyce maculata	(L.) Small	Euphorbiaceae	CHMA15	CHAMAC	NI (FACU)	1	spotted spurge
4	Chenopodium album	L.	Chenopodiaceae	CHAL7	CHEALB	FAC-	4	lambsquarters
4	Chenopodium spp.	L.	Chenopodiaceae		CHENOP		56	goosefoot spp.
4	Commelina spp.	L.	Commelinaceae		COMMEL		3	dayflower spp.

Table A-1. Plant species encountered in field sample plots for the Borderlands Ecosystem Management Area Vegetation Map (continued).

LF	Species Name	AUTH	Family	Kartesz Symbol	NMNHP Symbol	Wetland Status	No. Obs	Common Name
4	Convolvulus spp.	L.	Convolvulaceae		CONVOL2		1	bindweed spp.
4	Conyza canadensis	(L.) Cronq.	Asteraceae	COCA5	CONCAN	FACU (FAC)	1	Canadian horseweed
4	Croton pottsii	(Koltzsch) Muell.-Arg.	Euphorbiaceae	CRPO5	CROPOT		63	leatherweed
4	Croton spp.	L.	Euphorbiaceae		CROTON		1	Croton spp.
4	Cryptantha crassisepala	(Torr. & Gray) Greene	Boraginaceae	CRCR3	CRYCRA		3	hiddenflower
4	Cryptantha spp.	Lehm. ex G. Don	Boraginaceae		CRYPTA		2	catseye
4	Cucurbitaceae		Cucurbitaceae		CUCURB		2	Gourd Family
4	Dalea spp.	L.	Fabaceae		DALEA		1	prairieclover spp.
4	Descurainia spp.	Webb & Berth.	Brassicaceae		DESCUR		35	tansymustard spp.
4	Desmanthus cooleyi	(Eat.) Trel.	Fabaceae	DECO2	DESCOO	NI (UPL)	5	Cooley's bundleflower
4	Desmanthus spp.	Willd.	Fabaceae		DESMAN		5	bundleflower spp.
4	Echinocereus pectinatus	(Scheidw.) Engelm.	Cactaceae	ECPE	ECHPEC		11	rainbow cactus
4	Erigeron flagellaris	Gray	Asteraceae	ERFL	ERIFLA	FAC-	10	trailing fleabane
4	Eriogonum annuum	Nutt.	Polygonaceae	ERAN4	ERIANN	NI (UPL)	59	annual buckwheat
4	Eriogonum wrightii	Torr. ex Benth.	Polygonaceae	ERWR	ERIWRI		120	Wright's buckwheat
4	Escobaria spp.	Britt. & Rose	Cactaceae		ESCOBA		10	beehive cactus spp.
4	Escobaria vivipara var. vivipara	(Nutt.) Buxbaum	Cactaceae	ESVIV	ESCVIVV		1	spinystar
4	Eupatroium spp.		Asteraceae		EUPATO		1	
4	Euphorbia spp.	L.	Euphorbiaceae		EUPHOR1		33	spurge spp.
4	Euphorbiaceae		Euphorbiaceae		EUPHOR2		1	
4	Evolvulus spp.	L.	Convolvulaceae		EVOLVU		25	morningglory sp.
4	Fabaceae		Fabaceae		FABACE		31	
4	Gaillardia spp.	Foug.	Asteraceae		GAILLA		7	gaillardia spp.
4	Gaura hexandra ssp. gracilis	(Woot. & Standl.) Rav & Gregory	Onagraceae	GAHEG	GAUHEXG		1	harlequinbush
4	Gnaphalium stramineum	Kunth	Asteraceae	GNST	GNASTR	FAC	4	cottonbatting cudweed
4	Grindelia nuda var. aphanactis	(Rydb.) Nesom	Asteraceae	GRNU	GRINUD		1	curlytop gumweed
4	Grindelia spp	Willd.	Asteraceae		GRINDE		1	gumweed spp.
4	Guilleminea densa var. densa	(Humb. & Bonpl. ex. Willd.) Small	Amaranthaceae	GUDED	GUIDEND		8	Small matweed
4	Gutierrezia sphaerocephala	Gray	Asteraceae	GUSP	GUTSPH		8	roundleaf snakeweed
4	Helianthus annuus	L.	Asteraceae	HEAN3	HELANN	FAC-	2	common sunflower
4	Helianthus ciliaris	DC.	Asteraceae	HECI	HELCIL	FAC (FACW)	1	Texas blueweed
4	Heliomeris longifolia var. annua	(M.E. Jones) Yates	Asteraceae	HELOA2	HELLONA		1	longleaf falsegoldeneye
4	Heliomeris spp.	Nutt.	Asteraceae		HELIOM		1	goldeneye spp.
4	Hoffmannseggia glauca	(Ortega) Eifert	Fabaceae	HOGL2	HOFGLA		65	Indian rushpea
4	Hymenothrix wrightii	Gray	Asteraceae	HYWR	HYMWRI		3	Wright's thimblehead
4	Hymenoxys spp.	Cass.	Asteraceae		HYMENO		14	rubberweed spp.

