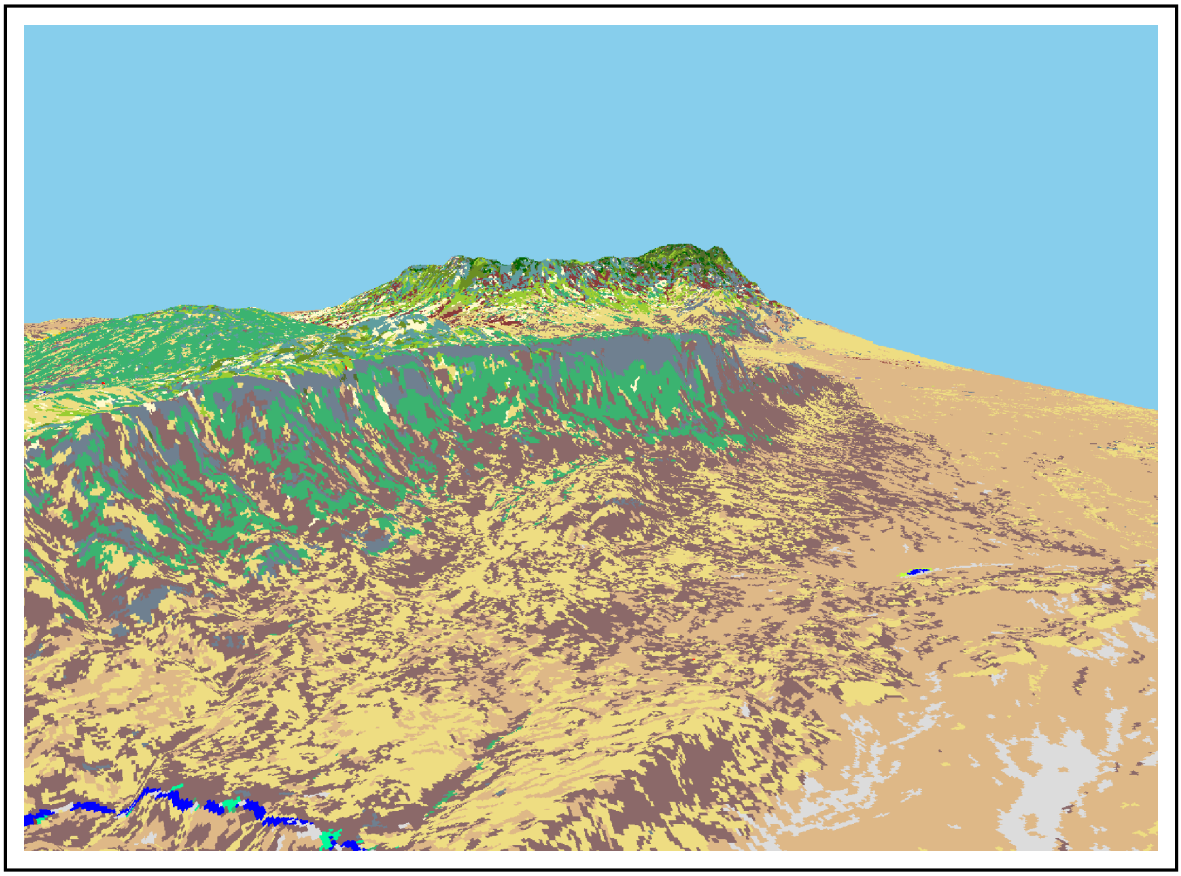
Vegetation Map of the Sierra Del Carmen

U.S.A. and Mexico

Final Report



USGS science for a changing world
NWRC

New Mexico Natural Heritage Program

NATIONAL PARK SERVICE

June 1999

EDAC

Vegetation Map of the Sierra Del Carmen, U.S.A. and Mexico

Final Report[1]

Sarah Wood, Glenn Harper, Esteban Muldavin and Paul Neville[2]

SUMMARY

The Sierra del Carmen straddles the border of the United States and Mexico near Boquillas, Coahuila, Mexico, and falls within the Maderas del Carmen Protected Area of Mexico, and the eastern portion of Big Bend National Park (Dead Horse Mountains) of the US. The Sierra del Carmen has long been known for its high biological values with respect to both flora and fauna. To support international cooperation on biological resources management of the range, a vegetation map with an annotated legend was produced at a scale of 1:100,000 using Thematic Mapper satellite imagery. To develop the map, a vegetation survey was conducted in both Mexico and the US resulting in the collection of 441 ground data points. Based on these data, a detailed provisional vegetation classification was developed using the International Classification of Ecological Communities system. This resulted in the initial identification of 121 plant associations, reflecting the high biodiversity of the area. The classification was used as a foundation for the development of 16 map units appropriate for management use at a scale of 1:100,000. Detailed map unit descriptions are provided, accompanied by wall-size paper maps. A discussion outlining the unique biological character of the Sierra del Carmen and a comparison of the distribution and composition of vegetation between Big Bend National Park and the Maderas del Carmen Protected Area is included.

RESUMEN

La Sierra del Carmen se encuentra en cada lado del borde de los Estados Unidos y México. La sierra está ubicada cerca de Boquillas, Coahuila, México, y queda dentro de la Área Protegida de Maderas del Carmen en México, y dentro de la parte este de Big Bend National Park (Dead Horse Mountains) de los Estados Unidos. La Sierra del Carmen a sido reconocido por muchos años por su valore biológico con respecto a la flora y fauna. Para apoyar cooperación internacional sobre el manejo de los recursos biológicas de esta area, producidmos un mapa de vegetación de escala 1:100,000 y con leyenda anotada usando imágenes de satélite de Thematic Mapper. Para desarollar el mapa, un estudio de vegetación fue conducida en México y en los Estados Unidos con el resulto de 441 puntos de muestras. Con estos datos, presentamos una clasificación provisional con todo detalle usando el sistema de Clasificación Internacional de Comunidades Ecológicos y resultamos en la identificación de 121 asociaciónes de plantas, que reflejan la calidad de biodiversidad del área. La clasificación fue usado como una fundación para el desarrollo de 16 grupos de mapa apropriadas para el manejo del area de estudio en una escala de 1:100,000. Acompañando el mapa hay descripciónes de los grupos de mapa y los tipos de vegetación que representan. Una discusión sobre la comparación de la distribución y composición de vegetación dentro de Big Bend National Park y de la Área Protegida del Maderas del Carmen de México es incluido.

Cover: *A computer generated scene of the Sierra del Carmen in Mexico with the vegetation map draped over the topography. The view looks southeast with the Rio Grandé in the foreground and the Centinela Peaks in the background.*

---

[1] Final report submitted to the US. Geological Survey, National Wetlands Research Center, and the National Park Service (Big Bend National Park) in partial fulfillment of Sub-agreement 14 of Cooperative Agreement No. CA7029-1-012 between the National Park Service and the University of New Mexico.

[2] Sarah Wood is an Associate Ecologist and Esteban Muldavin is the state ecologist and Senior Research Scientist with the Biology Department's New Mexico Natural Heritage Program, University of New Mexico, Albuquerque, NM 87131; Glenn Harper is presently Range Project Coordinator, Pueblo of Santa Ana, Department of Natural Resources, 51 Jemez Dam Road, Bernalillo, NM 87004; Paul Neville is a Remote Sensing Specialist at the Earth Data Analysis Center (EDAC) at the University of New Mexico, Albuquerque NM 87131.

ACKNOWLEDGEMENTS

A number of landowners, ranchers and *ejidatarios* (collective ranch owners) graciously granted us access to their land, permission to sample, and lodging in Mexico. Ranchhands were often the source of valuable local information, and were usually eager to talk with us and interested in what we were doing. Everyone we met was incredibly generous with their time and hospitable beyond their means. As communication with contacts was often informal, or through another mediating party, some people are mentioned here only by their first names. Nevertheless, we would like to acknowledge them in this document.

During our first month, Alberto Garza-Santos and Mauricio Brittingham permitted us to work from a base camp on their land in the high country of the Maderas del Carmen. We shared this camp with the Texas A&M team as well as Garza-Santos' ranchhands: Pepe, Bocho, Ramon, and Mario. The ranchhands were lively company, local guides for the area, occasional field helpers, and they also built most of the camp's infrastructure. Most importantly, they taught us the fine art of making tortillas, one of our food staples while in Mexico.

In mid-September, we moved to Pilares, a ranch at the base of the mountains on the western side where we stayed in an outbuilding of Ricardo Ramirez' ranch house. Here, ranchhands Chapita and his son Sergio were a good source of local information. Ramirez allowed us to sample on portions of his ranch and also secured permission for us to sample on *Don* Isiderio's ranch (at the base of the Maderas). We never met *Don* Isiderio, but his ranchhand Juan and family extended their hospitality and guided us around the land.

Ramirez and Diana Crider also mediated communication with *Don* Juan at Rancho Guadalupe on the east side where we stayed for a week. Also on the east side, local landowners Benjamin and his brother, of Piedra Blanca ranch, rented us their house in Morelos, and also invited us to sample on and around their ranch. Yolanda, of the Morelos *ejido*, was a good source of local information and authorized us to sample there. Sam and Jackie, caretakers of Rancho Santo Domingo, extended both hospitality and permission to sample around their property. Alejandro Falcon, owner of Rancho Potrero, was most welcoming and gave the field crew a tour of his property, as well permission to sample.

In Big Bend National Park, park botanist Denise Louie worked to provide us with lodging and logistical support, as well as botanical expertise. She made arrangements for two field helpers - Joe Sirotnik, a National Park Service technician, and Claudia Castillo-Jimenez, the botanist for the Canon de Santa Elena Protected Area in Mexico - to work with us for the week.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The Sierra del Carmen is a diverse and complex mountain range that extends from the Big Bend country of Texas, south across the Rio Grandé into northern Coahuila, Mexico. It has long been recognized as possessing highly valuable biological and scenic resources. On the US side, the Dead Horse Mountains section of the range is mostly within Big Bend National Park, and is one of the most remote areas of the park. Across the river on the Mexican side, the Sierra del Carmen are made up of the Sierra Fin del Jardin to the north and the Maderas del Carmen to the south, all within the boundaries of the government designated Maderas del Carmen Protected Area (variously made up of private and collectively owned lands or ejidos). Overall, this desert mountain landscape extends over 115 km (70 miles) from north to south, ranges from 16 to 48 km (10 to 30 miles) wide, and rises from the floor of the Chihuahuan Plateau at 700 m (2,290 ft) to over 3,100 m (9,000 ft) at the summit of the Maderas del Carmen. As a consequence of its size, topographic diversity and remoteness, the mountain range harbors a wide variety of ecosystems, from desert shrublands to high montane forests, and contains several endemic species and communities of high biological interest.

The establishment of the Maderas del Carmen Protected Area in 1994 has led to increased formal and informal cooperation between managers on both sides of the border. To enhance efforts by resource managers in the United States and Mexico for developing and implementing coordinated management strategies for protection of biota and sustainable use of the region by the public, an effort was initiated to acquire baseline information on vegetation and geology in both Mexico and the United States[3]. To fulfill the vegetation information needs, the New Mexico Natural Heritage Program (NMNHP) of the University of New Mexico was enlisted in 1996 to conduct a vegetation survey in the US and Mexico, and to develop a detailed vegetation map for the region based on satellite imagery.

There were four specific goals for the project: 1) produce a vegetation map with an annotated legend using Thematic Mapper satellite imagery of the Sierra del Carmen within the protected area of Mexico, and for the Dead Horse Mountains of Big Bend National Park [i.e., revise Plumb's (1991, 1992 &1993) vegetation map]; 2) survey the vegetation and develop a provisional classification of vegetation communities; 3) establish and monument a selected set of plots to serve as long term monitoring sites in as many vegetation communities as possible; and, 4) provide an initial comparative analysis of differences and similarities among vegetation communities in Mexico and the U.S.

Meeting these goals required multinational support and cooperation from researchers at the Universidad Autonoma de Nuevo Leon at Linares, Universidad Autonoma Agraria Antonio Narro, Texas A&M University at Kingsville and Texas Tech

[3] General plan of study for vegetational and geological survey of Big Bend National Park and Coahuila, Mexico. US National Biological Service and National Park Service undated file report.

University, along with technical and logistical support from park and protected area personnel. With their help, extensive field studies were completed in 1997 and 1998. These data formed the basis for producing a detailed vegetation map at a 1:100,000 scale. The map and associated survey information provide the first unified look across national boundaries at the distribution and vegetative composition of ecosystems in the Sierra del Carmen, and they are intended to provide a firm foundation for international cooperative natural resources planning in the future.

Previous Studies

Descriptions of the vegetation in the Sierra del Carmen are found within regional vegetation surveys of Coahuila, but there are also studies which focus exclusively on the protected area itself. For example, Villarreal and Valdes (1993) provide an excellent overview of the major vegetation types of Coahuila, building on the work of Muller (1947), Rzedowski (1978), Marroquin (1976), Henrickson and Johnston (1983) and others. Specific references to the distribution of vegetation in the Maderas del Carmen can be found in Henrickson and Johnston's (1997) draft of the flora of the Chihuahuan Desert Region, and Muller's (1947) description of vegetation associations and climate for the state of Coahuila. In 1988, before the area was designated as protected, the Universidad Autonoma de Nuevo Leon (UANL) Biology Department conducted plant and animal surveys in the Maderas del Carmen, with recommendations for conservation. Vegetation and faunistic associations for the mountains were also delimited and mapped on a broad scale (1:352,000) by Jimenez-Guzman and Zuniga-Ramos (1991). A generalized vegetation map was produced as part of the recent management plan developed for the Maderas del Carmen Protected Area by the Instituto de Ecologia which also includes information on soils, geology, animals, as well as plans to preserve, conserve, or rehabilitate defined management units.

Other surveys of the region cover geological and sociological aspects of the area. Collins and Raney (1996) produced a 1:250,000 scale geological map of the area through interpretation of aerial photography and compilation of previous maps and descriptions. Carrera (1995) surveyed the collective ranches (ejidos) west of the main mountain area with regards to land use practices, industry, infrastructure, and attitudes of the residents towards natural resources to determine how to implement natural resource conservation while improving living conditions.

Project Collaborations

Besides the University of New Mexico, Big Bend National Park, and the National Wetlands Research Center, the project was directly involved with the Universidad Autonoma de Nuevo Leon at Linares; Universidad Autonoma Agraria Antonio Narro at Saltillo, Coahuila; Maderas del Carmen Protected Area; Texas A&M, Kingsville; Texas Tech, Lubbock (center for the Texas and Mexican GAP programs); local landowners; and other contributing scientists. Details on these arrangements are listed below.

To expedite coordinated efforts and information exchange, we made several pre-

and post-field season trips to visit with our more distant collaborators. The month and year of these trips is listed in parentheses at the end of each numbered item.

1. *Universidad Autonoma de Nuevo Leon, Facultad de Ciencias Forestales, Linares, Nuevo Leon, Mexico*. Dr. Alfonso Martinez, a professor at Linares who has ongoing research projects in the Maderas del Carmen and elsewhere in northern Mexico, agreed to be our Mexican sponsor and collaborator because of our mutual interest in the project area. Marisela Pando-Moreno, M.Sc., a specialist in remote sensing and on the faculty at Linares, was a co-sponsor. Dr. Martinez, working with the authorities in Mexico City, provided us with the necessary permits to collect plant specimens. Dr. Muldavin has met with Dr. Martinez twice in Mexico and made a presentation to the faculty at the school on the project where the possibility of future and more extensive collaboration was discussed. (September 1997 and March 1998).

2. *Juan Medel-Añorve, Undergraduate at Universidad Autonoma de Nuevo Leon, Monterrey, Nuevo Leon, Mexico.* In keeping with our intent to support Mexican students through the project grant, we offered to support a student from Linares who might have an interest in vegetation analysis and mapping. Juan Medel-Añorve, an undergraduate in his final year of study, was offered a fellowship during and after the field season on the recommendation of Dr. Martinez. Juan assisted crews during the field season and spent seven weeks in Albuquerque in January and February of 1998, working on an independent project as part of the requirements for completion of his bachelor's degree. Using the data collected and our facilities, he produced a vegetation classification based on analysis of elevation, and "crosswalked" his classification to those developed by Rzedowski (1978) for Mexico, Villarreal and Valdes (1993) for Coahuila, and the New Mexico Natural Heritage Program for the Sierra del Carmens (this volume).

3. *Cesar Kleberg Wildlife Research Institute at Texas A&M, Kingsville, Texas, USA.* Diana and Cody Crider, respectively graduate students of Dr. David Hewitt and Dr. Tim Fulbright at the Institute, initiated a study on Mexican black bears in the Maderas del Carmen, following up on Ms. Crider's work in the Serranías del Burro, a neighboring mountain range to the east of the Maderas del Carmen. The Criders were introduced to us at the behest of the National Park Service Southwest Regional Office in Albuquerque in the fall of 1996 because of the potential value of our vegetation map to their black bear project, and because their experience working in Mexico might help us execute the project. At that time the Criders had established working relationships with landowners in the Maderas del Carmen and were planning to establish a camp for their research in the more remote area of the protected area.

   We enlisted their cooperation and had a meeting in Kingsville with Drs. Hewitt and Fulbright as well as the Kleberg Institute director, Dr. Fred Bryant. Cody Crider had a particular interest in our vegetation mapping and analysis with respect to his own thesis work on black bear habitat utilization. Because of this, we offered him a research assistantship (RA) on the project so that he could learn techniques to support his work. We also agreed to provide Global Positioning System (GPS) support to the

black bear project. The black bear project provided invaluable logistical support in the form of liaisons between us, landowners and other authorities to obtain permission for our sampling activities. (April 1997).

4. *Universidad Autonoma Agraria Antonio Narro (UAAAN), Saltillo, Coahuila, Mexico.* Dr. Jesus Valdes-Reyna, a botanist and ecologist at UAAAN and an expert on the flora of Coahuila and Chihuahua, agreed to help us with the identification of specimens. We brought unidentified specimens to UAAAN in March, 1998 for identification and accession to his herbarium, and agreed to deposit the main collection there. Juan Villarreal, the herbarium curator, was also of invaluable help in identifying specimens. (March 1998).

5. *Dr. Julio Carrera, Maderas del Carmen Protected Area, Mexico.* Dr. Muldavin contacted Dr. Carrera, director of the Maderas Del Carmen Protected Area, by phone and in writing in the Spring of 1997. Copies of the project proposal, study plan and interim report were sent to him for comment. By phone, Dr. Carrera authorized our work in the protected area on the assurance that we had the proper permits. At that time Dr. Carrera was not prepared to offer any direct collaboration or support, but he did express interest in receiving our results in a form that would be useful for the protected area's management. Dr. Muldavin also met briefly with Dr. Carrera in Boquillas del Carmen, Mexico where he described the project's progress and reaffirmed the need to cooperate more closely with protected area personnel in the future. We also presented the map to Dr. Carrera, among others, at a research meeting at Big Bend National Park in April 1998. (September & October 1997; April 1998).

6. *Alberto Garza Santos and Mauricio M. Brittingham, Maderas del Carmen, Mexico.* Alberto Garza and Mauricio Brittingham, major landowners in the central Maderas del Carmen area, were introduced to us by Diana and Cody Crider. They permitted us to maintain a cooperative base camp in the mountains with the Criders in exchange for a copy of our reports, maps and data. We met with Mr. Garza and Mr. Brittingham on two different occasions on their land in the Maderas del Carmen, and Dr. Muldavin and Mr. Brittingham met in Monterrey, Mexico where they discussed the project. (July, September 1997).

7. *Texas Cooperative Fish and Wildlife Research Unit, Texas Tech University (Texas and Mexico Gap Project), USA.* Dr. Nick Parker and Dr. Carlos Rebeles at the Cooperative Unit at Texas Tech are leading the Texas Gap project and helping to coordinate the Mexico Gap Project. The Texas Gap project had already acquired the most recent Landsat TM scenes for their project that also covered our study area. In a Memorandum of Understanding (MOU), we agreed to provide the Texas Gap project with ground data and a copy of our map in exchange for imagery of the area. This avoids duplication of effort over the same area. In addition, we also agreed to work closely to ensure that our map legends are compatible and can be cross-walked for later analysis and integration.

8. *Dr. James Henrickson, California State University, USA.* Dr. Henrickson has worked extensively in the Sierra del Carmen and the Northern Chihuahuan Desert region. He loaned us, for use and comment, a draft of his *Flora of the Chihuahuan Desert Region*, which he co-wrote with Marshall Johnston of the University of Texas. This flora covers the mountain ranges within the region, including the Sierra del Carmen, and contains distribution data specific to the range. This reference was invaluable as no other compiled flora exists for the region.

9. *Dr. Richard Spellenberg, New Mexico State University, Las Cruces, New Mexico, USA.* Dr. Spellenberg is an expert in oaks of the Frontera region the Sierra Madre Occidentale. He generously gave us a draft of his manuscript "The Oaks of La Frontera and Adjacent Regions," which contains a key as well as ecological and distributional information on most of the oaks we expected to encounter in the Maderas del Carmen. He also agreed to identify our troublesome oak specimens.

10. *Instituto Nacional de Estadistica, Geografia e Informática (INEGI), Saltillo, Nuevo Leon, Mexico.* INEGI is the branch of the Mexican government dealing with geographical resources. We purchased from them a set of black and white aerial photos (1:75,000) taken in November 1994 which covered 95% of the study area. These aided our mapping, especially in under-sampled areas. In addition we acquired 1:250,000 Digital Elevation Models (DEMs) of the area to supplement the digital line graphs (DLGs) we had acquired earlier from the Texas Department of Transportation.

MATERIALS AND METHODS

Study Site

The study area is located in Brewster County, Texas and northern Coahuila, Mexico at a latitude between 28°10' and 29°40'N and a longitude between 102°20' and 103°80'W (Figure 1). It is made up of a north-northwestward trending mountain range with surrounding desert basins on the east and west sides, and is part of the Chihuahuan Desert region as defined by Henrickson and Johnson (1997). The total area is 261,943 hectares (647,283 acres).

The mountain range may be divided into three broad sections based on latitude, geology, elevation and vegetation. The northern section in Texas - the Dead Horse (Caballo Muerto) Mountains (Figure 2) - is a large limestone fault block dipping eastward. This section has the lowest elevational range, from about 850 m to 1,600 m (2,700 ft to 5,250 ft). Vegetation is mostly succulent desert shrubland and grassland, with some oak chaparral at the highest elevations. Vehicle access is primarily limited to the Old Ore Road, which runs along the base of the escarpment on the west side; otherwise, it is necessary to hike on the primitive trails throughout the range.

The middle section, south across the Rio Grandé in Mexico, is the central portion

Vegetation Plot Sites at the Sierra Del Carmen, U.S.A. and Mexico

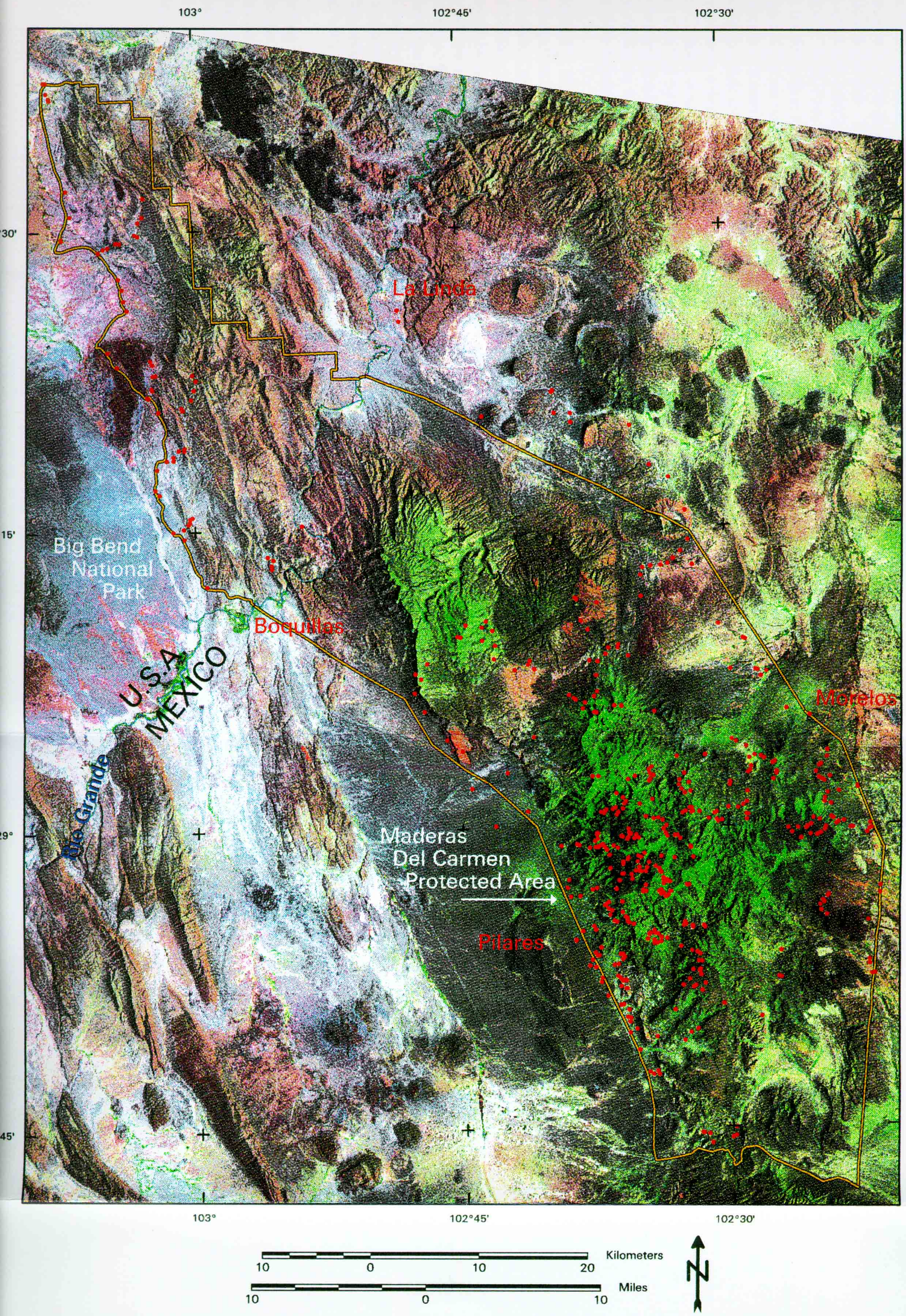


Figure 1. Sierra del Carmen study area showing distribution of sample points. The boundary of the study area is overlain on a false-color Thematic Mapper satellite image where red is TM band 7 (far infrared), green is TM 4 (near infrared), and blue is TM 2 (natural green).

of the Sierra del Carmen, known as Sierra Fin del Jardin (or El Jardin al Fin). It, too, is a tilted sedimentary fault block with a northeast-trending dipslope along with igneous rock intrusions. The dramatic limestone escarpment of the El Jardin is visible from Boquillas del Carmen and Big Bend National Park (Figure 3). Elevation ranges from about 500 m (1,640 ft) at Boquillas del Carmen to over 2,200 m (7,200 ft) at the top of the escarpment. Vegetation ranges from desert shrubland and grassland on the footslopes to chaparral at mid-elevations, and pinon-juniper-oak woodland at the highest elevations. There are few passable roads in these exceptionally remote mountains.

A moderately wide valley separates the Sierra Fin del Jardin from the Cerros el Centinela (Figure 4) and the rest of the southern section known as the Maderas del Carmen or Sierra Maderas del Carmen (Figure 5). From the Centinelas south the range is mostly exposed igneous volcanic rocks, commonly rhyolite and andesite, with some minor limestone exposures in the foothills. The elevations range from 700 m (2,300 ft) at the base of mountains to over 3,100 m (10,170 ft) at the top. Along with this wide range of elevation comes a concomitant range in vegetation from desert grasslands and shrublands in the lowlands to mixed conifer forests at the highest elevations. Roads in the high country are few and are associated with logging or ranching activities. The main road from Musquiz to Boquillas del Carmen runs north-south below the western escarpment, and the road to La Linda runs in the valley on the eastern side.