Table A-1. Plant species encountered in field sample plots for the Borderlands Ecosystem Management Area Vegetation Map (continued).

LF	Species Name	AUTH	Family	Kartesz Symbol	NMNHP Symbol	Wetland Status	No. Obs	Common Name
4	Ipomoea purpurea	(L.) Roth	Convolvulaceae	IPPU2	IPOPUR	NI (FACU)	1	tall morningglory
4	Ipomoea sp.		Convolvulaceae		IPOMOE		1	morningglory
4	Ipomopsis longiflora	(Torr.) V. Grant	Polemoniaceae	IPLO2	IPOLON	NI (FAC)	1	flaxflowered gilia
4	Ipomopsis thurberi	(Torr. ex Gray) V. Grant	Polemoniaceae	IPTH2	IPOTHU		4	El Paso skyrocket
4	Kallstroemia grandiflora	Torr. ex Gray	Zygophyllaceae	KAGR	KALGRA		6	Desert Poppy
4	Kallstroemia hirsutissima	Vail ex Small	Zygophyllaceae	KAHI	KALHIR		2	hairy caltrop
4	Krameria erecta	Rose & Painter	Krameriaceae	KRER	KRAERE		1	little leaf ratany
4	Krameria lanceolata	Torr.	Krameriaceae	KRLA	KRALAN1		10	trailing krameria
4	Krameria spp.	L.	Krameriaceae		KRAMER		1	ratany spp.
4	Lamiaceae		Lamiaceae		LAMIAC		3	
4	Lepidium montanum	Nutt.	Brassicaceae	LEMO2	LEPMON		67	mountain pepperweed
4	Lesquerella spp.	S. Wats.	Brassicaceae		LESQUE		3	bladderpod spp.
4	Liliaceace		Liliaceae		LILIAC		5	
4	Linaria spp.	P. Mill.	Scrophulariaceae		LINARI1		5	toadflax spp.
4	Linum spp.	L.	Linaceae		LINUM		13	flax spp.
4	Lotus spp.	L.	Fabaceae		LOTUS		3	trefoil spp.
4	Machaeranthera gracilis	(Nutt.) Shinners	Asteraceae	MAGR10	MACGRA	NI (FACU)	148	slender goldenweed
4	Machaeranthera spp.	Nees	Asteraceae		MACHAE		10	tansyaster
4	Machaeranthera tanacetifolia	(Kunth) Nees	Asteraceae	MATA2	MACTAN	NI (FACU)	147	tanseyleaf aster
4	Malvaceae		Malvaceae		MALVAC		1	
4	Malvella leprosa	(Ortega) Krapov.	Malvaceae	MALE3	MALLEP2		1	alkali mallow
4	Mammillaria grahamii	Engelm.	Cactaceae	MAGR9	MAMGRA		8	Graham's nipple cactus
4	Mammillaria grahamii var. grahamii	Engelm.	Cactaceae	MAGRG4	MAMGRAG		2	Fishhook Cactus; Pincushion
4	Marrubium vulgare	L.	Lamiaceae	MAVU	MARVUL	FAC+	2	horehound
4	Melampodium leucanthum		Asteraceae		MELLEUL		1	plains blackfoot
4	Menodora scabra	Gray	Oleaceae	MESC	MENSCA		11	rough menodora
4	Mentzelia spp.	L.	Loasaceae		MENTZE		1	mentzelia spp.
4	Mirabilis longiflora	L.	Nyctaginaceae	MILO2	MIRLON	NI (FACW)	1	sweet four o'clock
4	Mirabilis spp.	L.	Nyctaginaceae		MIRABI		1	four o'clock spp.
4	Monarda spp.	L.	Lamiaceae		MONARD		7	beebalm spp.
4	Penstemon spp.	Schmidel	Scrophulariaceae		PENSTE		17	penstemon spp.
4	Penstemon virgatus	Gray	Scrophulariaceae	PEVI4	PENVIR		2	upright blue beardtongue
4	Physalis spp.	L.	Solanaceae		PHYSAL		2	groundcherry spp.
4	Plantago patagonica	Jacq.	Plantaginaceae	PLPA2	PLAPAT	NI (UPL)	102	woolly plantain
4	Polygala alba	Nutt.	Polygalaceae	POAL4	POLALB	NI (FACW-)	1	white milkwort
4	Polygala macradenia	Gray	Polygalaceae	POMA7	POLMAC		4	glandleaf milkwort