Overall, the mountain range is positioned at the northern end of the Sierra Madre Orientale cordillera as well as between the Chihuahuan Desert and Tamaulipan Thorn Scrub vegetation provinces. It is the first major mountain mass that intercepts storm systems from the Gulf of Mexico to the east. The resultant precipitation at high elevations contributes to the maintenance of mixed conifer and deciduous oak forests characteristic of the Madrean biotic province (Muller 1947, Pase and Brown 1982). Higher precipitation on the east side may also contribute to the formation and maintenance of extensive grasslands found on the footslopes there. Lowland elevation on the east side of the range is typical of the Chihuahuan Desert, but there are elements of desert Tamaulipan Thorn Scrub (as defined by Muller 1947), although ‘pure’ Tamaulipan thorn scrub occurs further to the east at lower elevations. The west side, however, experiences a double rain shadow effect whereby storms from the east are blocked by the Sierra del Carmen mountain mass and storms originating in the Pacific Ocean and Gulf of California are blocked by the main mass of the Sierra Madre Occidentale (Muller 1947). This creates the most arid conditions within the study site at low elevations on the west side. Vegetation is similar to that of the Trans-Pecos region of the Chihuahuan Desert in west Texas and southern New Mexico (Muller 1947, MacMahon 1988).

Geologically, the area is complex and only broadly mapped (Collins and Raney 1996), although the Boquillas area and part of the Sierra del Carmen escarpment have been mapped in detail (Maler 1989, Carpenter 1996). Much of the main mountain mass is composed of Tertiary volcanic rocks of both intrusive and extrusive origins. Inactive splatter cones are present in the northeast section of the study area near Mesa Guadalupe. The igneous units overlay several well defined layers of Cretaceous sedimentary rock laid down when the area was submerged by the Mesozoic sea. Upper Cretaceous units are

limestone mixed with sandstone, claystone and siltstone; Lower Cretaceous units are predominantly limestone and metamorphic rocks (marl, chert, marble). Limestone is exposed in the foothills of the Maderas del Carmen and at the large block uplift that makes up the Sierras del Carmen—these sites were presumably beyond the reach of the Tertiary lava flows. Drainageways, arroyos and alluvial fans are filled with Tertiary and Quaternary alluvium.

According to a map produced by the Instituto Nacional de Ecologia, there are 23 land parcels within the Maderas del Carmen Protected Area. Approximately seven of these are in collective ranches or *ejidos*; another seven are private ranches, and ownership of the rest is unclear. Presently, the primary land use is domestic livestock grazing. Logging occurred in the highest elevations of the Maderas del Carmen throughout much of the 20th century, but has been discontinued (logging last occurred in the 1980's). Cattle grazing and hunting have also been excluded recently from the high country of the Maderas del Carmen.

Figure 2. The Alto Relex on the western flank of the Dead Horse Mountains of Big Bend National Park. The exposed limestone strata are typical of the U.S. portion of the Sierra del Carmen.

Figure 3. Sierra del Carmen in Mexico looking south from the Rio Grandé across from Boquillas del Carmen, Coahuila. The steep limestone escarpment of Sierra Fin del Jardin is to the left and the volcanic Maderas del Carmen are in the background.

Figure 4. Looking south across the valley from Sierra Fin del Jardin that are predominantly limestone to the volcanic Cerros el Centinela.

Figure 5. The western front of the Maderas del Carmen which is composed mostly of rhyolites and other volcanic extrusive rocks.

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 Geographic Information System – or GIS (Figure 6). 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 distortions of the raw imagery. A preliminary unsupervised classification analysis was run using ISODATA (ERDAS 1998) to determine optimal strategies for mapping and field sampling. Unusual spectral responses were identified and targeted for field sampling, and a field sampling strategy was devised that covered the range of spectral variation in the image.

A ground vegetation survey was then conducted to gather information on vegetation community composition, environmental characteristics and location throughout the study area. Using these 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 framework of the International Classification of Ecological communities and the U.S. National Vegetation Classification (Grossman et al. 1998) which meets Federal Geographic Data standards.

The next step was to develop a preliminary vegetation map using a supervised image classification procedure based on ground survey data and additional points interpreted from aerial photographs. At this stage, each ground point represents a map class, which in turn is defined in terms of community types of the vegetation classification. Individual map classes were then grouped into map units based on similar vegetation composition, similar landscape structure and spatial continuity. The final vegetation map was then generated. Map unit descriptions, which serve as the annotated map legend (Appendix A), were developed which summarize the vegetation composition and landscape characteristics of each unit.

VEGETATION MAPPING STRATEGY

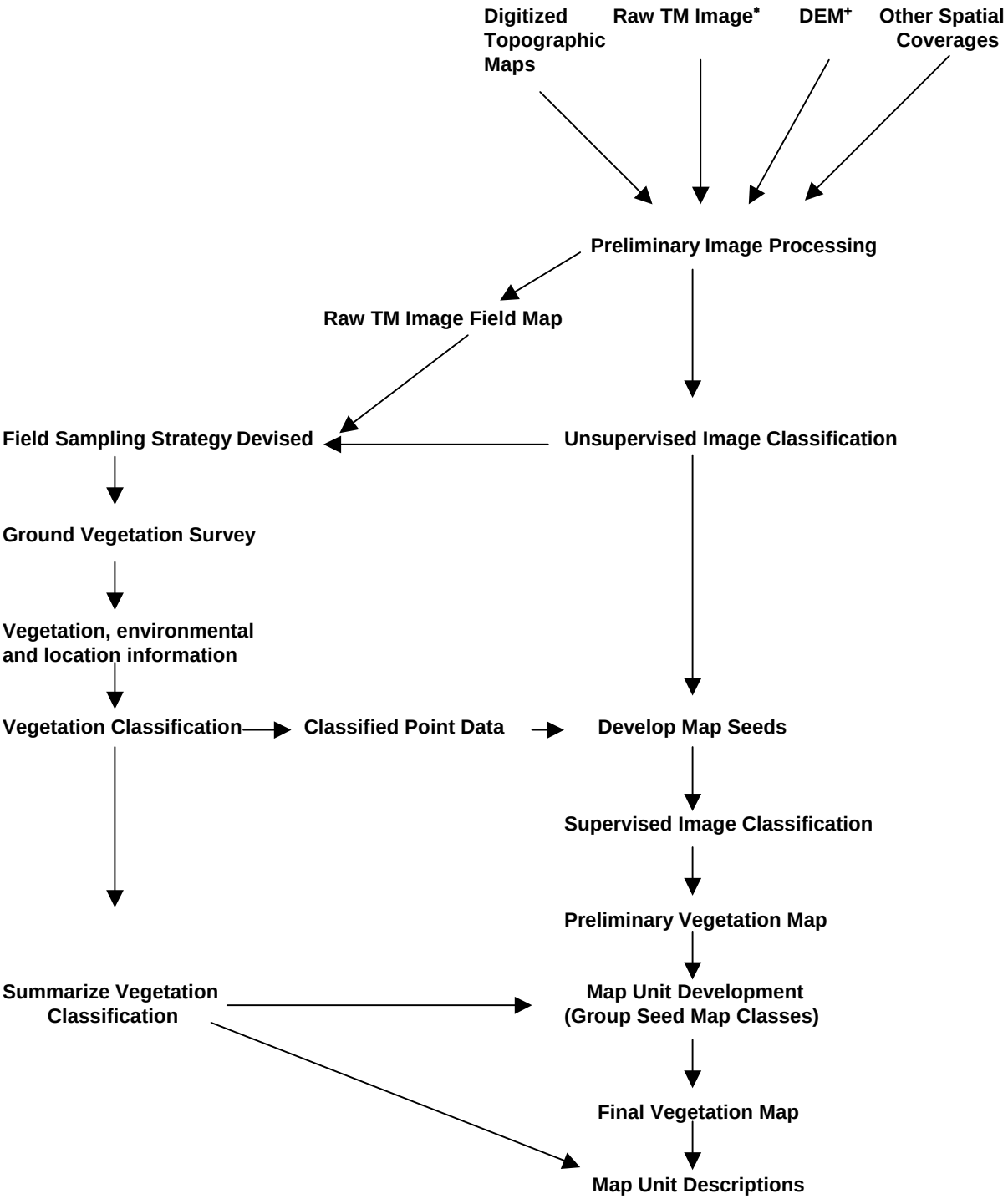


Figure 6. Flow chart of the mapping strategy used to develop the Sierra del Carmen Vegetation Map.

---

* TM = Thematic Mapper
+ DEM = Digital Elevation Model

Data Sources

Satellite Imagery

A July 23, 1993 Landsat Thematic Mapper (TM) satellite image covering the study area was provided by the Texas Gap Project and imported into ERDAS™ Imagine (Version 8.3) image processing program. The image is cloud free, but steep topography in the mountains and barrancas (ravines) created some deep shadows on northern aspects.

Late summer imagery was used to catch the “green up” period for this region, when most perennial vegetation is at peak production. TM 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. Only one full scene was required to cover this study area, and imagery comes in a digital form suitable for analytical and computerized map production. With its stable sensor platform, satellite imagery is relatively easy to geometrically correct to known coordinates of a base map, thus avoiding the complex geometry of orthorectifying and patching together 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 position 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. 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 evaluates and quantitatively identifies 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 these kinds of 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	Highly sensitive in the chlorophyll absorption region, which aids 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.

The imagery received from the Texas Gap Project was projected on a NAD83 Datum using a GRS 1980 spheroid, whereas the projection of the topographic maps is on a NAD27 Datum and a Clarke 1866 spheroid. Thus, points on the topographic (field) maps were 40 m west and 200 m north of the image location. Before rectifying the image, it was necessary to project the digitized topographic maps to agree with the image projection. Then the TM image was geo-rectified to a map-based coordinate system using a nearest-neighbor interpolation. This involves matching a point on a topographic map with the same point on the image and makes the image planimetric so that area, direction, and distance measurements can be calculated. The root mean square error is computed to determine how well the map and image coordinates fit in a least-squares regression equation.

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.

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, and thus helps distinguish vegetation reflectance over soil reflectance. The NDVI also allows quick assessment of class signatures; for example, a riparian area should have a higher NDVI response than a senescent grassland.

Ancillary Map Coverages and Aerial Photography

Several spatial coverages over the US portion of the study area were obtained from the Big Bend National Park GIS. These included roads, hydrological features, digital elevation models and the original Plumb (1991) vegetation map for Big Bend National Park. In Mexico, coverages were limited to digital elevation models at 90 m resolution and scanned versions of the regular 1:50,000 topograhic map quadrangles produced by Instituto Nacional de Estadistica Geographica e Informatica (INEGI). The best available high altitude black and white aerial photography from 1994 was also obtained from INEGI to support the mapping process and fieldwork.

Sampling Methods

The foundation for the image classification and map development is the field vegetation plot data. Potential field plot locations for the 1997 field survey in Mexico were identified using raw TM imagery, an unsupervised classification of the imagery, aerial photographs and the

1:50,000 scale maps for the study area. Spectral response, represented by the unsupervised classification, proved to be ineffective for allocating sampling points. For example, only three classes in the high country were generated, while 18 were produced for lower elevation alluvial fans and piedmonts. Prior experience in similar areas of the Southwest has led us to expect more classes in the mountain area than were produced and less on the fans. Hence, the unsupervised classification would have lead to a skewed sampling distribution towards desert vegetation types, although the majority of the area consists of high elevation montane vegetation. To ensure wider, more equitable coverage, potential sampling sites were distributed among a wide variety of landforms and geologic substrates and at different elevations, slopes, and aspects. The unsupervised classification did identify several spectrally distinct classes that were not easily interpretable and thus were specifically targeted for sampling. For example, dark irregularly shaped patches against a lighter colored background often indicate burns; similarly, limestone often appears as a pink-white color. For logistical reasons, all sample points were within a day's walking distance from road access (one overnight backpack trip was done).

Sampling in the Dead Horse Mountains of Texas in 1998 was done after production of the preliminary vegetation map, and was guided by vegetation classes generated from sampling in Mexico. In addition, areas of major discrepancy between the new map and Plumb's (1991) map for Big Bend were targeted for specific field sampling.

Potential sample sites were delineated on raw 1:50,000 satellite image maps using TM bands 2 (visible green), 4 (near infrared) and 7 (mid-infrared) overlain on the corresponding Mexican quadrangles of the area. The 2/4/7 band combination maximizes differences in reflectance between water (band 2), vegetation (band 4), and soils and geological features (band 7), while producing a 'natural' looking display where vegetation is shown as green and soils as red, blues or greys. Two copies of these maps were laminated for field use.

Field Sampling

Final plot selection was based on field reconnaissance and identification on the ground of large stands of homogeneous vegetation representing the major vegetation types. In the field, sampling was dictated by accessibility, both in terms of permission from landowners (see below) and topography. There are few roads in the Sierra del Carmen, and most sampling plots were reached by hiking. Plots were located at least 50 m from roads or trails, and within homogenous plant associations of at least one hectare or more in size.

There were five types of plots which varied with respect to use and the amount of quantitative data collected:

1) Monitoring Plots. These are highly quantitative and intensive 400 m^2 plots that are designed to be re-measured over long periods of time. Data provided include a complete plant species list for the stand along with high resolution plant cover estimates, and detailed site characterization. Within each plot, two parallel 20 m transects were established, monumented with white painted rebar, and tagged at each end with aluminum tags. Twenty,

50 X 20 cm quadrat frames (Daubenmire frames) were placed at one-meter intervals along each of the lines, beginning at the one-meter mark. Within each quadrat, percent canopy cover was estimated for each plant species along with total exposed soil, gravel, litter and plant basal area. Because this type of sampling is time consuming, it was limited to sites of high biological interest with the highest likelihood of being revisited (most are in the Maderas del Carmen). Monitoring plots were also used in the classification and mapping process and serve the purpose of calibrating visual estimates of species cover for the more rapid plot types described next. On the average, monitoring plots took about 6 hours.

2) Relevés. These are circular 400 m^2 plots which, like monitoring plots, have complete species lists that are compiled for the stand, and detailed site information but lack the intensive quadrat transects. Rather, canopy cover is visually estimated for each species over the entire plot area, and recorded using the a modified Domin-Krajina scale (Mueller-Dombois and Ellenberg 1974) that groups low-cover plants into narrower ranges than high-cover percentages (Table 2). This scale is advantageous when working in arid regions where cover values for plants are typically low, as it effects a finer resolution for low-cover plants. Relevés take a moderate amount of time (2+ hours) to sample, and were done to provide more comprehensive floristic definition to plant associations.

3) Standard plots. These plots are the same size and shape as relevés, but only those species found within the plot boundary are recorded (a comprehensive species list for the remainder of the stand outside the plot is not compiled). Cover estimates are made using the Domin-Krajina scale. Site characterization is sufficient for most mapping and plant association characterization and includes the following attributes: slope shape, grade and aspect, surface soil texture and color, ground cover (percent rock, gravel, bare soil and litter and basal area), elevation, surface rock type and erosion type along with a narrative description of the site and directions. Standard plots took about 30 minutes to complete.

4) Reconnaissance Plots. These are approximately 400 m^2 circular plots where only dominant species are recorded with their cover estimates, and a limited set of environmental characteristics is described. Most of these were done to quickly spatially replicate plant associations for the mapping process. They took roughly 15 minutes to complete.

5) Photo Points. Locations where panoramic photographs were taken of surrounding, but distant, and potentially inaccessible landscapes (although some areas in photos were later visited). Observers determined vegetation characteristics using binoculars, described the photos taken and drew the boundaries of the plant associations on the topographic or TM image map. Photo points were taken opportunistically, or in conjunction with a standard or reconaissance plot. These photo points served as a mapping tool in areas which were not accessible.

Species names follow Kartesz (1994) and Henrickson and Johnston[4]. A species list derived from the plot data is provided in Appendix B.

[4] *Flora of the Chihuahuan Desert Region* 1997 Draft

Table 2. Modified Domin-Krajina Vegetation Cover Scale from Mueller-Dumbois and Ellenberg (1974).

Cover Class is the scalar value assigned in the field; Percent Canopy Cover is the range of cover the class represents; meters^2 / 400 meters^2 is the actual area represented within the 400m^2 plot; and Midpoint % Cover is the midpoint canopy cover value used in analysis of the data.

Cover Class	Percent Canopy Cover	Meters^2 / 400 Meters^2	Midpoint % Cover
+0	<.01	outside plot	0.001
+	<.05	< 0.04	0.01
1	<0.1	≥ 0.04 & < 0.5	0.05
2	<1	≥ 0.5 & < 4	0.5
3	1 – 4	≥ 4 & < 16	2.5
4	5 – 10	≥ 20 & < 40	7.5
5	10 – 25	≥ 40 & < 100	17.5
6	25 – 33	≥ 100 & < 132	29
7	33 – 50	≥ 132 & < 200	41.5
8	50 – 75	≥ 200 & < 300	62.5
9	> 75	≥ 300	87.5

The highly accurate plot locations necessary for use in the mapping process were determined using a Global Positioning System (GPS). Locational data were collected with Trimble's Geoexplorers and differentially corrected with Trimble P-finder® software to within 10 m accuracy. Base station data were obtained from the closest stations available (Odessa and San Antonio, Texas) via the Texas Department of Transportation base station network. All plots were successfully corrected.

A total of 441 data points were collected that are distributed over most of the Sierra del Carmen in Texas and Mexico (except in the far northern quarter of the Mexico portion where access was especially difficult, see Figure 1). These include: 15 monitoring plots, 40 relevés and 159 standard plots over the study area in Mexico; 62 standard plots in the Dead Horse Mountains of the US; 140 reconnaissance plots in Mexico, and 25 photo points where vegetation was directly mapped on topographic quadrangles and image maps. With 15 monitoring plots, we exceeded our goal of 12. We also exceeded our goal of 300 quantitative relevé, standard and reconnaissance plots by 101 plots.

Field Sessions

Sampling in Mexico began in July, 1997. A total of 58 days in the field, not including travel to the site and back, were spent during that summer and fall, beginning with a week-long reconnaissance trip in July followed by two extended sampling trips between August 17 and October 30. Work began at the highest elevations and gradually moved to lower elevations in the autumn to coincide with plant growth and flowering. In 1998, the Dead Horse Mountains in Texas were sampled between June 9 and June 13. The relative vegetation homogeneity of the Dead Horse Mountains required less sampling time. In addition, sampling was primarily directed towards ground-truthing this section of the map rather than baseline data collection. A detailed schedule of our field activities in Mexico can be found in the Interim Report (NMNHP December 1997).

Data Processing and Analysis

All field data were entered into the NMNHP Microsoft Access-based Biological and Conservation Database (BCD) with quality control data review and error checks. In cooperation with the Texas A&M, Kingsville Ceaser Kleberg Wildlife Research Institute and their concurrent black bear habitat study in the Sierra del Carmen lead by Diana Crider, 701 plant specimens (this number includes duplicates) were collected under permit from the Instituto Nacional de Ecologia. The primary collection of specimens has been deposited with Dr. Jesus Valdes-Reyna at the Herbarium of the Universidad Autonoma Agraria Antonio Narro (UAAAN) in Saltillo, which is the primary reference herbarium in Coahuila and western Nuevo Leon. Dr. Valdes and his staff also provided consultation on species determinations on the bulk of the collection. Dr. Richard Spellenberg at New Mexico State University in Las Cruces, is an expert on the oaks of the Sierra Madres, and determined most of our oak specimens. Based on his determinations, the data were edited with species names following the nomenclature of Kartesz (1994).

Each plot was classified according to the protocols and hierarchy of the International Classification of Ecological Communities and the US National Vegetation Classification System (Grossman et al. 1998) which is the US geographic data standard (Table 3). In general, each plot was classified into an Alliance based on dominant or indicator species, and then to a particular Plant Association based on co-dominance and/or other groups of differential species. Phases of associations were assigned as necessary to further define the character of the plant community. Aerial photo interpreted data points were commonly only classified to the Alliance level. A GIS point coverage for image analysis was developed in the ARC/INFO® program and imported into the ERDAS™ image processing program. Each point was attributed according to its Alliance and Plant Association designation and its UTM coordinates.

Table 3. US National Vegetation Classification physiognomic-floristic hierarchy for terrestrial vegetation (Grossman et al. 1998) with a supplemental Alliance Group level.

Level	Primary Basis for Classification	Example
Class	Growth form and structure of vegetation	Woodland
Subclass	Growth form characteristics, e.g., leaf phenology	Deciduous Woodland
Group	Leaf types, corresponding to climate	Cold-deciduous Woodland
Subgroup	Relative human impact	Natural/Semi-natural
Formation	Additional physiognomic and environmental factors	Temporarily Flooded Cold-deciduous Woodland
[Alliance Group]	[Regional floristically and environmentally related Alliances]	[Chihuahuan Desert Deciduous Desert Scrub]
Alliance	Dominant/diagnostic species of the uppermost or dominant stratum	*Populus deltoides* Temporarily Flooded Woodland Alliance
Association	Additional dominant/diagnostic species from any stratum	*Populus deltoides/Salix exigua* Woodland Association

Map Development

Mapping Process

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), 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 plant associations. 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, field data are 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 black and white aerial photography, but only in cases when there was high confidence in the vegetation type designation and location.

Once an initial set of seeds was selected, a supervised classification of the entire image 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. 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.

The supervised classification was an iterative process of several runs (6) where the resulting classifications were evaluated to determine if the seed selection adequately modeled vegetation occurrences. 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. 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. The outcome of the seed selection in an supervised classification process is a preliminary vegetation map in which there as many map classes as seeds used to develop it.

Final Map Units and Vegetation Map Development

The next step was to aggregate the seed map classes 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 have similar landscape positions and are spatially near each other). 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. Mapping Units were also checked for the degree of spectral homogeneity across the unit and to detect any outliers or potential groupings not previously recognized. Direct manual editing (the transformation of sets of pixels into different map classes or units) was kept to a minimum. It was mostly used for small, distinctly shaped features which did not classify strongly within their boundaries, such as the river and livestock tanks; or where mesquite, known only from low elevations, was cross-classifying with dense oak forest at high elevations.

A provisional map was first created using data from the Mexican section of the study area and then extrapolated to the Dead Horse Mountains on the US side. This provisional 1997 map was used as a guide to sampling in the second field season in Big Bend in 1998. The data collected in 1998 were used in a seeding and supervised classification process to build a new map for the Dead Horse portion which then was merged with the Mexican portion completed earlier in 1997. Map units were finalized and detailed descriptions of each unit written.

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 AND DISCUSSION

Vegetation Classification[5]

A provisional hierarchical vegetation classification of the Sierra del Carmen in the US and Mexico is outlined in Table 4. There were 121 plant associations identified within 42 alliances, reflecting the high diversity of the vegetation composition in the Sierra del Carmen. Of these, 88 associations are considered new or provisional associations that have not been previously described in the Southwest. Most of these are represented by only one or two plots and are in need of further confirmation. However, there are 33 well-established associations, (e.g., those represented by five or more quantitative plots), and among them are 10 associations that are described only from the Sierra del Carmens.

The highest elevations of the Maderas del Carmen (over 7,000 ft or 2,300 m) are dominated by mixed conifer forests of Sierra Madrean floristic affinity (Madrean Upper and Lower Montane Conifer Forest). These forests are dominated by the Coahuila Fir (*Abies coahuilensis*), Douglas Fir (*Pseudotsuga menziesii*) or Arizona Pine (*Pinus arizonica*) Alliances with a wide variety of Associations. Canopies are often dense (on average at least 60% canopy closure) with a sub-canopy or shrub layer dominated by a wide variety of oaks such as netleaf oak (*Quercus rugosa*), silverleaf oak (*Q. hypoleucoides*), Arizona white oak (*Q. arizonica*), gray oak (*Q. grisea*) or Graves oak (*Q. gravesii*). Arizona cypress (*Cupressus arizonica*) and Southwestern white pine (*Pinus strobiformis*) are other common canopy associates. The herb layer can be sparse, or where the canopies are more open, a significant grass cover can develop with a wide variety of grasses such as Pringle needlegrass (*Piptochaetum pringlei*), poverty danthonia (*Danthonia spicata*) and wooly brome (*Bromus lanatipes*). Intermixed among the conifer forest, particularly in cool canyons, are deciduous oak forests dominated by Graves oak that lack significant conifer elements.

At mid elevations (4,800 to 8,200 ft; 1,450 to 2,500 m) of the mountains and on mesa tops, the forests give way to woodlands dominated by evergreen oaks (Silverleaf Oak, Arizona White Oak and Emory Oak Alliances) or low-statured conifers represented by the Mexican Pinyon (*Pinus cembroides*), Papershell Pinyon (*P. remota*) and Alligator Juniper (*Juniperus deppeana*) Alliances. Understories are quite varied as indicated by the 22 associations described among these alliances. Most have grassy undergrowths, and some, with open tree canopies, could be considered grassland "savannas". Others are decidedly shrubby in the understory and are dominated by "chaparral" species such as pointleaf manzanita (*Arctostaphylos pungens*), mountain mahogany (*Cercocarpus montanus*) and sandpaper oak (*Q. pungens* var. *pungens*). At the lower fringes of woodlands, chaparral becomes even more prevalent and is characterized by the Desert Ash (*Fraxinus greggii*), Mohr's Shin Oak (*Q. mohriana*) and Vasey's Oak (*Q. pungens* var. *vaseyana*) Alliances.

[5] Plant names are capitalized when they refer to a classification level, but otherwise are in lowercase.

Table 4. Provisional Vegetation Classification of Sierra del Carmen, United States and Mexico. The upper four levels of the hierarchy (Class, Subclass, Group, Formation), and the six and seventh (Alliance and Association) follow the International Classification of Ecological Communities: Terrestrial Vegetation of the United States (Grossman et al. 1998 and Anderson et al. 1998). The fifth level is a regional grouping of alliances (Alliance Group) similar to the Biotic Community of Brown, Lowe and Pase (1979). The status of a given plant association (PA) is indicated as follows: N = new association represented by one quantitative plot, P = provisional association represented by 2-4 quantitative plots E = established and represented by five or more plots, or well documented in the literature. The number of quantitative plots (n =) from the current study is also indicated following the status, and whether the association has been previously described elsewhere(*). Plant associations are listed by common name followed by scientific name and acronym abbreviation of the scientific name.