Table A-1. Plant species encountered in field sample plots for the Borderlands Ecosystem Management Area Vegetation Map (continued).

LF	Species Name	AUTH	Family	Kartesz Symbol	NMNHP Symbol	Wetland Status	No. Obs	Common Name
4	Polygonum aviculare	L.	Polygonaceae	POAV	POLAVI	FACW	1	prostrate knotweed
4	Polypodiaceae		Polypodiaceae		POLYPO		8	True Fern Family
4	Portulaca spp.	L.	Portulacaceae		PORTUL1		5	hogweed spp.
4	Proboscidea althaeifolia	(Benth.) Dcne	Martyniaceae	PRAL4	PROALT		1	devilshorn
4	Salsola kali	L.	Chenopodiaceae	SAKA	SALKAL	FACU	24	prickly Russian thistle
4	Sanvitalia abertii	Gray	Asteraceae	SAAB	SANABE		1	Albert's creeping zinnia
4	Schoenocrambe linearifolia	(Gray) Rollins	Brassicaceae	SCLI12	SCHLIN	NI (UPL)	2	slimleaf plainsmustard
4	Selaginella spp.	Beauv.	Selaginellaceae		SELAGI		10	spikemoss spp.
4	Senecio flaccidus	Less.	Asteraceae	SEFL3	SENFLA		12	threadleaf ragwort
4	Senecio flaccidus var. flaccidus	Less.	Asteraceae	SEFLF	SENFLAF		1	threadleaf ragwort
4	Senna bauhinioides	(Gray) Irwin & Barneby	Fabaceae	SEBA3	SENBAU		1	twinleaf senna
4	Sida abutifolia	P. Mill.	Malvaceae	SIAB	SIDABU		1	spreading fanpetals
4	Sidalcea neomexicana	Gray	Malvaceae	SINE3	SIDNEO	FACW	12	New Mexico checkermallow
4	Solanaceae		Solanaceae		SOLANA		1	
4	Solanum elaeagnifolium	Cav.	Solanaceae	SOEL	SOLELA	NI (FACU)	74	silverleaf nightshade
4	Solanum spp.	L.	Solanaceae		SOLANU		11	nightshade spp.
4	Solidago velutina	DC.	Asteraceae	SOVE6	SOLVEL	NI (FAC)	1	threenerve goldenrod
4	Sphaeralcea coccinea	(Nutt.) Rydb.	Malvaceae	SPCO	SPHCOC	NI (UPL)	1	scarlet globemallow
4	Sphaeralcea spp.	St.-Hil.	Malvaceae		SPHAER		56	globemallow spp.
4	Stephanomeria pauciflora	(Torr.) A. Nels.	Asteraceae	STPA4	STEPAU		8	brownplume wirelettuce
4	Stephanomeria spp.	Nutt.	Asteraceae		STEPHA		1	wirelettuce spp.
4	Talinum aurantiacum	Engelm.	Portulacaceae	TAAU	TALAUR		50	orange fameflower
4	Tragia ramosa	Torr.	Euphorbiaceae	TRRA5	TRARAM		1	branched noseburn
4	Trichostema arizonicum	Gray	Lamiaceae	TRAR	TRIARI	NI (UPL)	13	Arizona bluecurls
4	Trifolium spp.	L.	Fabaceae		TRIFOL		1	clover spp.
4	Verbena spp.	L.	Verbenaceae		VERBEN		12	vervain spp.
4	Verbesina encelioides	(Cav.) Benth. & Hook. f. ex Gray	Asteraceae	VEEN	VERENC	NI (FAC)	1	golden crownbeard
4	Viguiera spp.	Kunth	Asteraceae		VIGUIE		85	goldeneye spp.
4	Zinnia acerosa	(DC.) Gray	Asteraceae	ZIAC	ZINACE		20	desert zinnia
4	Zinnia grandiflora	Nutt.	Asteraceae	ZIGR	ZINGRA		47	Rocky Mountain zinnia
4	Zinnia spp.	L.	Asteraceae		ZINNIA		2	zinnia spp.