I. Forest
I.A Evergreen forest
I.A.8 Temperate or subpolar needle-leaved evergreen forest
I.A.8.N.b Rounded-crowned temperate or subpolar needle-leaved evergreen forest

Madrean Lower Montane Conifer Forest

Arizona Pine (*Pinus arizonica*) Forest Alliance

Arizona Pine-Graves Oak/Wooly Brome (*Pinus arizonica-Quercus gravesii/Bromus lantipes*; PINARI-QUEGRA/BROLAN) (P, n = 3)
Arizona Pine-Graves Oak/New Mexico Bluestem (*Pinus arizonica-Quercus gravesii/Schizachyrium neomexicanum*; PINARI-QUEGRA/SCHNEO) (N, n = 1)
Arizona Pine-Netleaf Oak/Junegrass (*Pinus arizonica-Quercus rugosa*/*Koeleria macrantha*; PINARI-QUERUG/KOEMAC) (N, n = 1)
Arizona Pine/Poverty Danthonia (*Pinus arizonica/Danthonia spicata;* PINARI/DANSPI) (E, n = 8)
Arizona Pine/Pringle Needlegrass (*Pinus arizonica/Piptochaetum pringlei*; PINARI/PIPPRI) (P, n = 2)
Arizona Pine-Silverleaf Oak/Pringle Needlegrass (*Pinus arizonica-Quercus hypoleucoides/Piptochaetum pringlei*; PINARI-QUEHYP/PIPPRI) (P, n = 2)

I.A.8.N.c Conical-crowned temperate or subpolar needle-leaved evergreen forest

Madrean Upper Montane Conifer Forest

Coahuila Fir (*Abies coahuilensis*) Forest Alliance

Coahuila Fir-Arizona Pine/Pringle Needlegrass (*Abies coahuilensis-Pinus arizonica*/*Piptochaetum pringlei*; ABICOA-PINARI/PIPPRI) (P, n = 2)
Coahuila Fir-Silverleaf Oak/Pringle Needlegrass (*Abies coahuilensis-Quercus hypoleucoides/Piptochaetum pringlei*; ABICOA-QUEHYP/PIPPRI) (P, n = 2)
Coahuila Fir/Umbrellawort (*Abies coahuilensis/Chimaphylla menziesii*; ABICOA/CHIMEN) (P, n = 1)

Douglas Fir (*Psuedotsuga menziesii*) Madrean Forest Alliance

Douglas Fir-Silverleaf Oak/Pringle Needlegrass (*Psuedotsuga menziesii-Quercus hypoleucoides/Piptochaetum pringlei*; PSEMEN-QUEHYP/PIPPRI) (P, n = 2)
Douglas Fir-Silverleaf Oak/Umbrellawort (*Psuedotsuga menziesii-Quercus hypoleucoides/Chimaphylla menziesii*; PSEMEN-QUEHYP/CHIMEN) (E, n = 5)
Douglas Fir-Texas Madrone (*Psuedotsuga menziesii-Arbutus xalapensis*; PSEMEN ARBXAL) (P, n = 2)
Douglas Fir/Umbrellawort (*Psuedotsuga menziesi/Chimaphylla menziesii*; PSEMEN/CHIMEN) (P, n = 2)

Table 4. Provisional Vegetation Classification of Sierra del Carmen, U.S. and Mexico (Cont.)

I.B. Deciduous Forest
I.B.2. Cold-deciduous Forest
I.B.2.N.b. Montane or boreal cold-deciduous forest

Madrean Lower Montane Broad-leaved Deciduous Forest

Graves Oak Forest (*Quercus gravesii*) Forest (Madrean) Alliance

Graves Oak-Arizona White Oak/Sacahuista (*Quercus gravesii-Quercus arizonica/Nolina microcarpa*; QUEGRA-QUEARI/NOLMIC) (N, n = 1)
Graves Oak-Arizona White Oak/Bull Muhly (*Quercus gravesii-Quercus arizonica/Muhlenbergia emersleyi*; QUEGRA-QUEARI/MUHEME) (N, n = 1)
Graves Oak-Arizona White Oak/Pringle Needlegrass (*Quercus gravesii-Quercus arizonica/Piptochaetium pringlei*; QUEGRA-QUEARI/PIPPRI) (N, n = 1
Graves Oak-Lacey's Oak/New Mexico Bluestem (*Quercus gravesii-Quercus laceyi/Schizachyrium neomexicanum*; QUEGRA-QUELAC/SCHNEO) (P, n = 2)
Graves Oak/Pinyon Rice Grass (*Quercus gravesii/Piptochaetium fimbriatum*; QUEGRA/PIPFIM) (P, n = 2)
Graves Oak/Pringle Needlegrass (*Quercus gravesii/Piptochaetium pringlei*; QUEGRA/PIPPRI) (P, n = 2)
Graves Oak-Silverleaf Oak/Pringle Needlegrass (*Quercus gravesii-Quercus hypoleucoides/Piptochaetium pringlei*; QUEGRA-QUEHYP/PIPPRI) (P, n = 2)

II Woodland
II.A Evergreen woodland
II.A.2 Temperate broad-leaved evergreen woodland
II.A.2.N.a Temperate broad-leaved evergreen woodland

Madrean Upper Broadleaf Evergreen Woodland

Silverleaf Oak (*Quercus hypoleucoides*) Woodland Alliance

Silverleaf Oak-Netleaf Oak/Desert Muhly (*Quercus hypoleucoides-Quercus rugosa/Muhlenbergia glauca*; QUEHYP-QUERUG/MUHGLA) (N, n = 1)
Silverleaf Oak-Netleaf Oak/Ragwort (*Quercus hypoleucoides-Quercus rugosa/Senecio caromasonii*; QUEHYP-QUERUG/SENCAR1) (N, n = 2)

Madrean Lower Broadleaf Evergreen Woodland

Arizona White Oak or Gray Oak (*Quercus Arizonica or Q. grisea*) Woodland Alliance

Arizona White Oak/Blue Grama (*Quercus arizonica/Bouteloua gracilis*; QUEARI/BOUGRA) (N, n = 1)
Arizona White Oak/Bull Muhly (*Quercus arizonica/Muhlenbergia emersleyi*; QUEARI/MUHEME) (E, n = 8)
Arizona White Oak/Faxon's Yucca/Sideoats Grama (*Quercus arizonica/Yucca faxoniana/Bouteloua curtipendula*; QUEARI/YUCFAX/BOUCUR) (P, n = 2)
Arizona White Oak/Finestem Needlegrass (*Quercus arizonica/Stipa tenuissima*; QUEARI/STITEN) (P, n = 2)
Arizona White Oak/Mountain Mahogany (*Quercus arizonica/Cercocarpus montanus*; QUEARI/CERMON) (P, n = 1)*
Arizona White Oak/New Mexico Bluestem (*Quercus arizonica/Schizachyrium neomexicanum*; QUEARI/SCHNEO) (P, n = 3)
Arizona White Oak/Pointleaf Manzanita/New Mexico Bluestem (*Quercus arizonica/Arctostaphylos pungens/Schizachyrium scoparium*; QUEARI/ARCPUN/SCHNEO) (P, n = 3)
Arizona White Oak/Sideoats Grama (*Quercus arizonica/Bouteloua curtipendula*; QUEARI/BOUCUR) (E, n = 7)*
Arizona White Oak/Sparse (*Quercus arizonica*/Sparse; QUEARI/Sparse) (N, n = 1)

Table 4. Provisional Vegetation Classification of Sierra del Carmen, U.S. and Mexico (Cont.)

Emory Oak (*Quercus emoryi*) Woodland Alliance

Emory's Oak/Sideoats Grama (Quercus emoryi/Bouteloua curtipendula; QUEEMO/BOUCUR) (E, n = 1)*

II.A.4 Temperate or subpolar needle-leaved evergreen woodland
II.A.4.N.a Rounded-crowned temperate or subpolar needle-leaved evergreen woodland

Madrean Upper Conifer Woodland

Mexican Pinyon (*Pinus cembroides*) Conifer Woodland Alliance

Mexican Pinyon-Arizona White Oak/Bull Muhly(*Pinus cembroides-Quercus arizonica/Muhlenbergia emersleyi*; PINCEM-QUEARI/MUHEME) (E, n = 7)
Mexican Pinyon/Bull Muhly (*Pinus cembroides/Muhlenbergia emersleyi*; PINCEM/MUHEME) (P, n = 2)
Mexican Pinyon-Mountain Mahogany (*Pinus cembroides-Cercocarpus montanus*; PINCEM/CERMON) (N, n = 1)
Mexican Pinyon/Sacahuista (*Pinus cembroides/Nolina texana*; PINCEM/NOLMIC) (P, n = 1)
Mexican Pinyon/Sideoats Grama (*Pinus cembroides/Bouteloua curtipendula*; PINCEM/BOUCUR) (N, n = 1)
Mexican Pinyon/Sparse (*Pinus cembroides*/Sparse Undergrowth; PINCEM/SPARSE) (P, n = 2)

Papershell Pinyon (*Pinus remota*) Conifer Woodland Alliance

Papershell Pinyon-Sandpaper Oak (*Pinus remota-Quercus pungens* var. *pungens*; PINREM/QUEPUNP) (N, n = 1)
Papershell Pinyon/Sideoats Grama (*Pinus remota/Bouteloua curtipendula*; PINREM/BOUCUR) (N, n = 1)

Madrean Lower Conifer Woodland

Alligator Juniper (*Juniperus deppeana*) Woodland Alliance

Alligator Juniper/New Mexico Bluestem (*Juniperus deppeana/Schizachyrium neomexicanum*; JUNDEP/SCHNEO) (P, n = 4)
Alligator Juniper/Finestem Needlegrass (*Juniperus deppeana/Stipa tenunissima*; JUNDEP/STITEN (N, n = 1)

III Shrubland
III.A Evergreen shrubland
III.A.2 Temperate broad-leaved evergreen shrubland
III.A.2.N.c Sclerophyllous temperate broad-leaved evergreen shrubland

Broadleaf Evergreen Interior Chaparral

Desert Ash (*Fraxinus greggii*) Shrubland Alliance

Desert Ash-Lechuguilla (*Fraxinus greggii-Agave lechuguilla*; FRAGRE-AGALEC) (N, n = 1)

Table 4. Provisional Vegetation Classification of Sierra del Carmen, U.S. and Mexico (Cont.)

Desert Ash-Slimleaf Vauquelina (*Fraxinus greggii-Vauquelina corymbosa* ssp. *angustifolia*; FRAGRE-VAUCORA) (P, n = 2)
Desert Ash/Southwestern Needlegrass (*Fraxinus greggii/Stipa eminens*; FRAGRE/STIEMI) (N, n = 1)

Mohr's shin oak (*Quercus mohriana*) Shrubland Alliance

Mohr's Shin Oak/Bull Muhly (*Quercus mohriana/Muhlenbergia emersleyi*; QUEMOH/MUHEME) (E, n = 6)*
Mohr's Shin Oak-Desert Ceanothus (*Quercus mohriana-Ceanothus greggii*; QUEMOH/CEAGRE) (N, n = 1)
Mohr's Shin Oak-Faxon's Yucca/Curlyleaf Muhly (*Quercus mohriana-Yucca faxoniana/Muhlenbergia setifolia*; QUEMOH-YUCFAX/MUHSET) (P, n = 2)
Mohr's Shin Oak-Mountain Mahogany (*Quercus mohriana-Cercocarpus montanus*; QUEMOH-CERMON) (P, n = 4)
Mohr's Shin Oak-Smooth Sotol (*Quercus mohriana-Dasylirion leiophyllum*; QUEMOH-DASLEI) (N, n = 1)

Vasey's Oak (*Quercus pungens* var. *vaseyana*) Shrubland Alliance

Vasey's Oak/Mountain Mahogany (*Quercus pungens* var. *vaseyana-Cercocarpus montanus*; QUEPUNV-CERMON) (N, n = 1)
Vasey's Oak/Sideoats Grama (*Quercus pungens* var. *vaseyana/Bouteloua curtipendula*; QUEPUNV/BOUCUR) (N, n = 1)

III.A.5 Extremely xeromorphic evergreen shrubland
III.A.5.N.a Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland

Chihuahuan Broadleaf/Microphyllous Evergreen Desert Scrub

Creosotebush (*Larrea tridentata*) Shrubland Alliance

Creosotebush-Candelilla (*Larrea tridentata-Euphorbia antisyphilitica*; LARTRI-EUPANT) (E, n = 5)
Creosotebush/Chino grama (*Larrea tridentata/Boutloua ramosa*; LARTRI/BOURAM) (E, n = 6)
Creosotebush-Lechuguilla (*Larrea tridentata-Agave lechuguilla*; LARTRI-AGALEC) (P, n = 2)
Creosotebush-Hairy Coldenia (*Larrea tridentata/Tiquilia hispidissima*; LARTRI-TIQHIS) (P, n = 2)
Creosotebush-Mariola (*Larrea tridentata-Parthenium incanum*; LARTRI-PARINC) (E, n = 9)*
Creosotebush/Sparse Undergrowth (*Larrea tridentata*/Sparse; LARTRI/SPARSE) (E, n = 8)*

Big Bend Silverleaf (*Leucophyllum minus*) Shrubland Alliance

Big Bend Silverleaf-Lechuguilla (*Leucophyllum minus-Agave lechuguilla*; LEUMIN-AGALEC) (N, n = 1)
Big Bend Silverleaf-Smooth Sotol (*Leucophyllum minus-Dasylirion leiophyllum*; LEUMIN-DASLEI) (N, n = 1)

Table 4. Provisional Vegetation Classification of Sierra del Carmen, U.S. and Mexico (Cont.)

III.B Deciduous shrubland
III.B.2 Cold-deciduous shrubland
III.B.2.N.a Temperate cold-deciduous shrubland

Madrean Montane Deciduous Scrub

Mountain mahogany (*Cercocarpus montanus*) Shrubland (Madrean) Alliance

Mountain Mahogany/Bull Muhly (*Cercocarpus montanus/Muhlenbergia emersleyi;* CERMON/MUHEME) (P, n = 1)*
Mountain Mahogany-Pointleaf Manzanita (*Cercocarpus montanus-Arctostaphylos pungens*; CERMON-ARCPUN) (P, n = 2)
Mountain Mahogany/Sideoats Grama (*Cercocarpus montanus/Bouteloua curtipendula*; CERMON/BOUCUR) (E, n = 4)*

III.B.3 Extremely xeromorphic deciduous shrubland
III.B.3.N.a Extremely xeromorphic deciduous subdesert shrubland

Chihuahuan Broadleaf Deciduous Desert Scrub

Whitethorn acacia (*Acacia constricta, A. neovernicosa*) Shrubland Alliance

Whitethorn Acacia/Black Grama (*Acacia constricta/Bouteloua eriopoda*; ACACON/BOUERI) (E, n = 4)*
Whitethorn Acacia-Engelmann's Prickly Pear (*Acacia constricta-Opuntia englemanii*; ACACON-OPUENG) (P, n = 4)
Whitethorn Acacia-Havard's Agave (*Acacia constricta-Agave havardiana*; ACACON-AGAHAV) (N, n = 1)
Whitethorn Acacia-Lechuguilla (*Acacia constricta-Agave lechuguilla*; ACACON-AGALEC) (E, n = 5)
Whitethorn Acacia-Mariola (*Acacia contricta-Parthenium incanum*; ACACON-PARINC) (E, n = 1)*

Tarbush (*Flourensia cernua*) Shrubland Alliance

Tarbush/Sparse Undergrowth (*Flourensia cernua*/Sparse; FLOCER/SPARSE) (E, n = 1)*

Honey Mesquite (*Prosopis glandulosa*) Shrubland Alliance

Honey Mesquite-Beebrush (*Prosopis glandulosa-Aloysia gratissima*; PROGLA-ALOGRA) (N, n = 1)
Honey Mesquite/Black Grama (*Prosopis glandulosa/Bouteloua eriopoda*; PROGLA/BOUERI) (E, n = 1)*
Honey Mesquite/Blue Grama (*Prosopis glandulosa/Bouteloua gracilis*; PROGLA/BOUGRA) (E, n = 4)*
Honey Mesquite-Mariola (*Prosopis glandulosa-Parthenium incanum*; PROGLA-PARINC) (P, n = 2)
Honey Mesquite/Purple Threeawn (*Prosopis glandulosa/Aristida purpurea*; PROGLA/ARIPUR) (P, n = 1)*
Honey Mesquite-Tarbush/Sparse Undergrowth (*Prosopis glandulosa-Flourensia cernua/*Sparse; PROGLA-FLOCER/SPARSE) (P, n = 2)*
Honey Mesquite/Tobosagrass (*Prosopis glandulosa/Hilaria mutica*; PROGLA/HILMUT) (E, n = 3)*

Table 4. Provisional Vegetation Classification of Sierra del Carmen, U.S. and Mexico (Cont.)

Ocotillo (*Fouquieria splendens*) Shrubland Alliance

Ocotillo/Purple Threeawn (*Fouquieria splendens/Aristida purpurea*; FOUSPL/ARIPUR) (N, n = 1)
Ocotillo-Lechuguilla-Candelilla (*Fouquieria splendens-Agave lechuguilla-Euphorbia antisyphilitica*; FOUSPL-AGALEC-EUPANT) (P, n = 2)

Catclaw Mimosa (*Mimosa aculeaticarpa*) Shrubland Alliance

Catclaw Mimosa-Beebrush (*Mimosa aculeaticarpa-Aloysia gratissima*; MIMACUB-ALOGRA) (E, n = 6)
Catclaw Mimosa-Beebrush/Blue Grama (*Mimosa aculeaticarpa-Aloysia gratissima*/*Bouteloua gracilis*; MIMACUB-ALOGRA/BOUGRA) (P, n = 3)
Catclaw Mimosa-Beebrush/Sideoats Grama (*Mimosa aculeaticarpa-Aloysia gratissima*/*Bouteloua curtipendula*; MIMACUB-ALOGRA/BOUCUR) (N, n = 1)
Catclaw Mimosa/Blue Grama (*Mimosa aculeaticarpa/Bouteloua gracilis*; MIMACUB/BOUGRA) (N, n = 1)
Catclaw Mimosa/Chino Grama (*Mimosa aculeaticarpa*/*Bouteloua ramosa*; MIMACUB/BOURAM) (N, n = 1)
Catclaw Mimosa/Sideoats Grama (*Mimosa aculeaticarpa/Bouteloua curtipendula*; MIMACUB/BOUCUR) (E, n = 5)*

III.C. Mixed evergreen-decidousous shrubland
III.C.3. Extremely xeromorphic mixed evergreen-deciduous shrubland
III.C.3.N.b. Mixed evergreen-deciduous subdesert shrubland

Chihuahuan Broadleaf Mixed Evergreen-Deciduous Desert Scrub

Creosotebush-Whitethorn Acacia (*Larrea tridentata-Acacia constricta*) Shrubland Alliance

Creosotebush-Whitethorn Acacia/Sparse Undergrowth (*Larrea tridentata-Acacia constricta*/Sparse; LARTRI-ACACON/SPARSE) (P, n = 2)

IV Dwarf-shrubland
IV.A Evergreen dwarf-shrubland
IV.A.2 Extremely xeromorphic evergreen dwarf-shrubland
IV.A.2.N.a Extremely xeromorphic evergreen subdesert dwarf-shrubland

Chihuahuan Dwarf Desert Scrub

Lechuguilla (*Agave lechuguilla*) Dwarf-shrub Alliance

Lechuguilla-Candelilla (*Agave lechuguilla-Euphorbia antisyphilitica*; AGALEC-EUPANT) (E, n = 8)
Lechuguilla-Texas False Agave (*Agave lechuguilla-Hechtia texensis*; AGALEC-HECTEX) (P, n = 2)

Candelilla (*Euphorbia antisyphilitica*) Dwarf-shrub Alliance

Candelilla-Smooth Sotol (*Euphorbia antisyphilitica-Dasylirion leiophyllum*; EUPANT-DASLEI) (N, n = 1)

Table 4. Provisional Vegetation Classification of Sierra del Carmen, U.S. and Mexico (Cont.)

Mariloa (*Parthenium incanum*) Dwarf-shrub Alliance

Mariola-Smooth Sotol (*Parthenium incanum-Dasylirion leiophyllum*; PARINC-DASLEI) (N, n = 1)
Mariola-Candelilla (*Parthenium incanum-Euphorbia antisyphilitica*; PARINC-EUPANT) (P, n = 2)
Mariola-Guayule (*Parthenium incanum-Parthenium argentatum*; PARINC-PARARG) (N, n = 1)
Mariola-Lechuguilla (*Parthenium incanum-Agave lechuguilla*; PARINC-AGALEC) (E, n = 8)

V Herbaceous Vegetation
V.A Perennial graminoid vegetation
V.A.5 Temperate or subpolar grassland
V.A.5.N.e Short sod/bunch temperate or subpolar grassland

Plains-Mesa Shortgrass Grasslands

Black Grama (*Bouteloua eripoda*) Herbaceous Alliance

Black Grama-Purple Threeawn (*Bouteloua eriopoda-Aristida purpurea*; BOUERI-ARIPUR) (E, n = 1)*

Blue Grama (*Bouteloua gracilis*) Herbaceous Alliance

Blue Grama-Finestem Needlegrass (*Bouteloua gracilis-Stipa tenuissima*; BOUGRA-STITEN) (P, n = 2)
Blue Grama-Monotypic Stand (*Bouteloua gracilis*-Monotypic; BOUGRA-MONTYP) (E, n = 1)*
Blue Grama-Sideoats Grama (*Bouteloua gracilis-Bouteloua curtipendula*; BOUGRA-BOUCUR) (E, n = 7)*

Chino grama (*Bouteloua ramosa*) Herbaceous Alliance

Chino grama-Sideoats Grama (*Bouteloua ramosa-Bouteloua curtipendula*; BOURAM-BOUCUR) (P, n = 2)

Hairy Grama (*Bouteloua hirsuta*) Herbaceous Alliance

Hairy Grama-Blue Grama (*Bouteloua hirsuta-Bouteloua gracilis*; BOUHIR-BOUGRA) (E, n = 5)*
Hairy Grama-New Mexico Bluestem (*Bouteloua hirsuta-Schizachyrium neomexicanum*; BOUHIR-SCHNEO) (N, n = 1)
Hairy Grama-Sideoats Grama (*Bouteloua hirsuta-Bouteloua curtipendula*; BOUHIR-BOUCUR) (E, n = 1)*
Hairy Grama-Finestem Needlegrass (*Bouteloua hirsuta-Stipa tenuissima*; BOUHIR-STITEN) (N, n = 1)

Purple Threeawn (*Aristida purpurea*) Herbaceous Alliance

Purple Threeawn-Tanglehead(*Aristida purpurea-Heteropogon contortus*; ARIPUR-HETCON) (P, n = 3)

Table 4. Provisional Vegetation Classification of Sierra del Carmen, U.S. and Mexico (Cont.)

Sixweeks Grama (*Bouteloua barabata*) Herbaceous Alliance

Sixweeks Grama-Feather Fingergrass (*Bouteloua barbata-Chloris virgata*; BOUBAR/CHLVIR (N, n=1)

Tobosa Grass (*Hilaria mutica*) Herbaceous Alliance

Tobosagrass/Montypic Stand (*Hilaria mutica/Monotypic Stand*; HILMUT/MONTYP) (E, n = 1)

V.A.7 Temperate or subpolar grassland with a sparse shrub layer

V.A.7.N.h Medium-tall temperate grassland with a sparse xeromorphic (often thorny) shrub layer

Chihuahuan Medium Tall Semi-Desert Grassland with Shrubs

Sideoats Grama (*Bouteloua curtipendula*) Shrub Herbaceous Alliance

Sideoats Grama/Beaked Yucca (*Bouteloua curtipendula/Yucca thompsoniana*; BOUCUR/YUCTHO) (P, n = 3)
Sideoats Grama/Faxon's Yucca (*Bouteloua curtipendula/Yucca faxoniana*; BOUCUR/YUCFAX) (N, n = 1)
Sideoats Grama/Smooth Sotol (*Bouteloua curtipendula/Dasylirion leiophyllum*; BOUCUR/DASLEI) (E, n = 23)
Sideoats Grama/Toothleaf Goldeneye (*Bouteloua curtipendula/Viguiera dentata*; BOUCUR/VIGDEN) (E, n = 5)*

Bullgrass (*Muhlenbergia emersleyi*) Shrub Herbaceous Alliance

Bullgrass/Beaked Yucca (*Muhlebergia emersleyi/Yucca thompsoniana*; MUHEME/YUCTHO) (N, n = 1)
Bullgrass/Smooth Sotol (*Muhlenbergia emersleyi/Dasylirion leiophyllum*; MUHEME/DASLEI) (N, n = 1)

Curlyleaf Muhly (*Muhlenbergia setifolia*)

Curlyleaf Muhly/Smooth Sotol (*Muhlenbergia setifolia/Dasylirion leiophyllum*; MUHSET/DASLEI) (N, n = 1)
Curlyleaf Muhly-Hairy Grama/Lechuguilla (*Muhlenbergia setifolia-Bouteloua hirsuta/Agave lechuguilla*; MUHSET-BOUHIR/AGALEC) (P, n = 2)

V.A.7.N.m Short temperate or subpolar grassland with a sparse xeromorphic (evergreen and/or deciduous) shrub layer

Chihuahuan Short Semi-Desert Grassland with Shrubs

Blue Grama (*Bouteloua gracilis*) Shrub Herbaceous Alliance

Blue Grama/Beaked Yucca (*Bouteloua gracilis/Yucca thompsoniana*; BOUGRA/YUCTHO) (P, n = 2)
Blue Grama/Skeletonleaf Goldeneye (*Bouteloua gracilis/Viguieria stenoloba*; BOUGRA/VIGSTE) (N, n = 1)

Table 4. Provisional Vegetation Classification of Sierra del Carmen, U.S. and Mexico (Cont.)

Hairy Grama (*Bouteloua hirsuta*) Shrub Herbaceous Alliance

Hairy Grama/Faxon's Yucca (*Bouteloua hirsuta/Yucca faxoniana*; BOUHIR/YUCFAX) (N, n = 1)
Hairy Grama/Smooth Sotol (*Bouteloua hirsuta*/*Dasylirion leiophyllum*; BOUHIR/DASLEI) (N, n = 1)

Black Grama (*Bouteloua eripoda*) Shrub Herbaceous Alliance

Black Grama/Smooth Sotol (*Bouteloua eriopoda/Dasylirion leiophyllum*; BOUERI/DASLEI) (P, n = 4)

Chino grama (*Bouteloua ramosa*) Shrub Herbaceous Alliance

Chino Grama/Smooth Sotol (*Bouteloua ramosa/Dasyliron leiophyllum*; BOURAM/DASLEI) (E, n = 14)

V.A.8 Temperate or subpolar grassland with a sparse dwarf-shrub layer
V.A.8.N.a Short temperate or subpolar lowland grassland with a sparse needle-leaved or microphyllous dwarf-shrub layer

Chihuahuan Shortgrass Semi-Desert Grassland with Dwarf Shrubs

Black Grama (*Bouteloua eripoda*) Dwarf-shrub Herbaceous Alliance

Black Grama/Havard's Agave (*Boutleoua eriopoda/Agave havardiana*; BOUERI/AGAHAV) (N, n = 1)
Black Gama/Mariola (*Bouteloua eriopoda/Parthenium incanum*; BOUERI/PARINC) (E, n = 1)

Chino grama (*Bouteloua ramosa*) Dwarf-shrub Herbaceous Alliance

Chino Grama/Candelilla (*Bouteloua ramosa/Euphorbia antisyphilitica*; BOURAM/EUPANT) (E, n = 5)
Chino Grama/Lechuguilla (*Bouteloua ramosa/Agave lechuguilla*; BOURAM/AGALEC) (E, n = 6)

Tobosa Grass (*Hilaria mutica*) Dwarf-shrub Herbaceous Alliance

Tobosagrass/Lechuguilla (*Hilaria mutica/Agave lechuguilla*; HILMUT/AGALEC) (N, n = 1)

Many of the forest and woodland associations have similarities to those found in the southwestern United States, differing mainly where a given dominant is replaced by a closely related species to the north. For example, the associations of the Arizona Pine Alliance are similar in terms of elevation range, community composition and stand structure to the those found in the Ponderosa Pine Alliance described for southeast Arizona and southwest New Mexico (Muldavin et al. 1996). *Pinus arizonica* and *Pinus ponderosa* are closely related, with *P. arizonica* often referred to as a southern variety of *P. ponderosa*. Similarly, there are white fir (*Abies concolor*) associations that are described from the southern Rocky Mountains that are similar in composition to the Coahuila fir types here. Many pinyon pine (*Pinus edulis*) associations from New Mexico and west Texas correspond to *Pinus cembroides/P. remota* communities. Likewise, there are oak and chaparral associations throughout the zone of the US-Mexico borderlands similar to those found in the Sierra del Carmens, but further west, species with their center of distribution in the Sierra Madre Orientale are replaced by those found in the Sierra Madre Occidentale (Muldavin and DeVelice 1987).