APPENDIX B

Image Processing Technical Specifications

Raster Thematic Mapper Satellite Data

An August, 1990 Landsat Thematic Mapper (TM) satellite scene, previously used for a Gray Ranch vegetation map, provided the basis for the Borderlands vegetation map. TM satellite 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. The image was imported into ERDAS Imagine (Version 8.2) where all raster processing and analysis was done.

Geometric Corrections

The image was map rectified 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 this image was sub-pixel error (less than 28.5 m). The image was georeferenced to the Universal Transverse Mercator (UTM) projection, Zone 12, using the 1984 World Geodetic System datum and the GRS 1980 spheroid.

Adjustment of Radiometric Errors

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:

$$\mathbf{L} = (\mathbf{DN} * \text{Gain}) + \text{Offset}$$

where **L** is the radiometrically corrected response and **DN** is the digital number value of the pixel. The gains and offsets found in Table B-1 were used to transform the image DN values (Lillesand and Kiefer, 1987).

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 for the sun above the horizon (solar elevation). The solar gain was calculated using the LOWTRAN 6 Atmospheric Modeling Program (Table B-2). The solar elevation can be calculated as:

$$\theta = 90 - \Phi$$

where θ is the solar elevation angle and Φ 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 λ 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 absorptions of these gasses was modeled by LOWTRAN 6. The absorptions of the different gasses were then added together to give total absorption which is then used to calculate transmittance (Table B-3). These factors are used to derive the actual reflectance ρ on the ground using the generalized formula as:

$$L_s = (1/\pi)\rho\tau_v(\varepsilon\tau_o \cos\theta + E) + L_p$$

where $\mathbf{L_s}$ is the light received at the sensor, $\boldsymbol{\tau_v}$ 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, **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.

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 either 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.

Table B-1. Gain and offsets used to radiometrically calibrate the image data.

	TM1	TM2	TM3	TM4	TM5	TM7
Offset	-0.15	-0.280487	-0.119403	-0.15	-0.014999	-0.014999
Gain	0.0602436	0.1175036	0.080597	0.0815399	0.0108074	0.0056984

Table B-2. Solar gain for the TM bands used in the study.

	TM1	TM2	TM3	TM4	TM5	TM7
SOLAR GAIN	189.0	168.0	144.0	101.63	21.6	7.6133

Table B-3 Atmospheric gas absorption and total atmospheric transmission coefficients used in the atmospheric modeling.

	TM1	TM2	TM3	TM4	TM5	TM7
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 Transmission	0.875	0.8945	0.9399	0.899	0.9431	0.9049