At elevations around 4,000 ft (1,200 m) mesa and foothill grasslands become dominant and are represented primarily by the Blue Grama (*Bouteloua gracilis*), Sideoats Grama (*B. curtipendula*), Hairy Grama (*B. hirsuta*) and Bull Muhly (*Muhlenbergia emersleyi*) Alliances. On steep hillslopes with shallow rocky substrates, associations often have a conspicuous shrub element such as smooth sotol (*Dasylirion leiophylllum*) or beaked yucca (*Yucca thompsoniana*), but these do not typically dominate (<10% cover). The lower foothills, alluvial fan piedmonts (bajadas), and desert basin bottoms are characterized by Semi-desert Grasslands and particularly the by the Chino Grama (*B. ramosa*) and Black Grama (*B. eriopoda*) Alliances. These do typically have a strong shrub component, and hence some are considered ecotonal to desert shrublands.

Throughout the bajadas and desert basins, and to some degree in the foothills, are true Chihuahuan Desert Scrub communities. Here, shrub cover exceeds 25% or shrubs typical of the Chihuahuan Desert are the dominant life form. The Creosotebush (*Larrea tridentata*), Mesquite (*Prosopis glandulosa*), Catclaw Mimosa (*Mimosa aculeaticarpa*) and Whitethorn (*Acacia constricta* and *A. neovernicosa*) Alliances are the most prevalent. At the lowest elevations (2,100 ft, 640 m) dwarf shrublands Alliances dominated by succulents, such as lechuguilla (*Agave lechuguilla*), candelilla (*Euphorbia antisyphilitica*), rubber plant (*Jatropha dioica*) and false agave (*Hechtia texensis*) are conspicuous, often cloaking large expanses of limestone outcrop. There are also floristic influences that extend in from the east that are representative of Tamaulipan Thorn Scrub, such as the Big Bend Silverleaf (*Leucophyllum minus*) Alliance.

Relation to other Vegetation Classifications

The classification developed here has a high degree of detail, but in its general outline it can be compared to other classifications that cover the area. Table 5 is a crosswalk between four Mexican classifications (Rzedowski 1978, Jimenez-Guzman and Zuniga-Ramos 1991, Villarreal and Valdes 1993, Medel- Añorve, unpub. data), Brown, Lowe and Pase (1979) biotic classification that covers the southwestern US and northern Mexico, our classification at the Alliance Group level, and the US National Vegetation Classification.

The classification schemes that cover the largest areas are also those with the broadest

categories, and generally agree with each other on four major vegetation types: coniferous forest, oak woodland or bosqué, desert shrubland and grassland (Rzedowski 1978, Brown et al. 1979). Villarreal and Valdes (1993) add a pine forest strata below the coniferous forest, a submontane (chaparral-like) shrubland and a *rosetófilo* or succulent desert shrubland. These three additional types for Coahuila are more or less recognized by all other workers in the Maderas del Carmen. Jimenez-Guzman and Zuniga-Ramos' classification differs the most from the other classifications: pine-oak forest is subdivided into three categories based on dominant species, and desert scrub vegetation is separated according to elevation and morphology of the dominant plants. They do not recognize a separate grassland class and subsume montane shrubland within pinyon-pine forest.

Our Formation level of the classification corresponds well to several structural and lifeform categories in the other classifications, but lacks the floristic specificity common to many of the classes. In contrast, our Alliance Groups tend to be more detailed than most classes, and only in a few instances do the other classifications approach the Alliance level itself, e.g., the White Fir Forest of Villarreal and Valdes (1993) and the many series described by Brown, Lowe and Pase (1979).

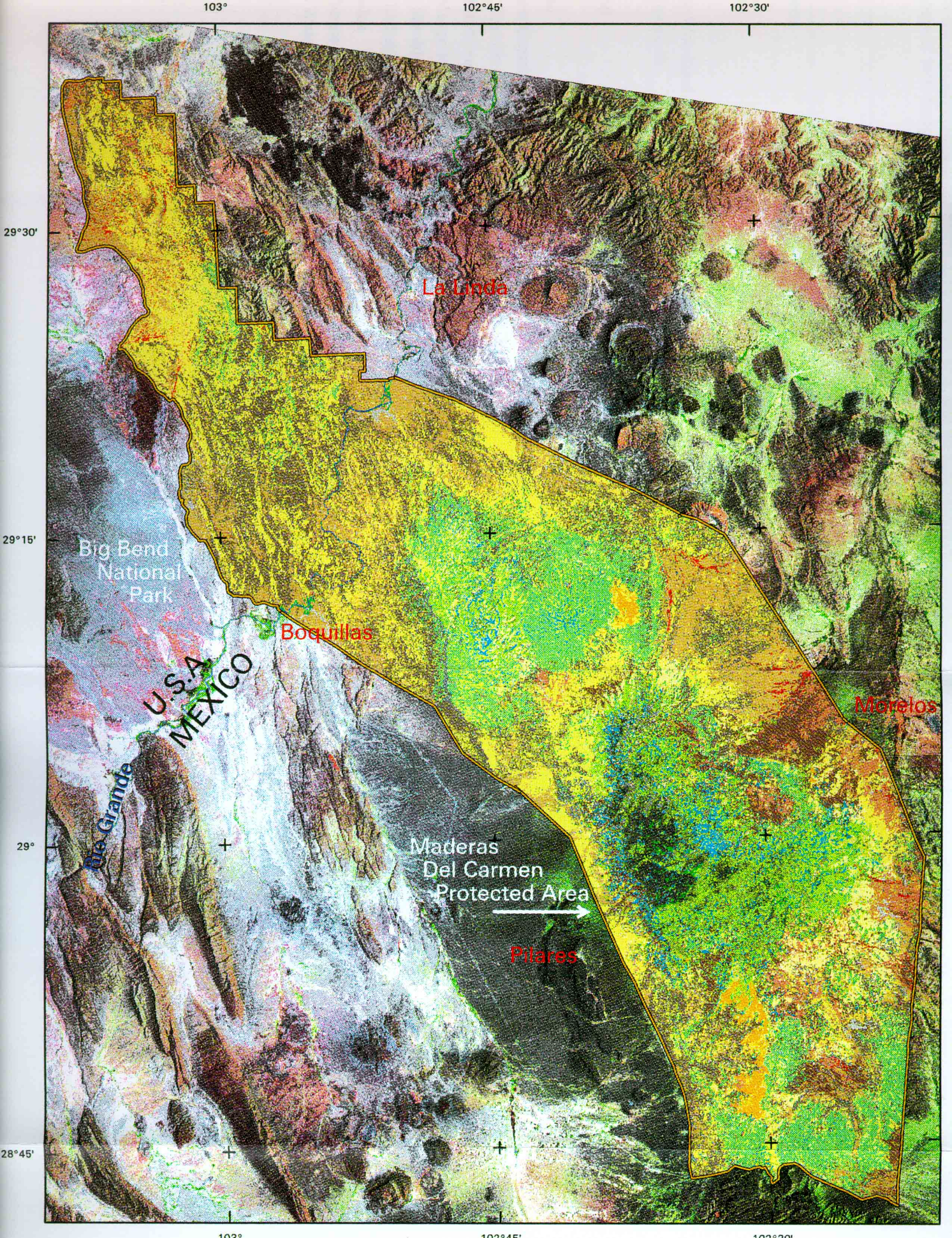
Table 5. Crosswalk of vegetation classifications that apply to the Sierra del Carmens, Coahuila, Mexico in relation to the Alliance Groups and the United States National Vegetation Classification (US NVC).

Brown, Lowe and Pase 1979, for the American Southwest (US and Mexico)	Rzedowski 1978, for Mexico	Villarreal and Valdez 1993, for Coahuila	Jimenez-Guzman and Zuniga-Ramos 1991, for Maderas del Carmen	Medel-Añorve 1998, for Maderas del Carmen	Alliance Group, this study	US NVC
Madrean Montane Conifer forest	Coniferous forest	White fir forest	Pine-Oak-Douglas fir-White fir forest	Coniferous forest	°Madrean upper montane conifer forest °Rocky Mountain montane forest	Temperate needle-leaved evergreen forest—conical crowned
		Pine forest	°Pine-Oak-Cypress forest °Oak-Pine-Juniper forest °Oak-Pine forest	°Pine-Oak forest °Pine-Juniper-Oak forest	Madrean lower montane conifer forest	Temperate needle-leaved evergreen forest -- rounded crown
Madrean Evergreen woodland	Oak forest	Oak forest	Oak-Juniper-Cypress forest	Oak forest	Madrean upper oak woodland	Temperate broad-leaved evergreen and deciduous forest
					Madrean lower oak woodland (encinal)	Temperate broad-leaved evergreen woodland
			Pinyon-pine forest	Pinyon-pine forest	Madrean upper conifer woodland	Temperate needle-leaved evergreen woodland with rounded crowns
	Xeric shrubland	Submontane shrubland		Submontane shrubland	°Madrean montane deciduous scrub °Broadleaf evergreen interior chaparral,	Sclerophyllous temperate broad-leaved evergreen shrubland
Chihuahuan Desert scrub		Microphyllous desert scrub	°High elevation spinose shrubland °Mid-elevation spinose shrubland °Spinose 'izotal' shrubland	Microphyllous desert shrubland	Chihuahuan broadleaf deciduous desert scrub	Extremely xeromorphic deciduous subdesert shrubland
					Chihuahuan broadleaf/microphyllous evergreen desert scrub	Broad-leaved and micophyllous evergreen extremely xeromorphic subdesert shrubland
		Rosette-leaved (rosetófilo) shrubland	'Izotal', Low-elevation, sub-shrub shrubland (in part)	Rosette-leaved (rosetófilo) shrubland	Chihuahuan dwarf desert scrub	Extremely xeromorphic evergreen subdesert dwarf-shrubland
Semi-desert grassland	Pastizal	Zacatal	No classification	Pastizal	°Short and medium, plains-mesa grassland °Chihuahuan semi-desert grassland, with and without shrubs	Short and medium sod/bunchgrass temperate and subpolar grasslandsland

Vegetation Map of the Sierra Del Carmen, US and Mexico

A single sheet, 1:100,000 scale vegetation map derived from digital Thematic Mapper (TM) satellite imagery accompanies this report which delineates the major vegetation patterns of the Sierra del Carmen in both Big Bend National Park in the US and the Maderas del Carmen Protected Area of Mexico. A reduced version of this map is presented in Figure 7. There are 16 map units derived from the plant associations outlined in the above classification along with three non-vegetation units (Table 6). Descriptions of each map unit and the major plant associations contained in each unit are presented in Appendix A. These descriptions provide the most pertinent information on map unit composition, size and distribution. A separate Data Addendum (on CD) to the report provides the detailed field plot information and the relation of each field point to the vegetation classification and the map units.

The map units correspond approximately to the Alliance Group of the classification, but with more specific floristic specifications. Map units commonly do not directly correspond to the vegetation classifications that they are based on. The degree of specificity of a map unit is dependent on the resolution and quality of the original imagery, the degree of inherent complexity to the vegetation pattern that is present, and the desired information content of the map units. Except in cases where one has exceptionally high-resolution imagery, most map units are complexes of vegetation units, or, in this case plant associations. For example, the map unit 'Creosote-Acacia shrubland' contains plant associations classified under two different alliance groups, but they were grouped together into a single map unit because they were strongly associated spatially and not easily separated on the basis of spectral response, particularly for a relatively coarse 1:100,000 scale map. Many of the plant associations that make up the 'Juniper-Oak Savannah' map unit are classified as grasslands with a tree phase, yet they are thought of as open woodlands, and are topographically and geographically separate from our other grassland units in the Sierra del Carmen. An 'Oak Forest' map unit was derived that is distinct from the Oak Woodland. The Oak Forest is characterized by dense stands of mature, tall-statured oak trees (*Quercus gravesii, Q. rugosa, Q. muhlenbergii, Q. hypoleucoides* and *Q. laceyi*) regardless of whether the included plant associations are classified as woodlands or forests. Oak Woodlands, on the other hand, contain more widely spaced and shorter oaks (*Q. arizonica, Q. emoryi* or *Q. mohriana*) that often take on a shrub form.



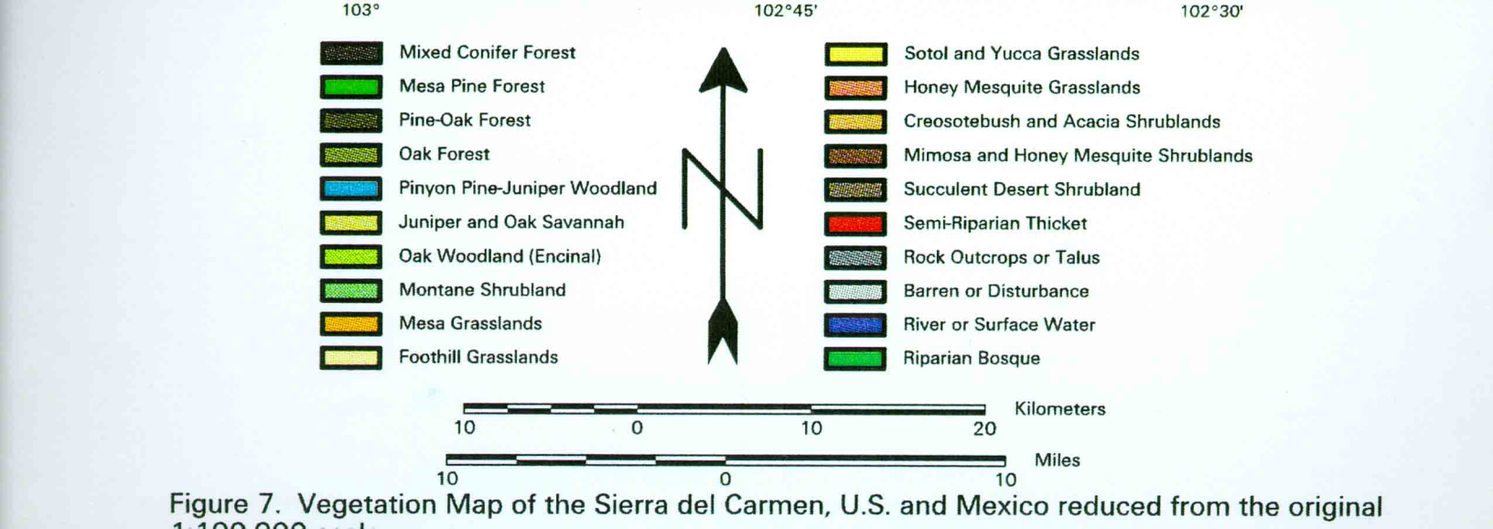


Figure 7. Vegetation Map of the Sierra del Carmen, U.S. and Mexico reduced from the original 1:100,000 scale.

Table 6. Map units for the vegetation map of the Sierra del Carmen, United States and Mexico with area in hectares and percentage of total mapped area per map unit, arranged in descending elevation order.

Map Unit	*Hectares*	*% Area*
1. Mixed Conifer Forest	2678	1.0%
2. Mesa Pine Forest	341	0.1%
3. Pine-Oak Forest	3246	1.2%
4. Oak Forest	5450	2.1%
5. Piñon-Pine-Juniper Woodland	8252	3.2%
6. Juniper and Oak Savannah	1896	0.7%
7. Oak Woodland	13600	5.2%
8. Montane Woodland	32758	12.5%
9. Mesa Grassland	2521	1.0%
10. Foothill Grassland	11219	4.3%
11. Sotol/Yucca Desert Grassland	59251	22.6%
12. Honey Mesquite Grassland	6762	2.6%
13. Creosotebush-Whitethorn Acacia Shrubland	51598	19.7%
14. Mimosa-Honey Mesquite-Beebrush Shrubland	15852	6.1%
15. Succulent Desert Shrubland	58186	22.2%
16. Semi-Riparian Thicket	698	0.3%
17. Rock Outcrop/Talus	4826	1.8%
18. Barren or Disturbance	4615	1.8%
19. River or Surface Water	303	0.1%
20. Riparian Bosque	280	0.1%

Individual map unit areas increase in size as elevation decreases (Table 6). High elevation coniferous and oak forest occupy just over 2% of the map area, with coniferous and oak woodlands at 9%, montane shrubland at almost 13%, followed by desert grasslands at 28% and desert shrublands at 38%. This is partly a function of landform area and structure as one descends the mountain slope. Steep, high elevation montane peaks have smaller areas with sharper changes of aspect than the mesa platforms, internal drainage valleys and foothills below them. Also, at higher elevations there are large expanses of unvegetated rock which make up the top of the escarpment on the west side, and talus slopes near the top of the Centinela Peaks and the Maderas del Carmen. Broad alluvial fans and terraces at the base of the mountains have the largest areas.

Dead Horse Mountains Vegetation - A Comparison with Plumb's Work

The Dead Horse Mountains within Big Bend National Park had been previously mapped by Plumb (1991, 1992 & 1993) from satellite imagery. Our vegetation map depicts five map units for the range, whereas seven map units can be discerned on Plumb's map (Table 7). The differences among Plumb's map units are not very great. He identified two Lechuguilla types that we represent within Succulent Desert Shrubland. He also delineates two different sotol grasslands that we have grouped in a single Sotol Grassland unit. The maps are similar in general pattern, but we tended to map greater amounts of montane shrubland dominated by scrub oaks than Plumb did. Also, we did very little direct editing on the map, whereas there are definite post-image analysis modifications in Plumb's map to account for known distributions of riparian and other vegetation that are especially difficult to map from TM imagery. Regardless, the efficacy of either map is hard to determine because of the limited ground surveys. Plumb's ground truthing was apparently very limited within the Dead Horse Mountains, and our sampling was also confined for logistical reasons to the periphery of the area. The interior of the Dead Horse Mountains still effectively remains uncharted wilderness.

Long-term Vegetation Monitoring

A total of 15 monitoring sites were established: two plots each in old growth mixed conifer forest, intermediate-aged mixed conifer, mesa pine forest, oak forest, and pinyon-juniper woodland; and one plot each in pine-oak forest, oak woodland, montane shrubland, desert foothill shrubland, and mesa grassland. The Data Addendum contains detailed site descriptions and data: cover data for every species in every quadrat on each transect line along with notes on the orientation of transect lines, UTM coordinates, and directions for relocating them. These plots provide highly precise data that can be effectively replicated in the future to evaluate long-term trends in vegetation change.

Table 7: Crosswalk between map units of Plumb (1993) and the Vegetation Map of the Sierra del Carmen, U.S. and Mexico

Plumb (1993)	Map units, this study
Oak-Ponderosa-Cypress	Mixed conifer forest
	Pine-oak forest, Mesa Pine forest
Mixed Oak	Oak forest
Pinyon-Oak-Juniper	Oak woodland (encinal)
Pinyon-Juniper-Grass	Pinyon Pine-Juniper woodland Juniper/Oak savannah
Oak Scrub	Montane shrubland
Mixed Shrubland	Honey mesquite grassland
Creosote-Yucca-Grass Creosote-Tarbush Creosote-Lechuguilla-Grass Creosote-Lechuguilla-Pricklypear	Creosotebush-Acacia shrubland
No equivalent	Mimosa-Honey Mesquite shrubland
Lechuguilla-Candelilla-Hechtia Lechuguilla-Grass Viguiera-Lechuguilla-Grass	Succulent desert shrubland
Forest Meadow Yucca-Sotol Sotol-Lechuguilla-Grass	Mesa grassland Foothill grassland Sotol-Yucca grassland Honey Mesquite Grassland
Desert Willow	Semi-riparian Thicket
Cottonwood Grove	Riparian Bosque
Pinyon Talus Bare and Water	Rock Outcrop/Talus River or Surface Water Barren or Disturbance

Other Biological Data—Bird Checklist

An informal observation checklist of birds from the Mexican portion of the study area was maintained for the duration of the 1997 sampling season (Glenn Harper and Juan Medel-Añorve were the primary observers). A total of 63 bird species visually identified in the study area from mid-July to October, and are listed in Appendix C.

Ecological Assessment

Species Diversity

A total of 546 species was recorded during the ground survey, and are listed in Appendix B. This is about one-third the number recorded for Big Bend National Park, but represents only one season of work. Hence, there are potentially a greater number of species still to be found. A 'species/plot' curve presented in Figure 8 shows the cumulative number of new species with each added plot within major vegetation groups. Curves should level off when most of the species within a map unit have been sampled. Grassland and shrubland, which have the highest number of plots due to additional sampling in the Dead Horse Mountains on the US side, are the only two that show some leveling off after 80 or so plots. This, however, is a weak pattern, and overall the graph suggests that the high number of samples in this study were not sufficient to capture the tremendous diversity of each major vegetation type. A comparison of all vegetation types at a point where there are an equal number of plots (n =14) shows montane shrubland with the highest number of species, followed by grasslands, oak forest and oak woodlands, then coniferous forest, and finally desert shrublands. From this analysis, it appears that the Sierra Madrean biome (oak forest, woodland, and montane shrubland vegetation groups), tend to have the highest diversity.

Several endemics were found in the Maderas del Carmen as well as new records of common species. The endemics include *Hedeoma johnstonii, Tilia mexicana* and *Quercus carmenensis. Muhlenbergia montana,* a common species in the Rocky Mountains, was recorded for the first time in the Sierra del Carmens. The white oaks in this range are a complex of *Quercus carmenensis, Q. mohriana, Q. arizonica* and *Q. vaseyana,* and are unlike any described oak complex in Mexico (Spellenberg, pers. comm).

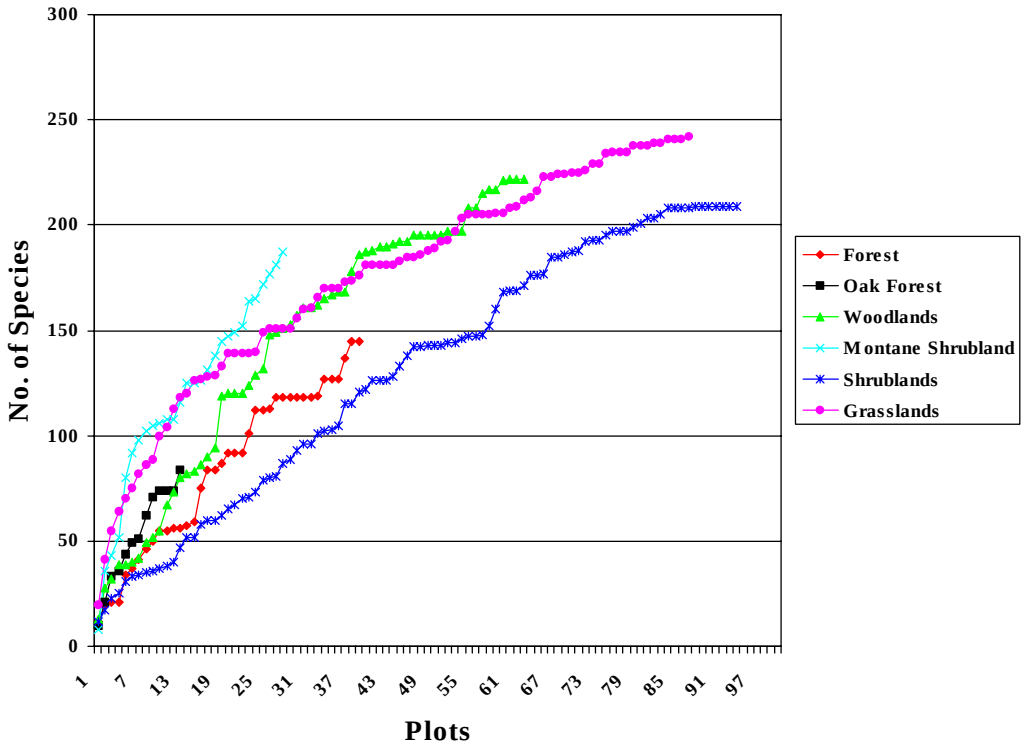


Figure 8. Number of species found as a function of plots sampled.

Biogeographical Significance

The unique character of the Sierra del Carmen and its high diversity are in part a function of geography. The mountain range lies at a southern latitude within the Sierra Madrean biome There is tremendous diversity of Madrean woodlands and forests compared to Rocky Mountain woodlands and forests further north. This is often attributed to a longer evolutionary history at southern latitudes with resultant evolutionary radiation of genera, particularly *Pinus* and *Quercus* (Axelrod 1958, Axelrod and Raven 1985, Perry 1991). During the last ice age in the Pleistocene, the southernmost ice pack was some 300 miles north near Ruidoso, New Mexico. While winters may have been colder, species would still have been able to survive at lower elevations south of the ice pack.

The Sierra del Carmen mountains also lie in an ecotone between the Chihuahuan desert to the west and Tamaulipan Thorn Scrub to the east, resulting in a mix of species from both biomes at lower elevations. This ecotonal character may be driven to some degree by precipitation patterns created by the mountain mass itself. Because the Sierra del Carmen is one of the first mountain ranges to intercept Gulf of Mexico storms from the east in summer and one of the last to receive precipitation from the west in winter, there is more effective moisture on the east side. This is expressed in striking vegetation differences between the east and west sides. Ecotones are biologically interesting as they are areas where ranges of many species correspond with the edges of the adjoining biomes, creating a large transitional zone of high diversity where habitats may be fragmented, leading to further diversity in vegetation communities (Risser 1995). Because species may already be at their limits of environmental tolerance at the edge of their range in fragmented habitat, ecotonal zones may be particularly susceptible to change with disturbance.

The Sierra del Carmen is at the eastern end of a chain of 'island' mountain ranges that extends along the US-Mexico borderlands through the Trans-Pecos of Texas into southern New Mexico and includes the Chisos, Davis, Guadalupe, Franklin, Sacramento and Organ mountains, and then westward to the 'sky island' mountain ranges of southeast Arizona and northwest Chihuahua. Following along the chain from the Sierra del Carmen is a floristic transition from species common in the Sierra Madre Orientale of eastern Mexico to those of the Sierra Madre Occidentale of western Mexico, with the Sierra del Carmen harboring elements of both. However, Gehlbach (1981) studied the borderland mountain ranges extensively and found that this transition pattern does not hold true for animals, especially birds. Although the ranges had several species in common, species distributions ‘skip’ unpredictably along the mountain chain. For example, northern pygmy owls occur in the del Carmens and the Sacramentos, but not the Davis or the Chisos. Similarly, the del Carmens, Davis and Guadalupe ranges share bird species not found in the Chisos. Gehlbach also discusses regional distinctions brought about by the rising Sierra Madre which isolated different populations of a common ancestor in different desert regions. This creates a patchy species distribution along the mountain chain with each range having its endemics and regional variations. Among the endemics and regional variants present in the Maderas del Carmens are a subspecies of the white-tailed deer, *Odocoileus virginianus carminis* and a subspecies of the cliff chipmunk, *Eutamias dorsalis carminis* (Jimenez-Guzman and Zuniga-Ramos 1991). With 115 mi^2 of montane habitat higher than 5,550 ft/1680m

(Wauer 1992), the range is also important for species dependent on montane habitat or large breeding/territorial ranges, such as black bear and mountain lion.

Geological and Topographic Effects on Vegetation Pattern

Superimposed on this complex ecotonal structure are striking differences in geology across the Sierra del Carmen. In arid areas, at the same elevations, more shrubs tend to occur on limestone soils and more grasses on igneous soils. This is because the coarser, more easily weathered soils of igneous substrates allow for better infiltration of falling water than the more clayey, impermeable soils of limestone where water is more likely to run off (Aide and Van Auken 1985). Weathering affects soil depth and structure and thus microsite availability. Slight differences in substrate material cause differential weathering that creates loamy skeletal soils at high elevations and gravelly or fine soils alternating with rocky outcrops at lower elevations. The southern Maderas del Carmen are composed primarily of volcanic rhyolitic substrates (extrusive versions of granite), whereas the remainder of the range is primarily fault-blocked sedimentary limestones (the middle Mexican portion—or the Sierra Fin del Jardin, and the northern Dead Horse Mountains in Big Bend National Park). Although elevation plays a role, substrate differences lead to a noticeable contrast in vegetation from extensive woodlands and grasslands on volcanic-derived soils in the south, to predominantly desert grasslands and desert scrub on limestone soils past the Cerros el Centinela in the north. Vegetation differences attributable to substrate are also apparent on the west side where scrubby limestone hills alternate with grasslands on igneous slopes.

Elevation gradient differences are mostly a function of temperature tolerances and water use efficiency of the dominant plants in this relatively dry climate. Aridity and low humidity at high elevations favor needle-bearing conifer species that can limit transpiration without increasing leaf temperature to damaging levels (Waring and Franklin 1979). Sclerophylly, C4 and CAM photosynthesis, succulence and reduced leaf area are mechanisms operating in lower elevation desert shrubs and grasses to conserve water and avoid lethal temperatures.

Based on the map by Plumb (1991, 1992 & 1993) for Big Bend National Park, the southern Maderas del Carmen are more similar to the volcanic Chisos Mountains than to the limestone portions of the Sierra del Carmen. The Chisos share many of the same woodland, forest and grassland communities, although the Chisos lack some significant elements such as Coahuila Fir (*Abies coahuilensis*), and stands tend to be more fragmented with less overall coverage.

The middle limestone section of the Sierra del Carmen in Mexico (Sierra Fin del Jardin) does have strong similarities to the Dead Horse Mountains of Big Bend National Park. In the heart of the Sierra Fin del Jardin there are considerable amounts of oak and pinyon woodlands as well as mesa grasslands, which are not strongly represented in the Dead Horse Mountains. But further north, as one approaches the Rio Grandé, there are remote canyonlands that appear to be dominated by succulent desert scrub similar to the low elevations of the Dead Horse Mountains directly across the river. On both sides of the border, these interior canyon lands are extremely rugged and remote. This ruggedness has prevented significant sampling, and further work is

needed. Along the western mountain fronts in the US and Mexico, the vegetation is very similar with desert grasslands and succulent desert scrub cloaking the slopes and alluvial fan piedmonts (see Figure 2).

Land Use

The higher elevations of the Maderas del Carmen contain large, intact stands of mature second growth forest along with isolated pockets of old-growth (Figure 9). They represent some of the largest contiguous forest in the region (Wauer 1992). It is unclear when logging began in the in the high country, but by the 1930's much of the area had already been harvested. Lumber was milled on site at one of the five sawmills, then hauled down steep mountain roads. Intermittent entries continued into the 1980's, but now most of the high country has been excluded from further logging by the current landowners. The logging appears to have been generally low impact selective cutting, probably using horses rather that tractors. The forests were high-graded for old growth Douglas fir and Ponderosa pine, leaving behind moderately open stands of white fir, Arizona cypress and Southwestern white pine. Since the 1930's, Douglas fir and ponderosa pine have been regenerating successfully, creating a young sub-canopy with well developed shrub and herbaceous layers.

The relatively infrequent logging entries during the last 50 years and the removal of livestock grazing from the upper elevations of the Maderas del Carmen has allowed the montane riparian areas to effectively recover. There are now few roads or structures, and even fewer people. The streams are clear and cool with well vegetated, stable banks, and the riparian zones are in excellent condition (Figure 10). Because of a smaller mountain mass and drier conditions, similar riparian zones do not exist in the Chisos Mountains, and the closest comparable site is probably in the Guadalupe Mountains. The Maderas del Carmen receive 40 inches of rain annually compared to 20 inches in the Chisos (Wauer 1992). Thus, the Maderas could be an important migratory stop over for forest birds traveling to and from the north.

Much of the mid-elevation woodlands in the Sierra del Carmen of Mexico are in good condition with well developed, but not overly dense canopies, and good grass cover (Figure 11). Significant grazing, particularly by goats, and fuelwood removals have occurred in the past and are continuing today, particularly in the lower canyons near human settlements. But at higher elevations, in more remote country, impacts are diminished because water development for livestock is limited and reduced road access discourages fuelwood removals. The same holds true for some of the larger, more remote mesa tops such as Guadalupe Mesa, Mesa los Fresnos, and those in the Sierra Fin del Jardin that support extensive grasslands in good condition (Figure 12).

In contrast to Big Bend National Park, grazing and mining still occur within the Maderas del Carmen Protected Area, both on private ranches and the ejidos. In the lowlands, overgrazing has led to significant amounts of shrub encroachment at the expense of native grasses (Figure 13 & 14). This is particularly true near the small ejidos at the base of the Sierra del Carmen which have been badly degraded with little prospect for rehabilitation (Carrera 1995). Still, some

a) West face of the main escarpment of the Maderas del Carmen.

b) Interior on the Maderas del Carmen overlooking Cañon Moreno.

Figure 9. Upper montane conifer forest of the Maderas del Carmen.

Figure 10. Stream in Cañon el Moreno with well-vegetated banks and clear water.

Figure 11. Juniper woodland on Guadalupe Mesa with a dense grass cover dominated by New Mexico bluestem (*Schizachyrium neomexicanum*).

Figure 12. Extensive, good-condition grasslands occur on Mesa los Fresnos that are dominated by a mixture of grama grasses (*Bouteloua gracilis, B. curtipendula, B. hirsuta*) and finestem needlegrass (*Stipa tenuissima*).

Figure 13. A view into the lowland valley east of the Maderas del Carmen (with the Sierra el Burro in the background) where shrublands have likely increased due to grazing.

Figure 14. Shrubs have become dominant on this alluvial piedmont along the southern flank of western Maderas del Carmen.

grazed areas in Mexico may have higher grass cover than some protected sites in the US. Using our plot data, a comparison of grass cover on both sides of the border on limestone soils at the same elevations (around 5,500 ft or 1,680m) show an average of 11.5% in Mexico and 7.6% in the Dead Horse Mountains. These figures are confounded by different sampling years and seasons - sampling took place in June,1998 before the growing season in the Dead Horse Mountains, while sampling in Mexico was at the peak of the growing season in 1997. Long-term monitoring in Big Bend National Park has shown an increase in grass cover since the release from grazing, an effect which is also tied to higher than normal precipitation and soil characteristics (Wondzell and Ludwig 1995). But some sites have always had poor soils and have been dominated by desert shrublands with little or no grass cover for a long period of time, regardless of land use history (Figure 16).

Fire History

Although not directly studied, we would suggest that the fire regime of these forests is as close to natural as possible, given the ineffectiveness of fire suppression within this remote mountain range. In the forests, there was no evidence of catastrophic fire events that typically result from long-term fire suppression, nor were there characteristics of stand stagnation that accompany long-term fire suppression such as 'doghair' thickets of tree saplings in the understory, high litter buildup and a depauperate herbaceous understory. There are also small pockets of unburned old growth that remain in the upper canyon reaches that may serve as refugia for species and are in need of further study.

To what extent forest fires were a significant historical element in this landscape can only be inferred. At the periphery of the high country, particularly in rugged and rocky areas, are areas dominated by extensive montane shrublands with chaparallic species such as pointleaf manzanita (*Arctostaphylos pungens*), sandpaper oak (*Quercus pungens* var. *pungens*) and mountain mahogany (*Cercocarpus montanus*) which are known to re-seed or sprout vigorously after a fire (Wright 1990) (Figure 16). Thus, these shrublands are probably fire-induced and may be fire-maintained, although the natural fire frequency for this vegetation type may be upward of 100 years (Keely and Keely 1988, Valiente-Banuet et al. 1998). Fire may be more frequent in the grasslands of the mesas and eastern footslopes. The lush grass cover is capable of carrying cool fires fairly frequently, thus limiting the establishment of a dense tree canopy on the mesas or shrubs on the footslopes.

Figure 15. A sparse creosotebush shrubland on shallow, poor soils at Ernst Tinaja in Big Bend National Park that is probably not grazing induced.

Figure 16. Montane shublands in upper El Diablo that may be maintained with periodic fire.

CONCLUSION AND RECOMMENDATIONS

The map presented here with the accompanying provisional vegetation classification is the most detailed work on vegetation conducted to date in the Sierra del Carmen/Dead Horse Mountain area. The map has not been validated with an independent data set, primarily because of the cost, but it is based directly on a significant amount of ground data and has been informally ground truthed. We feel the map effectively depicts the general vegetation patterns across the range in a way that will support trans-boundary cooperation on biological management at the scale provided.

Furthermore, managers are encouraged to use the vegetation classification by linking and discussing wildlife uses, fire behavior and other observations within the context of plant associations. The detailed information on species composition and environments within the plant association data should help to provide a context for evaluating the habitat needs for plants and animals that exist on both sides of the border, or travel between them across the Rio Grandé. There is still much to be learned about this rugged and remote mountain range (in both Mexico and the US), and further botanical and faunal surveys are strongly recommended to enhance our understanding of differences and similarities across the Rio Grandé between Big Bend National Park and the Maderas del Carmen Protected Area.

REFERENCES

Aide, M. and O.W. Van Auken. 1985. Chihuahuan desert vegetation of limestone and basalt slopes in west Texas. Southwestern Naturalist 30:533-542.

Anderson, M., P. Bourgeron, M.T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K.Goodin, D.H. Grossman, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, L. Sneddon and A.S. Weakley. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume II. The National Vegetation Classification System: List of Types. The Nature Conservancy, Arlington, Virginia, USA.

Axelrod, D.I. 1958. Evolution of the Madro-Tertiary geoflora. Botanical Review 24:433-509.

Axelrod, D.I. and P.H. Raven. 1985. Origins of the Cordilleran flora. Journal of Biogeography 12:21-47

Brown, D.E., C.H. Lowe and C.P. Pase. 1979. A digitized classification system for the biotic communities of North America, with community (series) and association examples for the Southwest. The Journal of the Arizona-Nevada Academy of Science 14 (Suppl. 1):1-16.

Carpenter, D.L. 1996. Tectonic history of the metamorphic basement rocks of the Sierra del Carment, Coahuila, Mexico. University of Texas at Austin, Master's thesis. 117 p.

Carrera, J.A. (est.)1995. Alternatives for the use of the natural resources of the region between Santa Elena and Boquillas, Mexico. Cooperative agreement between Big Bend National Park, Sul Ross State University and Profauna A.C. J.T. LeBaume, translator.

Collins, E.W. and J.A. Raney. 1996. Geology of Sierra del Carmen, west Texas and Mexico: A general geologic framework to support mapping of biologic (botanical) resources. Prepared for the National Biological Service.

Gehlbach, F.R. 1981. Mountain Islands and Desert Seas – A Natural History of the U.S.-Mexican Borderlands. Texas A&M University Press, College Station. 298 pp.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume 1. The National Vegetation Classification System: development, status, and applications. The Nature Conservancy, Arlington, Virginia, USA.

Henrickson, J. and M.C. Johnston. 1983. Vegetation and community types of the Chihuahuan Desert. IN: Barlow, J.C., A.M. Powell, B.N. Timmerman. [eds.] Invited Papers from the Second Symposium on Resources of the Chihuahuan Desert Region, United States and Mexico, 20-21 October, 1983. Chihuahuan Desert Research Institute, Sol Ross State University, Alpine, TX. pp. 20-39

Henrickson, J. and M.C. Johnston.1997. A Flora of the Chihuahuan Desert Region. Draft, Edition 1.2

Jimenez-Guzman, A. and M.A. Zuniga-Ramos. 1991. Caracterizacion biologica de Sierra Maderas del Carmen, Coahuila, Mexico. Anales Inst. Univ. Nac. Auton. Mexico Ser. Zool. 62:373-382.

Kartesz, J.T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. Second Edition. Timber Press, Portland, Oregon.

Keeley, J.E. and S.C. Keely. 1988. Chaparral. IN: Barbour, M.G. and W.D. Billings [eds.] North American Terrestrial Vegetation. Cambridge University Press. New York, N.Y. pp. 165-207

Lillesand, T.M. and R.W. Kiefer. 1987. Remote Sensing and Image Interpretation, 2nd edition, 721 p.

MacMahon, J.A.. 1988. Warm Deserts. IN: Barbour, M.G. and W.D. Billings [eds.]. North American Terrestrial Vegetation. Cambridge University Press, New York, NY. pp. 231-264.

Maler, M.O. 1989. Structural geology of the southernmost Sierra del Caballo Muerto/Boquillas Canyon area, Big Bend National Park, Texas. University of Texas at Austin, Master's thesis. 75 p.

Marroquin, J.S. 1976. A physiognomic analysis of the types of transitional vegetation in the eastern parts of the Chihuahuan Desert in Coahuila, Mexico. Botany pp. 249-272.

Mueller-Dombois, D. and H. Ellenberg. 1974. Amins and Methods of Vegetation Ecology. John Wiley and Sons, New York.

Muller, C.H. 1947. Vegetation and climate of Coahuila, Mexico. Madrono 9:1-32.

Muldavin, E.H. and R.L. DeVelice. 1987. A forest habitat type classification of southern Arizona and its relationship to forests of the Sierra Madre Occidental of Mexico. IN: Strategies for classification and management of native vegetation for food produtions in arid zones. USDA Forest Service General Technical Report RM-150, pp. 24-31.

Muldavin, E., Ronco, F.J. and Aldon, E.F. 1990. Consolidated stand tables and biodiversity database for Southwestern Forest habitat types. USDA Forest Service General Technical Report, RM-190, 51p + computer diskettes.

Muldavin, E.H., R.L. DeVelice and F. Ronco, Jr. 1996. A classification of forest habitat types of Southern Arizona and portions of the Colorado Plateau. USDA Forest Service General Technical Report, RM-GTR-287.

New Mexico Natural Heritage Program. 1997. Vegetation mapping, assessment and monitoring of the Maderas del Carmen Protected Area, Mexico. Unpublished report prepared for the National Park Service, Southwest Regional Office.

Parry, J.P. 1991. The pines of Mexico and Central America. Timber Press. 231 p.

Pase, C.P. and D.E. Brown. 1982. Rocky Mountain (Petran) and Madrean Montane Conifer Forests. Desert Plants. 4:43-48.

Plumb, G.A. 1991. Assessing vegetation types of Big Bend National Park, Texas for image-based mapping. Vegetation 94:115-124.

Plumb, G.A. 1992. Vegetation classifications of Big Bend National Park, Texas. The Texas Journal of Science 44:377-387.

Plumb, G.A. 1993. Knowledge-based digital mapping of vegetation types in Big Bend National Park, Texas. Geocarto International 2:29-38.

Risser, P.G. 1995. The status of the science of examining ecotones. Bioscience 45:318-325.

Rzedowski. 1978. Vegetacion de Mexico. Editorial Limusa, S.A. 432 p.

Universidad Autonoma de Nuevo Leon, Facultad Ciencias Biologicas. 1988. Infome del anteproyecto de una area natural protegida al gobierno del estado de Coahuila “Sierra Maderas del Carmen, un Paraiso Biologico”. Monterrey, Nuevo Leon.

Valiente-Banuet, A., N. Flores-Hernandez, M. Verdu and P. Davila. 1998. The chaparral vegetation in Mexico under nonmediterranean climate: the convergence and Madrean-Tethyan hypothesis reconsidered. Journal of Botany 85:1398-1408.

Villarreal, Q., and J.A. y J.Valdes R. 1993. Vegetacion de Coahuila. Manejo de Pastizales, 6:9-18.

Wauer, R.H. 1992. A Naturalist’s Mexico. Texas A&M University Press, College Station. 304 pp.

Waring, R.H. and J.F. Franklin. 1979. Evergreen coniferous forests of the Pacific Northwest. Science 204:1380-1386.

Wright, H.A. 1990. Role of fire in the management of southwestern ecosystems. IN: Effects of Fires Management of Southwestern Natural Resources, Proceedings of the Symposium, Nov. 15-17, 1988, Tucson, AZ. USDA Forest Service, Gen. Tech. Report RM-191. pp. 1-5.

Appendix A

Map Unit Descriptions

for the

Vegetation Map of the Sierra del Carmen

U.S. and Mexico

Map Unit 1: Mixed Conifer Forest (Figure 1)

Elevation: *7400-8900' (2250-2700m)*
Total Area: *6,615 acres (2678 hectares)*
Number of Plots: *29*

Description: Dense high-elevation forests on cool slopes which are characterized by a combination of Coahuila fir (*Abies coahuilensis*), Douglas fir (*Pseudotsuga menziesii*), Arizona cypress (*Cupressus arizonica*), Southwestern white pine (*Pinus strobiformis*) and Arizona pine (*Pinus arizonica*). Old-growth is included within the unit, but the majority consists of logged forests. Stands of old-growth are dominated by Douglas fir, while logged stands are dominated by Coahuila fir and southwestern white pine. Silverleaf oak (*Quercus hypoleucoides*) is generally present but not well established. The understory typically consists of a variety of sparsely scattered grasses and forbs including bulb panicgrass (*Panicum bulbosum)*, Pringle's needlegrass (*Piptochaetum pringlei*), brome grasses (*Bromus* spp.), false pennyroyal (*Hedoma* spp.), fleabane (*Erigeron* spp.), goldeneye (*Viguiera* spp.), woodsorrel (*Oxalis* spp.), meadowrue (*Thalictrum fendleri*) yarrow (*Achillea millefolium*), Carl Mason's senecio (*Senecio carlomasonii*), and umbrellawort (*Chimaphylla menziesii)*.

Representative Vegetation Communities:
Coahuila Fir-Arizona Pine/Pringle Needlegrass (*Abies coahuilensis-Pinus arizonica/Piptochaetum pringlei*)
Coahuila Fir-Silverleaf Oak/Pringle Needlegrass (*Abies coahuilensis-Quercus hypoleucoides/Piptochaetum pringlei)*
Coahuila fir/Umbrellawort (*Abies coahuilensis/Chimaphylla menziesii*)
Douglas-fir-Silverleaf Oak/Umbrellawort (*Psuedotsuga menziesi-Quercus hypoleucoides/Chimaphylla menziesii*)

Map Unit 2: Mesa Pine Forest (Figure 2)

Elevation: *7400-8600' (2250-2620m)*
Total Area: *341 acres (843 hectares)*
Number of Plots: *9*

Description: Forested areas on low slopes or mesa tops. Canopies are predominantly open and are dominated by Arizona pine (*Pinus arizonica*) or Southwestern white pine (*Pinus strobiformis*). This forest is characterized by a luxuriant understory of poverty danthonia (*Danthonia spicata*), Pringle's needlegrass (*Piptochaetum pringlei*), panic bulbgrass (*Panicum bulbosum*), Arizona fescue (*Festuca arizonica*), and scattered forbs including groundsels (*Senecio* spp.), goldeneyes (*Viguiera* spp.) and yarrow (*Achillea millefolium*).

Representative Vegetation Communities:

Arizona Pine/Poverty Danthonia (*Pinus arizonica/Danthonia spicata)*
Arizona Pine/Pringle Needlegrass (*Pinus arizonica/Piptochaetum pringlei)*

Figure 1: Mixed Conifer Forest.
97GC037 at El Cinco Asaderro in the Maderas del Carmen. Dominants Coahuila fir and Southwestern white pine are mixed with silverleaf oak. Scattered Arizona pine and Douglas-fir are regenerating in the understory.

Figure 2: Mesa Pine Forest.
97GC019 on Mesa Bonita in the Maderas del Carmen. Park-like stand of Arizona pine with a grassy understory of poverty oat grass.

Map Unit 3: Pine-Oak Forest (Figure 3)

Elevation: *5700-8900' (1740-2710 m)*
Total Area: *8,024 acres (3,247 hectares)*
Number of Plots: *20*

Description: Similar to Mixed Conifer, this type also occurs on high-elevation slopes but is marked by the near absence of Coahuila fir (*Abies coahuilensis*) and the presence of a strong oak association. The canopy is generally dominated by Arizona pine (*Pinus arizonica*), Douglas-fir (*Pseudotsuga menziesii*), Grave's oak (*Quercus gravesii*), silverleaf oak (*Q. hypoleucoides*) and Texas madrone (*Arbutus xalapensis*). Southwestern white pine (*Pinus strobiformis*) is common in logged areas. The understory is diverse and includes Pringle's needlegrass (*Piptochaetum pringlei*), bulb panicgrass (*Panicum bulbosum*), false pennyroyal (*Hedeoma* spp.), goldeneye (*Viguiera* spp.) and geranium (*Geranium caespitosum*).

Representative Vegetation Communities:
Arizona Pine-Graves Oak/Wooly Brome (*Pinus arizonica-Quercus gravesii/Bromus lantipes*)
Arizona Pine-Silverleaf Oak/Pringle Needlegrass (*Pinus arizonica-Quercus hypoleucoides/Piptochaetum pringlei*)
Arizona Pine-Netleaf Oak/Junegrass (*Pinus arizonica-Quercus rugosa/Koeleria macrantha*)
Douglas-fir-Texas Madrone (*Psuedotsuga menziesii-Arbutus xalapensis*)

Map Unit 4: Oak Forest (Figure 4)

Elevation: *5500-8200' (1680-2500 m)*
Total Area: *13,466 acres (5,449 hectares)*
Number of Plots: *20*

Description: Dense forests found within montane drainages or along mesic slopes. The canopy is generally dominated by a combination of Grave's (*Quercus gravesii*), silverleaf (*Q. hypoleucoides*), and chinkapin (*Q. muehlenbergii*) oaks. Co-dominants are Lacey's oak (*Quercus laceyi*) at lower elevations and netleaf oak (*Quercus rugosa*) at higher elevations; this may also reflect a longitudinal difference as *Q. rugosa* is at the western extent of it range in the Sierra del Carmens, and *Q. laceyi* is at its eastern edge of distribution. An Arizona pine variety that occurs in the eastern section of the mountains (*Pinus arizonica* var. *stormiae*) and Southwestern white pine (*Pinus strobiformis*) occur as scattered trees. Royal sage (*Salvia regla*) is conspicuous in the sub-canopy. Ground cover is diverse but sparse, dominated by scattered pinyon ricegrass (*Piptochaetum fimbriatum*) , Pringle's needlegrass (*Piptochaetum pringlei*), desert muhly (*Muhlenbergia glauca*), New Mexico bluestem (*Schizachyrium neomexicanum*), and various composites.

Representative Vegetation Communities: (* = a transitional community type)
Graves Oak/Pinyon Rice Grass (*Quercus gravesii/Piptochaetium fimbriatum*)
Graves Oak/Pringle Needlegrass (*Quercus gravesii/Piptochaetium pringlei*)
Graves Oak-Arizona White Oak/Pringle Needlegrass (*Quercus gravesii-Quercus arizonica/Piptochaetium pringlei*)
Graves Oak-Arizona White Oak/Bull Muhly (*Quercus gravesii-Quercus arizonica/Muhlenbergia emersleyi*)
Graves Oak-Lacey's Oak/New Mexico Bluestem (*Quercus gravesii-Quercus laceyi/Schizachyrium neomexicanum*;
Graves Oak-Silverleaf Oak/Pringle Needlegrass (*Quercus gravesii-Quercus hypoleucoides/Piptochaetium pringlei)*

Map Unit 5: Pinyon Pine-Juniper Woodland (Figure 5)

Elevation: *4500-7500' (1370-2290 m)*
Total Area: *20,832 acres (8,248 hectares)*
Number of Plots: *26*

Description: Mid-elevation coniferous woodlands characterized by (mostly) closed canopies of Mexican pinyon (*Pinus cembroides*) and alligator juniper (*Juniperus deppeana*). A complement of white oaks, including Arizona white oak (*Q. arizonica*), grey oak (*Q. grisea*), and Mohr's shin oak (*Quercus mohriana*) are generally scattered throughout stands; Emory's oak (*Q. emoryi*) is found less frequently. There is a tendency for Mexican pinyon to give way to Papershell pinyon (*Pinus remota*) as the dominant tree in stands below 5600 ft. Scattered shrubs, such as royal sage (S*alvia regla*), Havard agave (*Agave havardiana*), pricklypears (*Opuntia* spp.) and mimosa (*Mimosa aculeaticarpa* var. *biuncifera*) are found in the sub-canopy. The grass layer is well developed and consists of bull muhly (*Muhlenbergia emersleyi*), New Mexico bluestem (*Schizachyrium neomexicanum*), sideoats grama (*Bouteloua curtipendula*) and blue grama (*B. gracilis*).

Representative Vegetation Communities:
Mexican Pinyon/Sideoats Grama (*Pinus cembroides/Bouteloua curtipendula*)
Mexican Pinyon-Mountain Mahogany (*Pinus cembroides-Cercocarpus montanus*)
Mexican Pinyon/Sacahuista (*Pinus cembroides/Nolina texana*)
Mexican Pinyon/Bull Muhly (*Pinus cembroides/Muhlenbergia emersleyi*)
Mexican Pinyon-Arizona White Oak/Bull Muhly(*Pinus cembroides-Quercus arizonica/Muhlenbergia emersleyi*)
Papershell Pinyon/Sideoats Grama (*Pinus remota/Bouteloua curtipendula*)
Papershell Pinyon-Sandpaper Oak (*Pinus remota-Quercus pungens* var. *pungens*)

Figure 3: Pine-Oak Forest.
97GC090 in a sideslope of a canyon leading off of Mesa Guadalupe. Arizona pine and Graves oak dominate the overstory with mixed grasses and forbs in the understory.

Figure 4: Oak Forest.
97GC013 along the floodplain of Moreno Canyon. The canopy is nearly closed with tall stature silverleaf and Graves' Oak, but there is a sparse understory of mixed grasses.

Figure 5: Pinyon Pine-Juniper Woodland.
97SW069 on Guadalupe Mesa. Mexican pinyon, alligator juniper and Mohr's oak equally dominate the open canopy over a dense grassy understory of mixed grasses.

Figure 6: Juniper and Oak Savannah.
97SW031 in El Club Canyon. Arizona white oak is scattered on these diverse grassy slopes, although sideoats grama is the predominant species here. Succulents are dispersed within the grass layer.

Map Unit 6: Juniper and Oak Savannah (Figure 6)

Elevation: *5000-6500' (1530-1990 m)*
Total Area: *4,705 acres (1,904 hectares)*
Number of Plots: *14*

Description: Open (<10% canopy cover) savannah woodlands with grassy understories found locally on Fresno and Guadalupe Mesas and on mid-elevation slopes. Alligator juniper (*Juniperus deppeana*) or Arizona white oak (*Quercus arizonica*) dominate the tree layer, although Mohr's shin oak (*Quercus mohriana*) is found in some areas. Mexican pinyon (*Pinus cembroides*) and Mexican drooping juniper (*Juniperus flaccida*) may occur within stands as scattered individuals. The understory is a prairie-like grass layer dominated by sideoats grama (*Bouteloua curtipendula*), New Mexico bluestem (*Schizachyrium neomexicanum*), and plains lovegrass (*Eragrostis intermedia*). Scattered succulents, commonly pricklypear (*Opuntia* spp.) and Havard's agave (*Agave havardiana*) occur within the grass layer.

Representative Vegetation Communities:
Alligator Juniper/New Mexico Bluestem (*Juniperus deppeana/Schizachyrium neomexicanum*)
Alligator Juniper/Finestem Needlegrass (*Juniperus deppeana/Stipa tenunissima*)
Arizona White Oak/Sideoats Grama (*Quercus arizonica/Bouteloua curtipendula*)
Arizona White Oak/Finestem Needlegrass (*Quercus arizonica/Stipa tenuissima*)
Arizona White Oak/Bull Muhly (*Quercus arizonica/Muhlenbergia emersleyi*)
Mohr's Shin Oak/Bull Muhly (*Quercus mohriana/Muhlenbergia emersleyi)*

Map Unit 7: Oak Woodland (Encinal) (Figure 7)

Elevation: *4500-7900' (1370-2410 m)*
Total Area: *33,636 acres (13,612 hectares)*
Number of Plots: *42*

Description: Mostly closed-canopied evergreen woodlands dominated by Arizona white oak (*Quercus arizonica*), gray oak (*Quercus grisea*) or Mohr's shin oak (*Quercus mohriana*). Sparsely scattered Mexican pinyon (*Pinus cembroides*) and alligator juniper (*Juniperus deppeana*) are common in transition areas. Bull muhly (*Muhlenbergia emersleyi*), New Mexico bluestem (*Schizachyrium neomexicanum*), blue grama (*Bouteloua gracilis*) and sideoats grama (*B. curtipendula*) are found in the grassy understory.

Representative Vegetation Communities:
Arizona White Oak/Sideoats Grama (*Quercus arizonica/Bouteloua curtipendula*)
Arizona White Oak/Blue Grama (*Quercus arizonica/Bouteloua gracilis*)
Arizona White Oak/Bull Muhly (*Quercus arizonica/Muhlenbergia emersleyi)*
Arizona White Oak/Sparse (*Quercus arizonica*/Sparse)
Arizona White Oak/New Mexico Bluestem (*Quercus arizonica/Schizachyrium neomexicanum*)
Emory's Oak/Sideoats Grama (Quercus emoryi/Bouteloua curtipendula)

Map Unit 8: Montane Shrubland (Figure 8)

Elevation: *4500-7800' (1370-2380 m)*
Total Area: *83,564 acres (33,817 hectares)*
Number of Plots: *30*

Description: Highly diverse, low-growing and typically dense montane shrublands with a wide variety of shrubs and small trees, most often including oak (*Quercus* spp.), mountain mahogany (*Cercocarpus montanus*), manzanita (*Arctostaphylos pungens*), evergreen sumac (*Rhus virens*), littleleaf leadtree (*Leucana retusa*), and desert ash (*Fraxinus greggii*). Oak species within the unit include gray (*Q. grisea*), Arizona white (*Q. arizonica*), Mohr's shin (*Q. mohriana*), Vasey's shin (*Q. pungens* var. *vaseyana*), Carmen (*Q. carmenensis*), sandpaper (*Q. pungens*) and Emory (*Q. emoryi*) oaks. Succulent species are conspicuous and include sacahuista (*Nolina* spp.), sotol (*Dasylirion* spp.), lechuguilla (*Agave lechuguilla*) and giant dagger (*Yucca faxoniana*). Guayule (*Parthenium argentatum*) occurs on limestone slopes and Mexican pinyon (*Pinus cembroides*) is scattered in some areas. There is a high diversity of forbs, including several small-stemmed cacti (*Echinocereus, Echinocactus, Mammilaria, Coryphantha* and *Escobaria* spp.), resurrection moss (*Selaginella* spp.), baccharisleaf beardtongue (*Penstemon baccharifolius*), ferns (*Astrolepis cohisensis, Argyrochosma parviflora, Pleopeltis guttatum, Notholaena aschenbornia*), polkadots (*Dyschoriste linearis*), wild petunia (*Ruellia parryi*), menodora (*Menodora scabra, M. longiflora*) and others. Montane shrubland is commonly found on exposed ridges or montane flats with the most extensive contiguous stands being in the northcentral and southern portions of the area. Frequent fires may play a role in reducing conifers and maintaining high shrub diversity.

Representative Vegetation Communities:
Mountain Mahogany-Pointleaf Manzanita (*Cercocarpus montanus-Arctostaphylos pungens*)
Mountain Mahogany/Sideoats Grama (*Cercocarpus montanus/Bouteloua curtipendula*)
Mountain Mahogany/Bull Muhly (*Cercocarpus montanus/Muhlenbergia emersleyi)*
Desert Ash-Slimleaf Vauquelina (*Fraxinus greggii-Vauquelina corymbosa* ssp. *angustifolia*)
Desert Ash/Southwestern Needlegrass (*Fraxinus greggii/Stipa eminens*)
Desert Ash-Lechuguilla (*Fraxinus greggii-Agave lechuguilla*)
Arizona White Oak/Pointleaf Manzanita/New Mexico Bluestem (*Quercus arizonica/Arctostaphylos pungens/Schizachyrium scoparium*)
Arizona White Oak/Mountain Mahogany (*Quercus arizonica/Cercocarpus montanus*)
Arizona White Oak/Faxon's Yucca/Sideoats Grama (*Quercus arizonica/Yucca faxoniana*/*Bouteloua curtipendula*)
Mohr's Shin Oak-Desert Ceanothus (*Quercus mohriana-Ceanothus greggii*)
Mohr's Shin Oak-Faxon's Yucca/Curlyleaf Muhly (*Quercus mohriana-Yucca faxoniana/Muhlenbergia setifolia*)
Mohr's Shin Oak-Mountain Mahogany (*Quercus mohriana-Cercocarpus montanus*)
Mohr's Shin Oak-Smooth Sotol (*Quercus mohriana-Dasylirion leiophyllum*)
Mohr's Shin Oak/Bull Muhly (*Quercus mohriana/Muhlenbergia emersleyi*)
Vasey's Oak/Mountain Mahogany (*Quercus pungens* var. *vaseyana-Cercocarpus montanus*)

Figure 7: Oak Woodland (Encinal)
97GC088 on a side canyon of Guadalupe Mesa. Shrubby Mohr's shin oak dominates over a grassy understory of bull muhly. Sacahuista is well represented in the shrub layer.

Figure 8: Montane Shrubland.
97SW041 in a drainage slope off San Isidro Canyon. Mexican pinyon, leadtree and Mohr's shin oak are mixed with several succulent shrubs. Grasses are scattered.

Map Unit 9: Mesa Grassland (Figure 9)

Elevation: *4300-6400' (1310-1960 m)*
Total Area: *6,230 acres (2,521 hectares)*
Number of Plots: *10*

Description: A dense prairie-like grassland found on deep, fine soils of expansive flats or swales of mesa platforms. The largest uninterrupted stand occurs on Fresno Mesa but small disjunct stands may be found throughout the area. These grasslands may be highly heterogeneous, but are generally dominated by blue or hairy grama (*Bouteloua gracilis, B. hirsuta*) with patches of tobosagrass (*Hilaria mutica*) and cane bluestem (*Bothriochloa barbinodes*) in moist areas. Finestem needlegrass (*Stipa tenuissima*), poverty threeawn (*Aristida divaricata*) and broom snakeweed (*Gutierrizia sarothrae*) predominate in disturbed areas. Little-nipple cactus (*Mammillaria heyderi*) and Havard's agave (*Agave havardiana*) are commonly found growing within the grasses.

Representative Vegetation Communities:
Hairy Grama-Blue Grama (*Bouteloua hirsuta-Bouteloua gracilis*)
Chino Grama-Sideoats Grama (*Bouteloua ramosa-Bouteloua curtipendula*)
Blue Grama-Finestem Needlegrass (*Bouteloua gracilis-Stipa tenuissima*)

Map Unit 10: Foothill Grassland (Figure 10)

Elevation: *4000-6000' (1220-1830 m)*
Total Area: *27,756 acres (11,232 hectares)*
Number of Plots: *13*

Description: Well developed grasslands with occasional shrubs on shallow, rocky soils of foothill slopes. These grasslands are chiefly found on the eastern slopes of the Sierra del Carmens and tend to grade into Sotol Grasslands at lower elevations and Oak Woodlands at higher elevations. The grass layer is luxuriant and dominated by sideoats, blue, and hairy grama (*Bouteloua curtipendula*, *B. gracilis, B. hirsuta*), New Mexico bluestem (*Schizachyrium neomexicanum*), and on limestone, curlyleaf muhly (*Muhlenbergia setifolia*). Purple threeawn (*Aristida purpurea*) and tanglehead (*Heteropogon contortus*) may dominate in disturbed areas. Shrubs are absent or very sparsely scattered and are typical of the Trans-Pecos Chihuahuan Desert: mimosa (*Mimosa aculeaticarpa* var. *biuncifera*), lechuguilla (*Agave lechuguilla*), sotol (*Dasylirion leiophyllum*), honey mesquite (*Prosopis glandulosa*) and beebrush (*Aloysia gratissima*). The forbs are scattered in the grass layer with Louisiana sagewort (*Artemisia ludoviciana*) and Wright's buckwheat (*Eriogonum wrightii*) frequently encountered.

Representative Vegetation Communities:
Purple Threeawn-Tanglehead (*Aristida purpurea-Heteropogon contortus*)
Blue Grama-Sideoats Grama (*Bouteloua gracilis-Bouteloua curtipendula*)
Hairy Grama-Sideoats Grama (*Bouteloua hirsuta-Bouteloua curtipendula*)
Hairy Grama-New Mexico Bluestem (*Bouteloua hirsuta-Schizachyrium neomexicanum*)
Curlyleaf Muhly-Hairy Grama/Lechuguilla (*Muhlenbergia setifolia-Bouteloua hirsuta/Agave lechuguillai*)

Figure 9: Mesa Grassland.
97SW097 in a vega of the Sierra El Jardin. Blue grama and tobosagrass form a thick grassy swale, although forbs are clumped in open patches.

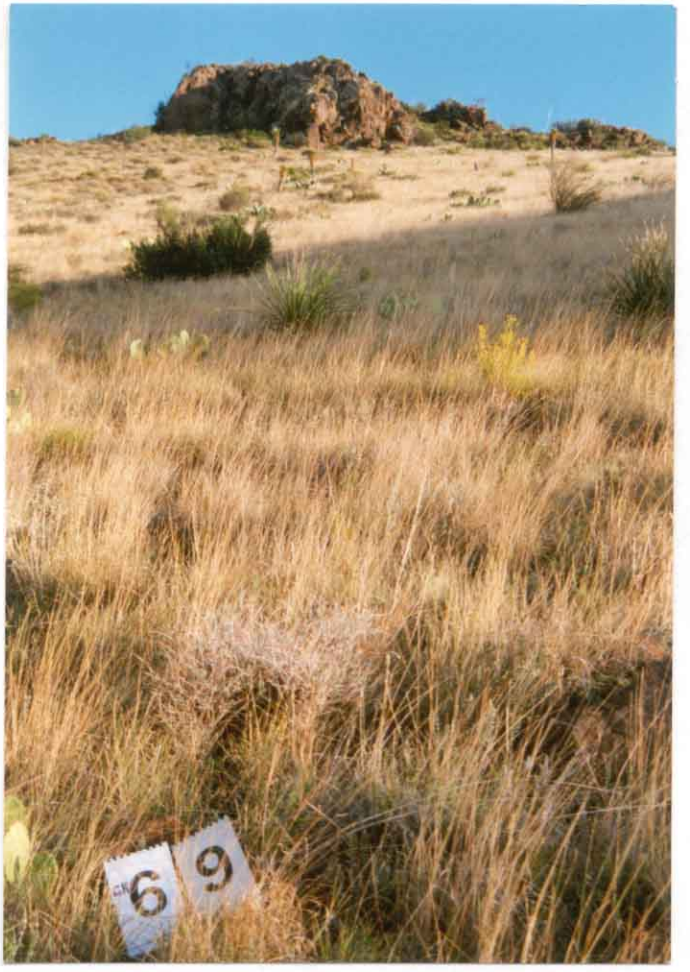


Figure 10: Foothill Grassland.
97GC069 on a north facing slope North of Los Cojos mine. Shrubs are interspersed within a dense grassy layer of blue and sideoats grama on a rocky slope.

Map Unit 11: Sotol-Yucca Grassland (Figure 11)

Elevation: *3600-6500' (1090-1990 m)*
Total Area: *154,127 acres (62,373 hectares)*
Number of Plots: *55*

Description: Diverse foothill or upper bajada grassland is a major map unit throughout the study area. Species composition is similar to that of the Foothill Grassland unit, but this grassland has a much stronger Chihuahuan shrub component. Sotol (*Dasylirion leiophyllum*) or yucca (*Yucca thompsoniana, Y. faxonia*) are the most common shrub dominants with skeletonleaf goldeneye (*Viguiera stenoloba*) occurring in recently burned areas. Other shrubs commonly present include cactus apple (*Opuntia englemanii*), Texas falseagave (*Hechtia texensis*) and lechuguilla (*Agave lechuguilla*). The grass layer typically consists of sideoats, chino or black grama (*Bouteloua curtipendula, B. ramosa*, *B. eriopoda*) but there is an abundance of tanglehead (*Heteropogon contortus*) and purple and sixweeks threeawns (*Aristida purpurea, A. adscensionis*) in grazed areas. Additionally, curlyleaf muhly (*Muhlenbergia setifolia*) is found on limestone soils. Although grasses are typically scattered, luxuriant growth is common in undisturbed areas.

Representative Vegetation Communities:
Sideoats Grama/Smooth Sotol (*Bouteloua curtipendula/Dasylirion leiophyllum*)
Sideoats Grama/Toothleaf Goldeneye (*Bouteloua curtipendula/Viguiera dentata*)
Sideoats Grama/Faxon's Yucca (*Bouteloua curtipendula/Yucca faxoniana*)
Sideoats Grama/Beaked Yucca (*Bouteloua curtipendula/Yucca thompsoniana*)
Black Grama/Smooth Sotol (*Bouteloua eriopoda/Dasylirion leiophyllum*)
Blue Grama/Beaked Yucca (*Bouteloua gracilis/Yucca thompsoniana*)
Hairy Grama/Faxon's Yucca (*Bouteloua hirsuta/Yucca faxoniana*)
Hairy Grama/Smooth Sotol (*Bouteloua hirsuta/Dasylirion leiophyllum*)
Chino Grama/Lechuguilla (*Bouteloua ramosa/Agave lechuguilla*)
Chino Grama/Smooth Sotol (*Bouteloua ramosa/Dasyliron leiophyllum*)
Chino Grama/Candelilla (*Bouteloua ramosa/Euphorbia antisyphilitica*)
Bullgrass/Beaked Yucca (*Muhlebergia emersleyi/Yucca thompsoniana*)
Bullgrass/Smooth Sotol (*Muhlenbergia emersleyi/Dasylirion leiophyllum)*
Curlyleaf Muhly/Smooth Sotol (*Muhlenbergia setifolia/Dasylirion leiophyllum*)

Map Unit 12: Honey Mesquite Grassland (Figure 12)

Elevation: 3800-5000' *(1160-1530 m)*
Total Area: *18,847 acres (7,627 hectares)*
Number of Plots: *11*

Description: Basin bottom or alluvial flat grassland with a strong honey mesquite (*Prosopis glandulosa*) presence found predominantly on the east side of the Sierra del Carmens. The structure of the grassland varies from a savanna-like aspect with mature mesquite trees to a sparse shrubland with scattered low-lying shrubs. Luxuriant understories of tobosagrass (*Hilaria mutica*) and black or blue grama (*Bouteloua eripoda, B. gracilis*) occur in undisturbed or low impact areas (Dead Horse Mountains). In overgrazed areas, these grasses decrease in proportion to disturbance responders, such as sixweeks grama (*Bouteloua barbata*), purple and sixweeks threeawn (*Aristida purpurea, A. adscensionis*), feather fingergrass (*Chloris virgata*) and bristlegrass (*Setaria* spp.). Soil erosion can be severe in these areas, with unchecked runoff creating a maze of headcuts.

Representative Vegetation Communities:
Whitethorn Acacia/Black Grama (*Acacia constricta/Bouteloua eriopoda*)
Black Grama/Havard's Agave (*Boutleoua eriopoda/Agave havardiana*)
Sixweeks Grama-Feather Fingergrass (*Bouteloua barbata-Chloris virgata*)
Honey Mesquite/Purple Threeawn (*Prosopis glandulosa/Aristida purpurea*)
Honey Mesquite/Black Grama (*Prosopis glandulosa/Bouteloua eriopoda*)
Honey Mesquite/Blue Grama (*Prosopis glandulosa/Bouteloua gracilis*)
Honey Mesquite/Tobosagrass (*Prosopis glandulosa/Hilaria mutica*)

Figure 11: Sotol-Yucca Grassland. 97GC081 in an upland valley near the Florida Ranch. Yucca, sotol and mesquite are well represented in a moderately dense blue grama swale.

Figure 12: Honey Mesquite Grassland.
97SW070 in a grassy mesquite flat near Guadalupe ranch. There is a high diversity of shrubs, grasses and forbs, but mesquite dominates the shrub layer, while blue and black grama are the predominate grasses.

Map Unit 13: Creosotebush-Acacia Shrubland (Figure 13)

Elevation: *2900-5800' (880-1770 m)*
Total Area: *79,764 acres (32,279 hectares)*
Number of Plots: *38*

Description: Foothill or bajada shrubland dominated by creosotebush or acacia. This is a major unit that dominates most of the lowlands of the northern Sierra del Carmens and the Dead Horse Mountains. Creosotebush (*Larrea tridentata*) is generally limited to gravelly bajadas or alluvial flats where it occurs with candelilla (*Euphorbia antisyphillitica*), bristly coldenia (*Tiquilia hispidissima*), mariola (*Parthenium incanum*), tarbush (*Flourensia cernua*), chino grama (*Bouteloua ramosa*) or fluffgrass (*Erioneuron pulchellus*). In contrast, acacia (*Acacia constricta*), although ubiquitous on both bajadas and foothills, becomes more prevalent on mid-bajadas at about 4000 feet and continues up onto the surrounding foothill slopes. Here it commonly grows alongside cactus apple (*Opuntia englemanii*), lechuguilla (*Agave lechuguilla*) and scattered grasses which generally include blue and sideoats grama (*Bouteloua gracilis, B. curtipendula*) and purple threeawn (*Aristida purpurea*). Other common associates within the unit include slim tridens (*Tridens muticus*), white ratany (*Krameria grayi*), Havard's agave (*Agave havardiana*), Christmas cactus (*Opuntia leptocaulis*) and giant dagger (*Yucca faxoniana*).

Representative Vegetation Communities:
Whitethorn Acacia-Havard's Agave (*Acacia constricta-Agave havardiana*)
Whitethorn Acacia-Lechuguilla (*Acacia constricta-Agave lechuguilla*)
Whitethorn Acacia-Engelmann's Prickly Pear (*Acacia constricta-Opuntia englemanii*)
Whitethorn Acacia-Mariola (*Acacia contricta-Parthenium incanum*)
Creosotebush-Whitethorn Acacia/Sparse Undergrowth (Larrea tridentata-Acacia constricta/Sparse)
Creosotebush-Lechuguilla (*Larrea tridentata-Agave lechuguilla*)
Creosotebush/Chino Grama (*Larrea tridentata/Boutloua ramosa*)
Creosotebush-Candelilla (*Larrea tridentata-Euphorbia antisyphilitica*)
Creosotebush-Mariola (*Larrea tridentata-Parthenium incanum*)
Creosotebush/Sparse Undergrowth (*Larrea tridentata*/Sparse)
Creosotebush-Hairy Coldenia (*Larrea tridentata/Tiquilia hispidissima*)

Map Unit 14: Mimosa-Honey Mesquite Shrubland (Figure 14)

Elevation: *3300-6500' (1000-1990 m)*
Total Area: *38,696 acres (15,660 hectares)*
Number of Plots: *24*

Description: Diverse thorny shrubland typically found on the foothill or bajada slopes of the southeastern Sierra del Carmens. Shrub canopy cover ranges from closed to open and is dominated by mimosa (*Mimosa aculeaticarpa* var. *biuncifera*) or honey mesquite (*Prosopis glandulosa*) with beebrush (*Aloysia gratissima*) as a common co-dominant. Generally, mesquite dominates the lower bajadas and alluvial flats where it may occur with tarbush (*Flourensia cernua*), wolfberry (*Lycium berlanderi*), tobosagrass (*Hilaria mutica*) and giant dagger (*Yucca faxoniana*). At about 4000 ft. elevation on bajada slopes, mimosa and beebrush become more prevalent, and may extend up onto surrounding foothills where they grow alongside Havard's agave (*Agave havardiana*) and cactus apple (*Opuntia englemanii*) with an understory of blue and sideoats grama (*Bouteloua gracilis, B. curtipendula*).

Representative Vegetation Communities:
Tarbush/Sparse Undergrowth (*Flourensia cernua*/Sparse)
Catclaw Mimosa-Beebrush (*Mimosa aculeaticarpa-Aloysia gratissima*)
Catclaw Mimosa-Beebrush/Blue Grama (*Mimosa aculeaticarpa-Aloysia gratissima*/*Bouteloua gracilis*)
Catclaw Mimosa-Beebrush/Sideoats Grama (*Mimosa aculeaticarpa-Aloysia gratissima*/*Bouteloua curtipendula*)
Catclaw Mimosa/Sideoats Grama (*Mimosa aculeaticarpa/Bouteloua curtipendula*)
Catclaw Mimosa/Blue Grama (*Mimosa aculeaticarpa/Bouteloua gracilis*)
Honey Mesquite-Beebrush (*Prosopis glandulosa-Aloysia gratissima*)
Honey Mesquite-Tarbush/Sparse Undergrowth (*Prosopis glandulosa-Flourensia cernua*/Sparse)
Honey Mesquite/Tobosagrass (*Prosopis glandulosa/Hilaria mutica*)

Figure 13: Creosotebush-Acacia Shrubland.
97SW065 on an alluvial plain near Rancho Guadalupe. Little is present save creosotebush.

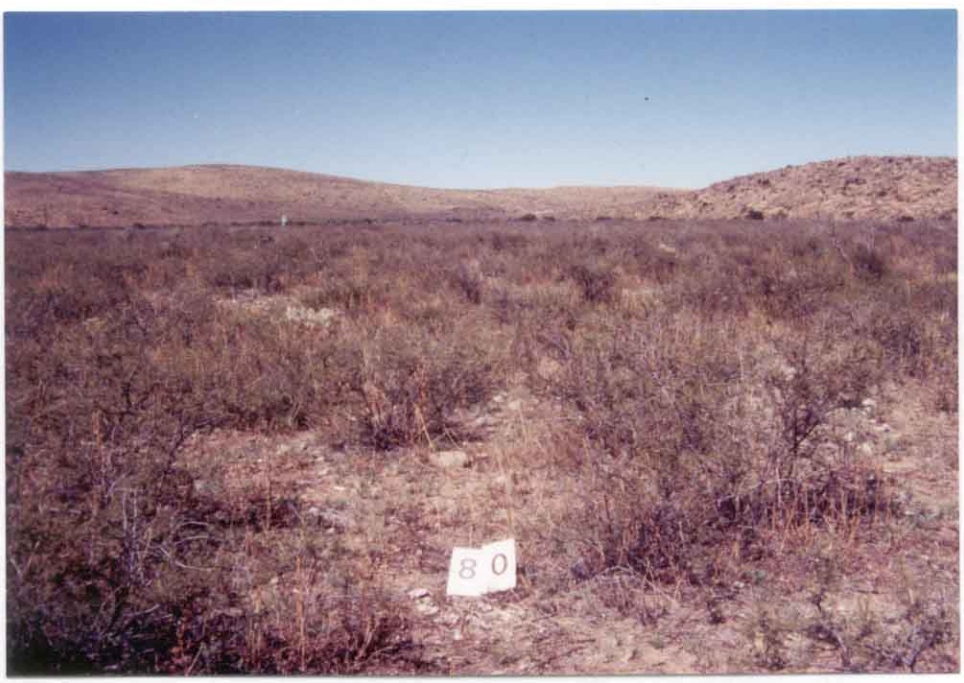


Figure 14: Mimosa-Honey Mesquite Shrubland.
97SW080 near El Portrero is a weedy, brushy site with both mimosa and whitethorn acacia co-dominating the shrub layer.

Map Unit 15: Succulent Desert Shrubland (Figure 15)

Elevation: *2900-5600' (880-1710 m)*
Total Area: *128,839 acres (52,139 hectares)*
Number of Plots: *24*

Description: Low-growing, dense and diverse desert shrublands with a high number of succulent species found predominantly on limestone footslopes and upper bajadas. These shrublands are generally dominated by lechuguilla (*Agave lechuguilla*), mariola (*Parthenium incanum*) or Big Bend silver-leaf (*Leucophyllum minus*) with co-dominants candelilla (*Euphorbia antisyphillitica*), ocotillo (*Fouquieria splendens*), Texas false agave (*Hechtia texensis*) or shortleaf jefea (*Jefea brevifolia*). Other species such as sotol (*Dasylirion leiophyllum*), cactus apple (*Opuntia englemanii*) and skeletonleaf goldeneye (*Viguieria stenoloba*) are commonly encountered, but have low cover. Beneath the shrub canopy is a species-rich cactus layer growing alongside forbs such as croton (*Croton suaveolens*) and menodora (*Menodora scabra*). Sideoats grama (*Bouteloua curtipendula*) and slim tridens (*Tridens muticus*) are scattered between shrubs, whereas chino grama (*Bouteloua ramosa*) is often found intermixed in shrub canopies (notably candelilla). In the Dead Horse Mountains, chino grama occurs at a higher cover than in Mexico, and dominates the understory. Other grasses that may appear include Hall's panicgrass (*Panicum hallii*) and purple threeawn (*Aristida purpurea*), which are indicative of overgrazing.

Representative Vegetation Communities:
Lechuguilla-Candelilla (*Agave lechuguilla-Euphorbia antisyphilitica*)
Chino Grama/Candelilla (*Bouteloua ramosa/Euphorbia antisyphilitica*)
Chino Grama/Lechuguilla (*Bouteloua ramosa/Agave lechuguilla*)
Candelilla-Smooth Sotol (*Euphorbia antisyphilitica-Dasylirion leiophyllum*)
Ocotillo-Lechuguilla-Candelilla (*Fouquieria splendens-Agave lechuguilla-Euphorbia antisyphilitica*)
Ocotillo/Purple Threeawn (*Fouquieria splendens/Aristida purpurea*)
Big Bend Silverleaf-Lechuguilla (*Leucophyllum minus-Agave lechuguilla*)
Big Bend Silverleaf-Smooth Sotol (*Leucophyllum minus-Dasylirion leiophyllum*)
Mariola-Lechuguilla (*Parthenium incanum-Agave lechuguilla*)
Black Grama/Mariola (*Bouteloua eriopoda/Parthenium incanum*)
Mariola-Candelilla (*Parthenium incanum-Euphorbia antisyphilitica*)
Mariola-Guayule (*Parthenium incanum-Parthenium argentatum*)

MICELLANEOUS MAP UNITS:

16) Semi-riparian Thicket (Figure 16): Mixed-shrub thickets found around bodies of water or along arroyos of lowland areas. They are characterized by dense stands of honey mesquite (*Prosopis glandulosa*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), littleleaf sumac (*Rhus microphylla*), beebrush (*Aloysia gratissima*) and Texas persimmon (*Diospyros texana*).

17) Rock Outcrops or Talus: Non-vegetated rock outcrops, escarpment faces and unstable talus occurring on the steep slopes of the Sierra del Carmens.

18) Barren or Disturbance: This represents bare soil and development including roadside disturbance, homesteads, runways, and other extensive development.

19) River or Surface Water: This represents bodies of water, such as ponds or tanks, and the Rio Grandé channel.

20) Riparian Bosque: This is represented by saltcedar (*Tamarix ramomissima*), bermudagrass (*Cynodon dactylon*), buffelgrass (*Pennisetum ciliare*) and cocklebur (*Xanthium* spp.).

Figure 15: Succulent Desert Shrubland.
97SW035 on a limestone slope near Rancho Santo Domingo. A variety of succulent shrubs characterize the vegetation on this and other slopes in the area.

Figure 16: Semi-riparian Thicket.
98SW020 in the Dead Horse Mountains. Mesquite and beebrush are the dominants on a fine silty soil.

Appendix B: Plant species list for the Sierra Del Carmen Vegetation Map.

Plant species recorded on vegetation plots for the Maderas del Carmen, Sierra Fin del Jardin and Dead Horse Mountains. Species names follow Kartesz (1994) and Henrickson and Johnston[1] with New Mexico Natural Heritage Program database species codes.

Family	*Species Name*	*Common Name*	*Species Code*
	Annual		ANNUAL
	Lichen		LICHEN
	Moss	moss	MOSS
Acanthaceae	*Carlowrightia linearifolia*	heath wrightwort	CARLIN
Acanthaceae	*Dyschoriste linearis*	polkadots	DYSLIN
Acanthaceae	*Ruellia parryi*	Parry's wild petunia	RUEPAR
Acanthaceae	*Siphonoglossa pilosella*	tube-tongue	SIPPIL
Acanthaceae	*Tetramerium nervosum*	hairy fournwort	TETNER
Aceraceae	*Acer grandidentatum*	bigtooth maple	ACEGRA
Adiantaceae	*Astrolepis cochisensis*	Cochise scaly cloakfern	ASTCOC
Adiantaceae	*Astrolepis spp.*	cloakfern	ASTROL
Adiantaceae	*Bommeria hispida*	copper fern	BOMHIS
Adiantaceae	*Cheilanthes eatonii*	Eaton's lipfern	CHEEAT
Adiantaceae	*Cheilanthes spp.*	lipfern	CHEILA
Adiantaceae	*Notholaena spp.*	cloak fern	NOTHOL
Adiantaceae	*Notholaena standleyi*	star cloak fern	NOTSTA
Adiantaceae	*Pellaea ovata*	ovateleaf cliffbrake	PELOVA
Agavaceae	*Agave havardiana*	Havard's agave	AGAHAV
Agavaceae	*Agave lechuguilla*	lechuguilla	AGALEC
Agavaceae	*Dasylirion leiophyllum*	green sotol	DASLEI
Agavaceae	*Dasylirion spp.*	sotol	DASYLI
Agavaceae	*Nolina spp.*	sacahuista	NOLINA
Agavaceae	*Nolina texana*	Texas sacahuiste	NOLTEX
Agavaceae	*Yucca constricta*	Buckley yucca	YUCCON
Agavaceae	*Yucca faxoniana*	giant dagger	YUCFAX
Agavaceae	*Yucca spp.*	yucca	YUCCA

[1] *Flora of the Chihuahuan Desert Region* 1997 Draft

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Agavaceae	*Yucca thompsoniana*	Thompson's yucca	YUCTHO
Agavaceae	*Yucca torreyi*	Torrey's yucca	YUCTOR
Agavaceae	*Yucca treculeana*	Spanish dagger	YUCTRE
Amaranthaceae	*Amaranthus hybridus*	slim amaranth	AMAHYB
Amaranthaceae	*Amaranthus palmeri*	carelessweed	AMAPAL
Amaranthaceae	*Froelichia arizonica*	Arizona snakecotton	FROARI
Amaranthaceae	*Iresine heterophylla*	Standley's bloodleaf	IREHET
Amaranthaceae	*Tidestromia lanuginosa*	wooly tidestromia	TIDLAN
Amaranthaceae	*Tidestromia spp.*	tidestromia	TIDEST
Anacardiaceae	*Rhus microphylla*	littleleaf sumac	RHUMIC
Anacardiaceae	*Rhus trilobata*	skunkbush sumac	RHUTRI
Anacardiaceae	*Rhus virens*	evergreen sumac	RHUVIR
Anacardiaceae	*Rhus virens var. choriophylla*	evergreen sumac	RHUVIRC
Anacardiaceae	*Rhus virens var. virens*	evergreen sumac	RHUVIRV
Apiaceae	*Aletes acaulis*	stemless Indian parsley	ALEACA
Apiaceae	*Osmorhiza mexicana*	sweet cicely	OSMMEX
Apiaceae	*Pseudocymopterus montanus*	alpine false spring parsley	PSEMON
Apocynaceae	*Macrosiphonia languinosa var. microsiphon*	plateau rocktrumpet	MACLANM
Asclepiadaceae	*Asclepias latifolia*	broadleaf milkweed	ASCLAT
Asclepiadaceae	*Asclepias spp.*	milkweed	ASCLEP
Asclepiadaceae	*Asclepias texana*	Texas milkweed	ASCTEX
Asclepiadaceae	*Cynanchum kunthii*		CYNKUN
Asteraceae	*Achillea millefolium var. occidentalis*	yarrow	ACHMILO
Asteraceae	*Ageratina hyssopina*		AGEHYS
Asteraceae	*Ageratina wrightii*	Wright's snakeroot	AGEWRI
Asteraceae	*Ambrosia spp.*	ragweed	AMBROS
Asteraceae	*Amphiachryis dracunculoides*	prairie snakeweed	AMPDRA
Asteraceae	*Anaphalis margaritacea*	western pearlyeverlasting	ANAMAR

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Asteraceae	*Artemisia ludoviciana*	Louisiana sagewort	ARTLUD
Asteraceae	*Aster ericoides*	heath aster	ASTERI
Asteraceae	*Baccharis pteronioides*	yerba de pasmo	BACPTE
Asteraceae	*Bahia absinthifolia*	hairyseed bahia	BAHABS
Asteraceae	*Bidens pilosa*	Spanish needles	BIDPIL
Asteraceae	*Bidens spp*	beggartick	BIDENS
Asteraceae	*Brickellia betonicifolia*	betony leaf brickelbush	BRIBET
Asteraceae	*Brickellia grandiflora*	tasselflower brickellbush	BRIGRA
Asteraceae	*Brickellia nelsonii*	Nelson's brickellia	BRINEL
Asteraceae	*Brickellia spp.*	brickellbush	BRICKE
Asteraceae	*Brickellia veronicaefolia*	brickellia	BRIVER
Asteraceae	*Chaptalia texana*	silver puff	CHATEX
Asteraceae	*Cirsium pringlei*	thistle	CIRPRI
Asteraceae	*Cirsium texanum*	Texas thistle	CIRTEX
Asteraceae	*Conyza canadensis*	Canadian horseweed	CONCAN
Asteraceae	*Cosmos parviflorus*	southwestern cosmos	COSPAR
Asteraceae	*Dyssodia papposa*	fetid marigold	DYSPAP
Asteraceae	*Dyssodia setifolia var. radiata*	dogweed	DYSSETR
Asteraceae	*Erechtites hieracifolia*	burnweed	EREHIE
Asteraceae	*Ericameria laricifolia*	turpentine bush	ERILAR
Asteraceae	*Erigeron flagellaris*	trailing fleabane	ERIFLA
Asteraceae	*Erigeron modestus*	plains fleabane	ERIMOD
Asteraceae	*Erigeron spp.*	fleabane	ERIGER
Asteraceae	*Eupatorium greggii*	palmleaf thoroughwort	EUPGRE
Asteraceae	*Flourensia cernua*	tarbush	FLOCER
Asteraceae	*Gnaphalium canescens*	Wright's cudweed	GNACAN
Asteraceae	*Gnaphalium oxyphyllum*	everlasting	GNAOXY
Asteraceae	*Gnaphalium pringlei*	Pringle's cudweed	GNAPRI

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Asteraceae	*Gnaphalium spp.*	cudweed	GNAPHA
Asteraceae	*Grindelia havardii*	Havard's gumweed	GRIHAV
Asteraceae	*Grindelia spp.*	gumweed	GRINDE
Asteraceae	*Gutierrezia sarothrae*	broom snakeweed	GUTSAR
Asteraceae	*Gymnosperma glutinosum*	gumhead	GYMGLU
Asteraceae	*Helianthella mexicana*	Mexican sunflower	HELMEX
Asteraceae	*Helianthus nuttallii*	Nuttall's sunflower	HELNUT
Asteraceae	*Helianthus spp*	common sunflower	HELIAN
Asteraceae	*Heliomeris longifolia var. longifolia*	longleaf falsegoldeneye	HELLONL
Asteraceae	*Heliomeris multiflora*	showy goldeneye	HELMUL
Asteraceae	*Heterotheca fulcrata*	rockyscree	HETFUL
Asteraceae	*Hieracium carneum*	Huachuca hawkweed	HIECAR
Asteraceae	*Hieracium fendleri*	yellow hawkweed	HIEFEN
Asteraceae	*Jefea brevifolia*	shortleaf jefea	JEFBRE
Asteraceae	*Liatris punctata*	dotted grayfeather	LIAPUN
Asteraceae	*Machaeranthera blephariphylla*	Texas tansyaster	MACBLE
Asteraceae	*Machaeranthera pinnatifida ssp. pinnatifida var.*	lacy tansyaster	MACPINP
Asteraceae	*Melampodium leucanthum*	plains blackfoot	MELLEU
Asteraceae	*Parthenium argentatum*	guayule	PARARG
Asteraceae	*Parthenium hysterophorus*	false ragweed	PARHYS
Asteraceae	*Parthenium incanum*	mariola	PARINC
Asteraceae	*Porophyllum scoparium*	TransPecos poreleaf	PORSCO
Asteraceae	*Psilostrophe tagetina*	woolly paperflower	PSITAG
Asteraceae	*Ratibida columnifera*	upright prairie coneflower	RATCOL
Asteraceae	*Senecio carlomasonii*	ragwort	SENCAR1
Asteraceae	*Senecio flaccidus var. douglasii*	Douglas's groundsel	SENFLAD
Asteraceae	*Senecio millelobatus*	lobed groundsel	SENMIL
Asteraceae	*Senecio multicapitatus*	ragwort groundsel	SENMUL

Appendix B: Plant Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Asteraceae	*Senecio parryi*	mountain ragwort	SENPAR
Asteraceae	*Senecio scalaris*	groundsel	SENSCA
Asteraceae	*Senecio toluccanus*	groundsel	SENTOL
Asteraceae	*Solidago muelleri*	Mueller's solidago	SOLMUE
Asteraceae	*Solidago velutina*	threenerve goldenrod	SOLVEL
Asteraceae	*Stevia odontophylla*	stevia	STEODO
Asteraceae	*Stevia ovata*	stevia	STEOVA
Asteraceae	*Stevia salicifolia*	candyleaf	STESAL
Asteraceae	*Stevia serrata*	sawtooth candyleaf	STESER
Asteraceae	*Tetraneuris scaposa*	stemmy hymenoxys	TETSCA
Asteraceae	*Thelesperma megapotamicum*	Hopi tea greenthread	THEMEG
Asteraceae	*Thelesperma simplicifolium*	slender greenthread	THESIM
Asteraceae	*Thelesperma spp.*	greenthread	THELES
Asteraceae	*Thymophylla acerosa*	pricklyleaf dogweed	THYACE
Asteraceae	*Thymophylla pentachaeta*	fiveneedle pricklyleaf	THYPEN
Asteraceae	*Trixis californica*	California trixis	TRICAL
Asteraceae	*Verbesina rothrockii*	Rothrock's crownbeard	VERROT
Asteraceae	*Verbesina spp.*	crownbeard	VERBES
Asteraceae	*Viguiera cordifolia*	heartleaf goldeneye	VIGCOR
Asteraceae	*Viguiera dentata*	toothleaf goldeneye	VIGDEN
Asteraceae	*Viguiera dentata var dentata*	toothleaf goldeneye	VIGDEND
Asteraceae	*Viguiera spp.*	goldeneye	VIGUIE
Asteraceae	*Viguiera stenoloba*	skeletonleaf goldeneye	VIGSTE
Asteraceae	*Wedelia acapulcensis var. hispida*		WEDACAH
Asteraceae	*Wedelia hispida*	hairy wedelia	WEDHIS
Asteraceae	*Zinnia acerosa*	desert zinnia	ZINACE
Asteraceae	*Zinnia grandiflora*	Rocky Mountain zinnia	ZINGRA
Berberidaceae	*Mahonia spp.*	berberis sp.	MAHONI

Appendix B: Plant Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Berberidaceae	*Mahonia trifoliata*	algerita	MAHTRI
Betulaceae	*Alnus spp.*	alder	ALNUS
Bignoniaceae	*Tecoma stans*	yellow trumpetbush	TECSTA
Bignoniaceae	*Tecoma stans var. angustata*	yellow trumpetbush	TECSTAA
Boraginaceae	*Boraginaceae*		BORAGI
Boraginaceae	*Mertensia spp.*	bluebells	MERTEN
Boraginaceae	*Tiquilia canescens*	woody crinklemat	TIQCAN
Boraginaceae	*Tiquilia greggii*	plume tiquilia	TIQGRE
Boraginaceae	*Tiquilia hispidissima*	hairy coldenia	TIQHIS
Brassicaceae	*Lesquerella fendleri*	Fendler's bladderpod	LESFEN
Brassicaceae	*Lesquerella purpurea*	rose bladderpod	LESPUR
Brassicaceae	*Lesquerella spp.*	bladderpod	LESQUE
Brassicaceae	*Lesquerella valida*	Trong bladderpod	LESVAL
Bromeliaceae	*Hechtia texensis*	Texas false agave	HECTEX
Cactaceae	*Ariocarpus fissuratus*	star cactus	ARIFIS
Cactaceae	*Coryphantha spp.*	beehive cactus	CORYPH
Cactaceae	*Echinocactus horizonthalonius*	devilshead	ECHHOR
Cactaceae	*Echinocactus spp.*	echinocactus	ECHINO1
Cactaceae	*Echinocactus texensis*	horse crippler	ECHTEX
Cactaceae	*Echinocereus chloranthus*	brownspine hedgehog	ECHCHL
Cactaceae	*Echinocereus enneacanthus*	strawberry pitaya	ECHENN
Cactaceae	*Echinocereus pectinatus var. dasyacanthus*	rainbow cactus	ECHPECD
Cactaceae	*Echinocereus spp.*	hedgehog cactus	ECHINO2
Cactaceae	*Echinocereus stramineus*	strawberry hedgehog	ECHSTR
Cactaceae	*Echinocereus triglochidiatus*	kingcup cactus	ECHTRI
Cactaceae	*Epithelantha micromeris*	pingpong ball cactus	EPIMIC
Cactaceae	*Escobaria tuberculosa*	whitecolumn foxtail cactus	ESCTUB
Cactaceae	*Escobaria vivipara var. vivipara*	spinystar	ESCVIVV

Appendix B: Plant Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Cactaceae	*Ferocactus hamatacanthus*	turk's head	FERHAM
Cactaceae	*Ferocactus spp.*	barrelcactus	FEROCA
Cactaceae	*Lophophora williamsii*	peyote	LOPWIL
Cactaceae	*Mammillaria heyderi*	little nipple cactus	MAMHEY
Cactaceae	*Mammillaria spp.*	nipple cactus	MAMMIL
Cactaceae	*Opuntia engelmannii*	cactus apple	OPUENG
Cactaceae	*Opuntia imbricata*	tree cholla	OPUIMB
Cactaceae	*Opuntia kleiniae*	candle cholla	OPUKLE
Cactaceae	*Opuntia leptocaulis*	Christmas cactus	OPULEP
Cactaceae	*Opuntia macrocentra*	purple pricklypear	OPUMAC
Cactaceae	*Opuntia phaeacantha*	tulip pricklypear	OPUPHA
Cactaceae	*Opuntia rufida*	blind prickly pear	OPURUF
Cactaceae	*Opuntia schottii*	clavellenna	OPUSCH
Cactaceae	*Opuntia spp.*	pricklypear	OPUNTI
Cactaceae	*Opuntia x spinosibacca*		OPUSPI
Cactaceae	*Sclerocactus spp.*	fishhook cactus	SCLERO
Campanulaceae	*Campanula rotundifolia*	bluebell bellflower	CAMROT
Campanulaceae	*Campanula spp.*	bellflower	CAMPAN
Campanulaceae	*Lobelia cardinalis*	cardinalflower	LOBCAR
Campanulaceae	*Lobelia gruina*	lobelia	LOBGRU
Campanulaceae	*Triodanis coloradensis*	Venus' looking glass	TRICOL
Caprifoliaceae	*Lonicera albiflora*	western white honeysuckle	LONALB
Caprifoliaceae	*Symphoricarpos spp.*	snowberry	SYMPHO
Caryophyllaceae	*Drymaria glandulosa*	fendler's drymary	DRYGLA
Caryophyllaceae	*Paronychia jamesii*	James' nailwort	PARJAM
Caryophyllaceae	*Stellaria cuspidata*	Mexican starwort	STECUS
Celastraceae	*Mortonia sempervirens var. sempervirens*	Rio Grande saddlebush	MORSEM2
Chenopodiaceae	*Atriplex canescens*	fourwing saltbush	ATRCAN

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Chenopodiaceae	*Chenopodium album*	lambsquarters	CHEALB
Chenopodiaceae	*Salsola kali*	prickly Russian thistle	SALKAL
Commelinaceae	*Commelina erecta*	whitemouth dayflower	COMERE
Commelinaceae	*Commelina erecta var. angustifolia*	whitemouth dayflower	COMEREA
Commelinaceae	*Commelina spp.*	dayflower	COMMEL
Commelinaceae	*Tradescantia crassifolia*	spiderwort	TRACRA
Commelinaceae	*Tradescantia leiandra*	spiderwort	TRALEI
Commelinaceae	*Tradescantia pringlei*	spiderwort	TRAPRI
Convolvulaceae	*Dichondra brachypoda*	New Mexico ponysfoot	DICBRA
Convolvulaceae	*Evolvulus alsinoides*	ojo de vibora	EVOALS
Convolvulaceae	*Ipomoea collina*	morning glory	IPOCOL
Convolvulaceae	*Ipomoea spp.*	morning glory	IPOMOE
Cornaceae	*Cornus sericea*	redosier dogwood	CORSER
Crassulaceae	*Sedum spp.*	stonecrop	SEDUM
Crossosomataceae	*Glossopetalon spinescens*	spiny greasebush	GLOSPI
Cupressaceae	*Cupressus arizonica*	Arizona cypress	CUPARI
Cupressaceae	*Cupressus arizonica*	Arizona cypress - mature	CUPARI3
Cupressaceae	*Juniperus ashei*	Ashe's juniper	JUNASH
Cupressaceae	*Juniperus deppeana*	alligator juniper	JUNDEP
Cupressaceae	*Juniperus deppeana - mature*	alligator juniper	JUNDEP3
Cupressaceae	*Juniperus deppeana - yng regen*	alligator juniper	JUNDEP1
Cupressaceae	*Juniperus erythrocarpa*	redberry juniper	JUNERY
Cupressaceae	*Juniperus flaccida*	Mexican drooping juniper	JUNFLA
Cupressaceae	*Juniperus monosperma*	oneseed juniper	JUNMON
Cyperaceae	*Carex spp.*	sedge	CAREX
Dennstaedtiaceae	*Pteridium aquilinum*	western brackenfern	PTEAQU
Dryopteridaceae	*Cystopteris fragilis*	brittle bladderfern	CYSFRA
Ebenaceae	*Diospyros texana*	Texas persimmon	DIOTEX

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Ephedraceae	*Ephedra nevadensis var. aspera*	Nevada jointfir	EPHNEVA
Ephedraceae	*Ephedra spp.*	Momon tea	EPHEDR
Ephedraceae	*Ephedra torreyana*	Torrey's jointfir	EPHTOR
Ephedraceae	*Ephedra trifurca*	longleaf jointfir	EPHTRI
Ericaceae	*Arbutus xalapensis*	Texas madrone	ARBXAL
Ericaceae	*Arctostaphylos pungens*	pointleaf manzanita	ARCPUN
Euphorbiaceae	*Acalypha lindheimeri*	shrubby copperleaf	ACALIN
Euphorbiaceae	*Bernardia obovata*	Johnston bernardia	BEROBO
Euphorbiaceae	*Chamaesyce cinerascens*	sandmat	CHACIN
Euphorbiaceae	*Chamaesyce fendleri*	Fendler's sandmat	CHAFEN
Euphorbiaceae	*Chamaesyce spp.*	spurge	CHAMAE
Euphorbiaceae	*Chamaesyce villifera*	hairy sandmat	CHAVIL
Euphorbiaceae	*Croton dioicus*	grassland croton	CRODIO
Euphorbiaceae	*Croton fruticulosus*	bush croton	CROFRU
Euphorbiaceae	*Croton incanus*	leatherweed	CROINC
Euphorbiaceae	*Croton pottsii*	leatherweed	CROPOT
Euphorbiaceae	*Croton spp.*	Croton	CROTON
Euphorbiaceae	*Croton suaveolens*	scented croton	CROSUA
Euphorbiaceae	*Euphorbia antisyphilitica*	candelilla	EUPANT
Euphorbiaceae	*Euphorbia macropus*		EUPMAC
Euphorbiaceae	*Jatropha dioica*	sangre de drago	JATDIO
Euphorbiaceae	*Tragia amblyodonta*	dogtooth noseburn	TRAAMB
Euphorbiaceae	*Tragia spp.*	noseburn	TRAGIA
Fabaceae	*Acacia angustissima*	prairie acacia	ACAANG
Fabaceae	*Acacia constricta*	mescat acacia	ACACON
Fabaceae	*Acacia greggii*	catclaw acacia	ACAGRE
Fabaceae	*Acacia neovernicosa*	viscid acacia	ACANEO
Fabaceae	*Acacia smallii*	huisache	ACASMA

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Fabaceae	*Acacia spp.*	acacia	ACACIA
Fabaceae	*Acacia wrightii*	Wright acacia	ACAWRI
Fabaceae	*Astragalus carminis*	Carmine astragalus	ASTCAR
Fabaceae	*Astragalus spp.*	milkvetch	ASTRAG
Fabaceae	*Calliandra conferta*	False mesquite	CALCON
Fabaceae	*Calliandra eriophylla*	fairyduster	CALERI
Fabaceae	*Calliandra humilis*	dwarf stickpea	CALHUM
Fabaceae	*Calliandra humilis var. humilis*	dwarf stickpea	CALHUMH
Fabaceae	*Canavalia villosa*	hairy swordbean	CANVIL
Fabaceae	*Centrosema spp.*	butterfly pea	CENTRO
Fabaceae	*Cologania angustifolia*	longleaf cologania	COLANG
Fabaceae	*Cologania pallida*	pale cologania	COLPAL
Fabaceae	*Dalea bicolor var. argyraea*	silver prairieclover	DALBICA
Fabaceae	*Dalea formosa*	featherplume	DALFOR
Fabaceae	*Dalea frutescens*	black prairieclover	DALFRU
Fabaceae	*Dalea greggii*	Gregg dalea	DALGRE
Fabaceae	*Dalea lanata*	woolly prairieclover	DALLAN
Fabaceae	*Dalea nana var. carnescens*	dwarf prairieclover	DALNANC
Fabaceae	*Dalea spp.*	prairieclover	DALEA
Fabaceae	*Desmanthus velutinis*	velvet bundleflower	DESVEL
Fabaceae	*Desmodium lindheimeri*	tickclover	DESLIN
Fabaceae	*Desmodium psilophyllum*	tickclover	DESPSI
Fabaceae	*Eysenhardtia texana*	Texas kidneywood	EYSTEX
Fabaceae	*Fabaceae*		FABACE
Fabaceae	*Galactia canescens*	Hoary milkpea	GALCAN
Fabaceae	*Hoffmannseggia spp.*	rushpea	HOFFMA
Fabaceae	*Lathyrus spp.*	peavine	LATHYR
Fabaceae	*Leucaena retusa*	littleleaf leadtree	LEURET

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Fabaceae	*Lotus oroboides*	deervetch	LOTORO
Fabaceae	*Lotus spp.*	trefoil	LOTUS
Fabaceae	*Mimosa aculeaticarpa var. biuncifera*	catclaw mimosa	MIMACUB
Fabaceae	*Mimosa emoryana*	Emory mimosa	MIMEMO
Fabaceae	*Mimosa spp.*	mimosa	MIMOSA
Fabaceae	*Oxytropis spp*	crazyweed	OXYTRO
Fabaceae	*Phaseolus filiformis*	slimjim bean	PHAFIL
Fabaceae	*Prosopis glandulosa*	honey mesquite	PROGLA
Fabaceae	*Rhynchosia senna var. texana*	Texas snoutbean	RHYSENT
Fabaceae	*Senna lindheimeriana*	velvet leaf wild sensitive	SENLIN
Fabaceae	*Senna orcuttii*	shrubby senna	SENORC
Fabaceae	*Sophora secundiflora*	Texas mountain laurel	SOPSEC
Fabaceae	*Trifolium spp.*	clover	TRIFOL
Fabaceae	*Vicia ludoviciana*	Louisiana vetch	VICLUD
Fabaceae	*Vicia spp.*	vetch	VICIA
Fagaceae	*Quercus arizonica*	Arizona white oak	QUEARI
Fagaceae	*Quercus carmenensis*	Carmen oak	QUECAR
Fagaceae	*Quercus emoryi*	Emory's oak	QUEEMO
Fagaceae	*Quercus gambelii*	Gambel's oak	QUEGAM
Fagaceae	*Quercus gravesii*	Graves oak	QUEGRA
Fagaceae	*Quercus grisea*	gray oak	QUEGRI
Fagaceae	*Quercus hypoleucoides*	silverleaf oak	QUEHYP
Fagaceae	*Quercus laceyi*	Lacey oak	QUELAC
Fagaceae	*Quercus mohriana*	Mohr shin oak	QUEMOH
Fagaceae	*Quercus muehlenbergii*	chinkapin oak	QUEMUE
Fagaceae	*Quercus pungens var. pungens*	sandpaper oak	QUEPUNP
Fagaceae	*Quercus pungens var. vaseyana*	Vasey oak	QUEPUNV
Fagaceae	*Quercus rugosa*	netleaf oak	QUERUG

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Fagaceae	*Quercus spp.*	oak	QUERCU
Fouquieriaceae	*Fouquieria splendens*	ocotillo	FOUSPL
Garryaceae	*Garrya ovata*	eggleaf silktassel	GAROVA
Garryaceae	*Garrya ovata ssp. lindheimeri*	eggleaf silktassel	GAROVAL
Gentianaceae	*Halenia recurva*	spurred gentian	HALREC
Geraniaceae	*Geranium caespitosum*	pineywoods geranium	GERCAE
Geraniaceae	*Geranium richardsonii*	Richardson's geranium	GERRIC
Geraniaceae	*Geranium spp*	geranium	GERANI
Grossulariaceae	*Ribes leptanthum*	trumpet gooseberry	RIBLEP
Hydrangeaceae	*Fendlera rupicola*	cliff fendlerbrush	FENRUP
Hydrangeaceae	*Philadelphus microphyllus*	littleleaf mockorange	PHIMIC
Hydrophyllaceae	*Nama hispidisum*	bristly nama	NAMHIS
Hydrophyllaceae	*Phacelia congesta*	caterpillars	PHACON
Iridaceae	*Sisynchrium dimorphum*	blue-eyed grass	SISDIM
Iridaceae	*Sisyrinchium convolutum*	blue-eyed grass	SISCON
Iridaceae	*Sisyrinchium spp.*	blue-eyed grass	SISYRI
Koeberliniaceae	*Koeberlinia spinosa*	crown of thorns	KOESPI
Krameriaceae	*Kramaria grayi*	white ratany	KRAGRA
Krameriaceae	*Krameria lanceolata*	trailing krameria	KRALAN1
Krameriaceae	*Krameria spp.*	ratany	KRAMER
Lamiaceae	*Hedeoma johnstonii*	Johnston pennyroyal	HEDJOH
Lamiaceae	*Hedeoma nana*	false pennyroyal	HEDNAN
Lamiaceae	*Hedeoma plicata*	false pennyroyal	HEDPLI
Lamiaceae	*Hedeoma spp.*	false pennyroyal	HEDEOM
Lamiaceae	*Marrubium vulgare*	horehound	MARVUL
Lamiaceae	*Monarda citriodora ssp. citriodora*	lemon beebalm	MONCITC
Lamiaceae	*Monarda fistulosa ssp. fistulosa var. menthifolia*	mintleaf beebalm	MONFISM

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Lamiaceae	*Monarda pectinata*	pony beebalm	MONPEC
Lamiaceae	*Monarda pringlei*	horsemint	MONPRI
Lamiaceae	*Prunella vulgaris*	common selfheal	PRUVUL
Lamiaceae	*Salvia farinacea*	mealycup sage	SALFAR
Lamiaceae	*Salvia greggii*	autumn sage	SALGRE
Lamiaceae	*Salvia pinguifolia*	rock sage	SALPIN
Lamiaceae	*Salvia regla*	Mountain sage	SALREG
Lamiaceae	*Salvia spp.*	sage	SALVIA
Lamiaceae	*Scutellaria resinosa*	resinous skullcap	SCURES
Lamiaceae	*Stachys coccinea*	scarlet hedgenettle	STACOC
Leguminosae	*Acacia roemeriana*	catclaw	ACAROE
Liliaceae	*Allium drummondii*	Drummond's onion	ALLDRU
Liliaceae	*Maianthemum stellatum*	starry false Solomon's seal	MAISTE
Linaceae	*Linum schiedeanum*	Schied's flax	LINSCH
Linaceae	*Linum spp.*	flax	LINUM
Linaceae	*Linum vernale*	Chihuahuan flax	LINVER
Loasaceae	*Mentzelia spp.*	mentzelia	MENTZE
Loganiaceae	*Buddleia marrubifolia*	woolly butterflybush	BUDMAR
Loganiaceae	*Emorya suaveolens*	Emorybush	EMOSUA
Malvaceae	*Abutilon malacum*	yellow Indian mallow	ABUMAL
Malvaceae	*Herissantia crispa*	bladdermallow	HERCRI
Malvaceae	*Hibiscus coulteri*	desert rosemallow	HIBCOU
Malvaceae	*Hibiscus spp.*	rosemallow	HIBISC
Malvaceae	*Malvaceae*		MALVAC
Malvaceae	*Pavonia lasiopetala*	Wright pavonia	PAVLAS
Malvaceae	*Sida abutifolia*	spreading fanpetals	SIDABU
Malvaceae	*Sida elliottii*	Elliott's sida	SIDELL
Malvaceae	*Sphaeralcea angustifolia*	copper globemallow	SPHANG

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Malvaceae	*Sphaeralcea spp.*	globemallow	SPHAER
Martyniaceae	*Proboscidea spp.*	devilsclaw	PROBOS
Monotropaceae	*Monotropa hypopithys*	pinesap	MONHYP
Nyctaginaceae	*Boerhavia linearifolia*	narrowleaf spiderling	BOELIN
Nyctaginaceae	*Cyphomeris gypsophiloides*	red cyphomeris	CYPGYP
Nyctaginaceae	*Mirabilis spp.*	four o'clock	MIRABI
Nyctaginaceae	*Nyctaginaceae*		NYCTAG
Oleaceae	*Forestiera angustifolia*	desert olive. panalero	FORANG
Oleaceae	*Fraxinus cuspidata*	fragrant ash	FRACUS
Oleaceae	*Fraxinus greggii*	Gregg's ash	FRAGRE
Oleaceae	*Fraxinus velutina*	velvet ash	FRAVEL
Oleaceae	*Menodora longiflora*	showy menodora	MENLON
Oleaceae	*Menodora scabra*	rough menodora	MENSCA
Oleaceae	*Menodora scoparia*	broom menodora	MENSCO
Onagraceae	*Gaura calcicola*	gaura	GAUCAL
Onagraceae	*Oenothera spp.*	eveningprimrose	OENOTH
Orchidaceae	*Corallorrhiza striata*	hooded coralroot	CORSTR1
Oxalidaceae	*Oxalis alpina*	alpine woodsorrel	OXAALP
Oxalidaceae	*Oxalis corniculata*	yellow woodsorrel	OXACOR
Oxalidaceae	*Oxalis spp.*	woodsorrel	OXALIS
Phytolaccaceae	*Rivinia humilis*	rougeplant	RIVHUM
Pinaceae	*Abies coahuilensis*	Coahuila fir	ABICOA
Pinaceae	*Pinus arizonica*	Arizona pine	PINARI
Pinaceae	*Pinus arizonica var. stormiae*	pino real	PINARIS
Pinaceae	*Pinus cembroides*	Mexican pinyon	PINCEM
Pinaceae	*Pinus remota*	papershell pinyon	PINREM
Pinaceae	*Pinus strobiformis*	Southwestern white pine	PINSTR
Pinaceae	*Pseudotsuga menziesii*	Douglas-fir	PSEMEN

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Poaceae	*Agrostis scabra*	rough bentgrass	AGRSCA
Poaceae	*Agrostis spp.*	bentgrass	AGROST
Poaceae	*Aristida adscensionis*	sixweeks threeawn	ARIADS
Poaceae	*Aristida arizonica*	Arizona threeawn	ARIARI
Poaceae	*Aristida brownii*	Brown's threeawn	ARIBRO
Poaceae	*Aristida divaricata*	poverty threeawn	ARIDIV
Poaceae	*Aristida havardii*	Havard's threeawn	ARIHAV
Poaceae	*Aristida orcuttiana*	single threeawn	ARIORC
Poaceae	*Aristida purpurea*	purple threeawn	ARIPUR
Poaceae	*Aristida purpurea var. nealleyi*	Nealley's threeawn	ARIPURN
Poaceae	*Aristida purpurea var. purpurea*	purple threeawn	ARIPURP
Poaceae	*Aristida purpurea var. wrightii*	Wright's threeawn	ARIPURW
Poaceae	*Aristida spp.*	threeawn	ARISTI
Poaceae	*Aristida ternipes*	spidergrass	ARITER
Poaceae	*Blepharoneuron tricholepis*	pine dropseed	BLETRI
Poaceae	*Bothriochloa barbinodis*	cane bluestem	BOTBAR
Poaceae	*Bothriochloa laguroides*	silver beardgrass	BOTLAG
Poaceae	*Bothriochloa laguroides ssp. torreyana*	silver beardgrass	BOTLAGT
Poaceae	*Bothriochloa spp.*	beardgrass	BOTHRI
Poaceae	*Bouteloua barbata*	sixweeks grama	BOUBAR
Poaceae	*Bouteloua curtipendula*	sideoats grama	BOUCUR
Poaceae	*Bouteloua eriopoda*	black grama	BOUERI
Poaceae	*Bouteloua gracilis*	blue grama	BOUGRA
Poaceae	*Bouteloua hirsuta*	hairy grama	BOUHIR
Poaceae	*Bouteloua ramosa*	chinograss/ chino grama	BOURAM
Poaceae	*Bouteloua trifida*	red grama	BOUTRI
Poaceae	*Bromus anomalus*	nodding brome	BROANO
Poaceae	*Bromus ciliatus*	fringed brome	BROCIL
Poaceae	*Bromus lanatipes*	woolly brome	BROLAN
Poaceae	*Bromus polyanthus*	polyanthus brome	BROPOL

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Poaceae	*Bromus spp.*	brome	BROMUS
Poaceae	*Chloris virgata*	feather fingergrass	CHLVIR
Poaceae	*Danthonia spicata*	poverty oat grass	DANSPI
Poaceae	*Digitaria californica*	Arizona cottontop	DIGCAL
Poaceae	*Digitaria cognata*	Carolina crabgrass	DIGCOG
Poaceae	*Elymus arizonicus*	Arizona wheatgrass	ELYARI
Poaceae	*Elymus elymoides*	bottlebrush squirreltail	ELYELY
Poaceae	*Elymus trachycaulus*	slender wheatgrass	ELYTRA
Poaceae	*Eragrostis barrelieri*	Mediterranean lovegrass	ERABAR
Poaceae	*Eragrostis intermedia*	plains lovegrass	ERAINT
Poaceae	*Erioneuron avenaceum*	shortleaf woollygrass	ERIAVE
Poaceae	*Erioneuron nealleyi*	Nealley's woollygrass	ERINEA
Poaceae	*Erioneuron pilosum*	hairy woollygrass	ERIPIL
Poaceae	*Erioneuron pulchellum*	fluffgrass	ERIPUL
Poaceae	*Festuca arizonica*	Arizona fescue	FESARI
Poaceae	*Glyceria striata*	fowl mannagrass	GLYSTR
Poaceae	*Heteropogon contortus*	tanglehead	HETCON
Poaceae	*Hilaria mutica*	tobosa grass	HILMUT
Poaceae	*Koeleria macrantha*	prairie junegrass	KOEMAC
Poaceae	*Leptochloa dubia*	green sprangletop	LEPDUB
Poaceae	*Lycurus phleoides*	common wolfstail	LYCPHL
Poaceae	*Lycurus setosus*	bristly wolfstail	LYCSET
Poaceae	*Melica porteri*	Porter's melicgrass	MELPOR
Poaceae	*Muhlenbergia arenacea*	ear muhly	MUHARE1
Poaceae	*Muhlenbergia arenicola*	sand muhly	MUHARE2
Poaceae	*Muhlenbergia dubia*	pine muhly	MUHDUB
Poaceae	*Muhlenbergia emersleyi*	bullgrass	MUHEME
Poaceae	*Muhlenbergia glauca*	desert muhly	MUHGLA
Poaceae	*Muhlenbergia montana*	mountain muhly	MUHMON
Poaceae	*Muhlenbergia parviglumis*	longawn muhly	MUHPAR
Poaceae	*Muhlenbergia pauciflora*	New Mexico muhly	MUHPAU
Poaceae	*Muhlenbergia porteri*	bush muhly	MUHPOR
Poaceae	*Muhlenbergia richardsonis*	mat muhly	MUHRIC

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Poaceae	*Muhlenbergia rigens*	deergrass	MUHRIG
Poaceae	*Muhlenbergia rigida*	purple muhly	MUHRIG2
Poaceae	*Muhlenbergia setifolia*	curlyleaf muhly	MUHSET
Poaceae	*Muhlenbergia spp.*	muhly	MUHLEN
Poaceae	*Muhlenbergia tenuifolia*	slimflower muhly	MUHTEN
Poaceae	*Panicum bulbosum*	bulb panicgrass	PANBUL
Poaceae	*Panicum hallii*	Hall's panicgrass	PANHAL
Poaceae	*Panicum spp.*	panicgrass	PANICU
Poaceae	*Piptochaetium fimbriatum*	pinyon ricegrass	PIPFIM
Poaceae	*Piptochaetium pringlei*	Pringle needlegrass	PIPPRI
Poaceae	*Schizachyrium neomexicanum*	New Mexico bluestem	SCHNEO
Poaceae	*Schizachyrium sanguineum var. hirtiflorum*	crimson bluestem	SCHSANH
Poaceae	*Scleropogon brevifolius*	burrograss	SCLBRE
Poaceae	*Setaria leucopila*	streambed bristlegrass	SETLEU
Poaceae	*Setaria spp.*	bristlegrass	SETARI
Poaceae	*Sorghastrum nutans*	Indiangrass	SORNUT
Poaceae	*Sorghum halepense*	Johnsongrass	SORHAL
Poaceae	*Sphenopholis obtusata*	prairie wedgescale	SPHOBT
Poaceae	*Sporobolus contractus*	spike dropseed	SPOCON
Poaceae	*Sporobolus cryptandrus*	sand dropseed	SPOCRY
Poaceae	*Stipa eminens*	southwestern needlegrass	STIEMI
Poaceae	*Stipa lobata*	little awn needlegrass	STILOB
Poaceae	*Stipa neomexicana*	New Mexico needlegrass	STINEO
Poaceae	*Stipa spp.*	needlegrass	STIPA
Poaceae	*Stipa tenuissima*	finestem needlegrass	STITEN
Poaceae	*Tridens muticus*	slim tridens	TRIMUT
Poaceae	*Tripsacum dactyloides*	eastern gamagrass	TRIDAC
Polemoniaceae	*Gilia rigidula*	bluebowls	GILRIG
Polemoniaceae	*Gilia spp.*	gilia	GILIA
Polemoniaceae	*Loeselia scariosa*		LOESCA

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Polemoniaceae	*Polemonium foliosissimum*	towering Jacobsladder	POLFOL
Polygalaceae	*Polygala alba*	white milkwort	POLALB
Polygalaceae	*Polygala barbeyana*	blue milkwort	POLBAR
Polygonaceae	*Eriogonum hemipterum*	Chisos mountain buckwheat	ERIHEM
Polygonaceae	*Eriogonum jamesii*	James' buckwheat	ERIJAM
Polygonaceae	*Eriogonum spp.*	buckwheat	ERIOGO
Polygonaceae	*Eriogonum wrightii*	Wright's buckwheat	ERIWRI
Polygonaceae	*Polygonum lapathifolium*	curlytop knotweed	POLLAP
Polypodiaceae	*Pleopeltis guttatum*	sorus fern	PLEGUT
Polypodiaceae	*Pleopeltis polylepis var. erythrolepis*	red scale polypody	PLEPOLE
Polypodiaceae	*Pleopeltis riograndensis*	Rio Grande scaly polypody	PLERIO
Portulacaceae	*Portulaca pilosa*	kiss me quick	PORPIL
Pteridaceae	*Argyrochosma parviflora*	false cloak fern	ARGPAR
Pteridaceae	*Notholaena aschenborniana*	scaly cloak fern	NOTASC
Pteridaceae	*Pellaea ternifolia*	ternate cliffbrake	PELTER
Pyrolaceae	*Chimaphila menziesii*	Umbrellawort/pipsissewa	CHIMEN
Pyrolaceae	*Chimaphila umbellata ssp. acuta*	Umbrellawort/pipsissewa	CHIUMBA
Ranunculaceae	*Aquilegia chrysantha*	golden columbine	AQUCHR
Ranunculaceae	*Clematis drummondii*	Drummond's clematis	CLEDRU
Ranunculaceae	*Clematis spp.*	clematis	CLEMAT
Ranunculaceae	*Ranunculus peruvianus*	Peruvian buttercup	RANPER
Ranunculaceae	*Ranunculus petiolaris*	longstemmed buttercup	RANPET
Ranunculaceae	*Thalictrum fendleri*	Fendler's meadowrue	THAFEN
Rhamnaceae	*Adolphia infesta*	Texas adolphia	ADOINF
Rhamnaceae	*Ceanothus fendleri*	Fendler's ceanothus	CEAFEN
Rhamnaceae	*Ceanothus greggii*	desert ceanothus	CEAGRE
Rhamnaceae	*Condalia ericoides*	javelina bush	CONERI
Rhamnaceae	*Condalia viridis*	green condalia	CONVIR

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Rhamnaceae	*Condalia warnockii*	Warnock's snakewood	CONWAR
Rhamnaceae	*Frangula betulifolia ssp. betulifolia*	birchleaf buckthorn	FRABETB
Rhamnaceae	*Ziziphus obtusifolia*	lotebush	ZIZOBT
Roasaceae	*Cercocarpus montanus var. glaber*	smooth mountain mahogany	CERMONG
Roasaceae	*Cercocarpus montanus var. paucidentatus*	shaggy mountain mahogany	CERMONP
Rosaceae	*Cercocarpus fothergilloides var. mojadensis*	mountain mahogany	CERFOTM
Rosaceae	*Cercocarpus montanus*	true mountain mahogany	CERMON
Rosaceae	*Craetagus tracyi*	mountain hawthorn	CRATRA
Rosaceae	*Fragaria spp*	strawberry	FRAGAR
Rosaceae	*Holodiscus discolor*	rock spirea	HOLDIS
Rosaceae	*Holodiscus dumosus*	rock spirea	HOLDUM
Rosaceae	*Physocarpus monogynus*	mountain ninebark	PHYMON
Rosaceae	*Potentilla thurberi var atrorubens*	scarlet cinquefoil	POTTHUA
Rosaceae	*Prunus serotina*	black cherry	PRUSER
Rosaceae	*Prunus spp.*	chokecherry	PRUNUS
Rosaceae	*Prunus virginiana*	common chokecherry	PRUVIR
Rosaceae	*Purshia ericifolia*	heath cliffrose	PURERI
Rosaceae	*Rosa woodsii*	Woods' rose	ROSWOO
Rosaceae	*Rosa woodsii var. maderensis*	Sierra de la Madera rose	ROSWOOM
Rosaceae	*Rubus idaeus*	red raspberry	RUBIDA
Rosaceae	*Rubus idaeus ssp. strigosus*	grayleaf red raspberry	RUBIDAS
Rosaceae	*Vauquelina corymbosa ssp. angustifolia*	slimleaf vauquelina	VAUCORA
Rubiaceae	*Bouvardia ternifolia*	scarlet bouvardia	BOUTER
Rubiaceae	*Galium microphyllum*	bracted bedstraw	GALMIC
Rubiaceae	*Galium spp.*	bedstraw	GALIUM
Rubiaceae	*Hedyotis intricata*	tangled starviolet	HEDINT
Rubiaceae	*Hedyotis nigricans*	diamond flowers	HEDNIG
Rubiaceae	*Hedyotis spp.*	star violet	HEDYOT

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Rubiaceae	*Houstonia acerosa ssp. acerosa*	needleleaf bluet	HOUACEA
Rubiaceae	*Houstonia spp.*	bluet	HOUSTO
Salicaceae	*Populus tremuloides*	quaking aspen	POPTRE
Salicaceae	*Salix lucida ssp. lasiandra*	Pacific willow	SALLUCL
Salicaceae	*Salix riskindii*	Riskind's willow	SALRIS
Sapindaceae	*Sapindus saponaria*	wingleaf soapberry	SAPSAP
Saxifragaceae	*Fendlera rigida*	narrowleaf fendlerbush	FENRIG
Saxifragaceae	*Heuchera spp.*	alumroot	HEUCHE
Scrophulariaceae	*Castilleja lanata*	Sierran woolly Indian	CASLAN
Scrophulariaceae	*Castilleja scorzonerifolia*	Indian paintbrush	CASSCO
Scrophulariaceae	*Castilleja sessiliflora*	downy paintedcup	CASSES
Scrophulariaceae	*Castilleja spp.*	paintbrush	CASTIL
Scrophulariaceae	*Leucophyllum frutescens*	Texas purple sage	LEUFRU
Scrophulariaceae	*Leucophyllum minus*	Big Bend silver-leaf	LEUMIN
Scrophulariaceae	*Maurandella antirrhiniflora*	roving sailor	MAUANT
Scrophulariaceae	*Penstemon baccharifolius*	baccharisleaf beardtongue	PENBAC
Scrophulariaceae	*Penstemon henricksonii*	Henrickson's beardtongue	PENHEN
Scrophulariceae	*Leucophyllum spp.*	leucophyllum	LEUCOP
Selaginellaceae	*Selaginella lepidophylla*	resurrection plant	SELLEP
Selaginellaceae	*Selaginella spp.*	spikemoss	SELAGI
Solanaceae	*Lycium berlandieri*	Berlandier's wolfberry	LYCBER
Solanaceae	*Solanum elaeagnifolium*	silverleaf nightshade	SOLELA
Tiliaceae	*Tilia mexicana*	Mexican basswood	TILMEX
Ulmaceae	*Celtis laevigata var. reticulata*	netleaf hackberry	CELLAER
Ulmaceae	*Celtis pallida*	Granjeño desert hackberry	CELPAL
Vebeneaceae	*Lantana achyranthifolia*	desert lantana	LANACH
Verbenaceae	*Aloysia gratissima*	beebrush	ALOGRA
Verbenaceae	*Aloysia wrightii*	Wright's beebrush	ALOWRI

Appendix B: Plant species list for the Sierra del Carmen (continued)

Family	*Species Name*	*Common Name*	*Species Code*
Verbenaceae	*Glandularia bipinnatifida*	Dakota mock vervain	GLABIP
Verbenaceae	*Glandularia bipinnatifida var. bipinnatifida*	Dakota mock vervain	GLABIPB
Verbenaceae	*Verbena bracteata*	bigbract verbena	VERBRA
Verbenaceae	*Verbena neomexicana*	hillside vervain	VERNEO
Verbenaceae	*Verbena neomexicana var. neomexicana*	New Mexico vervain	VERNEON
Verbenaceae	*Verbena spp.*	vervain	VERBEN
Verbeneaceae	*Bouchea spathulata*	spoonleaf bouchea	BOUSPA
Verbeneaceae	*Verbena halei*	Texas vervain	VERHAL
Violaceae	*Viola spp*	violet	VIOLA
Vitaceae	*Cissus incisa*	ivy treebine	CISINC
Vitaceae	*Parthenocissus spp.*	Virginia creeper	PARTHE2
Vitaceae	*Parthenocissus vitacea*	Virginia creeper	PARVIT
Vitaceae	*Vitis arizonica*	canyon grape	VITARI
Vitaceae	*Vitis cinerea var. helleri*	Heller's grape	VITCINH
Zygophyllaceae	*Guajacum angustifolium*	guayacan	GUAANG
Zygophyllaceae	*Kallstroemia spp.*	caltrop	KALLST
Zygophyllaceae	*Larrea tridentata*	creosotebush	LARTRI

Appendix C: Birds Observed in the Maderas and Sierra del Carmens, July - October 1997

Common Name	Scientific Name
Acorn Woodpecker	*Melanerpes formicivorus*
American Coot	*Fulica americana*
American Kestrel	*Falco sparverius*
American Pipit	*Anthus rubescens*
Audubon's Oriole	*Icterus graduacauda*
Band-tailed Pigeon	*Columbia fasciata*
Bewick's Wren	*Thryomanes bewickii*
Black Phoebe	*Sayornis nigricans*
Black-throated Sparrow	*Amphispiza bilineata*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Blue-throated Hummingbird	*Lampornis clemenciae*
Brewer's Blackbird	*Euphagus cyanocephalus*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Cactus Wren	*Campylorhynchus brunneicapillus*
Canyon Towhee	*Pipilo fuscus*
Cassin's Kingbird	*Tyrannus vociferans*
Common Barn Owl	*Tyto alba*
Common Bushtit	*Psaltriparus minimus*
Crissal Thrasher	*Toxostoma crissale*
Curve-billed Thrasher	*Toxostoma curvirostre*
Golden Eagle	*Aquila chrysaetos*
Great Horned Owl	*Bubo virginianus*
Greater Roadrunner	*Geococcyx californianus*
Green-tailed Towhee	*Pipilo chlorurus*
Harris's Hawk	*Parabuteo unicinctus*
Killdeer	*Charadrius vociferus*
Ladder-backed Woodpecker	*Picoides scalaris*
Lark Bunting	*Calamospiza melanocorys*
Lesser Goldfinch	*Carduelis psaltria*
Loggerhead Shrike	*Lanius ludovicianus*
Lucifer Hummingbird	*Calothorax lucifer*
Meadowlark species	*Sturnella* spp.
Mexican Jay	*Aphelocoma ultramarina*
Montezuma Quail	*Cyrtonyx montezumae*
Mourning Dove	*Zenaida macroura*
Northern Cardinal	*Cardinalis cardinalis*

Appendix C (cont.): Birds Observed in the Maderas and Sierra del Carmens, July - October 1997

Common Name	Scientific Name
Northern Flicker	*Colaptes auratus*
Northern Harrier	*Circus cyaneus*
Northern Mockingbird	*Mimus polyglottos*
Painted Redstart	*Myioborus pictus*
Peregrine Falcon	*Falco peregrinus*
Phainopepla	*Phainopepla nitens*
Pyrrhuloxia	*Cardinalis sinuatus*
Raven species	*Corvus* spp.
Red-tailed Hawk	*Buteo jamaicensis*
Rock Wren	*Salpinctes obsoletus*
Ruddy Duck	*Oxyura jamaicensis*
Rufous-crowned Sparrow	*Aimophila ruficeps*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Say's Phoebe	*Sayornis saya*
Scaled Quail	*Callipepla squamata*
Scissor-tailed Flycatcher	*Tyrannus forficatus*
Scott's Oriole	*Icterus parisorum*
Sparrow species	*Zonotrichia* spp.
Swainson's Hawk	*Buteo swainsoni*
Tufted Titmouse	*Parus bicolor*
Turkey Vulture	*Cathartes aura*
Vermilion Flycatcher	*Pyrocephalus rubinus*
Vireo species	*Vireo* spp.
Western Kingbird	*Tyrannus verticalis*
White-breasted Nuthatch	*Sitta carolinensis*
White-crowned Sparrow	*Zonotrichia leucophrys*
White-throated Swift	*Aeronautes saxatalis*
White-winged Dove	*Zenaida asiatica*
Wild Turkey	*Meleagris gallopavo*
Wilson's Warbler	*Wilsonia pusilla*
Yellow-eyed Junco	*Junco phaeonotus*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Yellow-rumped Warbler	*Dendroica coronata*

Appendix D: Analytical Plot Floristic Data and Directions

This appendix contains the raw data from the monitoring plots along with GPS coordinates, directions and other relevant information, such as transect configuration and local directions. Most monitoring was done by setting up two, 20m long transects parallel to each other with endpoints monumented by rebar and tagged. A meter tape was then stretched between the two endpoints and a 20 x 50cm quadrat frame was used to estimate vegetative cover every meter starting at 50cm. There are a total of 15 monitoring plots.

97SW002 Monitoring Plot Map Unit: Mesa-Pine Forest

GPS Coordinates: Northing 3211506 Easting 733277 taken at east stake.

Directions: Head north on road from Cañon Moreno to Mesa Bonita. Head east on the Mesa near a draw.

Configuration: This monitoring plot consists of one, 40m long transect to capture the patchiness of the grass community. It was read from southwest to northeast, and is marked with rebar painted white. Bearing from the south to the north stake is 232 º.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*	*Achillea millefolium var. occidentalis*	4
		Agrostis scabra	23
		Bromus polyanthus	11
		Erigeron spp.	0.001
		Halenia recurva	1
		Muhlenbergia montana	9
		Prunella vulgaris	15
A	*2*		
		Agrostis scabra	4
		Bromus polyanthus	0.002
		Halenia recurva	4
		Muhlenbergia montana	38
		Senecio toluccanus	7
A	*3*		
		Achillea millefolium var. occidentalis	0.001
		Bromus polyanthus	1
		Erigeron modestus	0.001
		Halenia recurva	1
		Muhlenbergia montana	61
		Ranunculus peruvianus	0.001
		Senecio toluccanus	18
A	*4*		
		Achillea millefolium var. occidentalis	3
		Agrostis scabra	50
		Bromus polyanthus	2
		Halenia recurva	1
		Muhlenbergia montana	63
		Senecio toluccanus	16
A	*5*		
		Agrostis scabra	65
		Danthonia spicata	25
		Prunella vulgaris	3
A	*6*		
		Agrostis scabra	90
		Danthonia spicata	10
		Halenia recurva	5

97SW002 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*7*		
		Agrostis scabra	40
		Danthonia spicata	50
		Ranunculus peruvianus	1
		Senecio millelobatus	2
A	*8*		
		Danthonia spicata	58
		Ranunculus peruvianus	2
		Senecio toluccanus	25
A	*9*		
		Achillea millefolium var. occidentalis	2
		Agrostis scabra	25
		Danthonia spicata	75
		Halenia recurva	4
		Ranunculus peruvianus	2
A	*10*		
		Achillea millefolium var. occidentalis	1
		Agrostis scabra	90
		Danthonia spicata	15
		Halenia recurva	1
		Ranunculus peruvianus	2
A	*11*		
		Achillea millefolium var. occidentalis	1
		Agrostis scabra	70
		Halenia recurva	1
		Ranunculus peruvianus	1
		Senecio toluccanus	37
A	*12*		
		Agrostis scabra	100
		Halenia recurva	4
		Prunella vulgaris	1
A	*13*		
		Achillea millefolium var. occidentalis	2
		Agrostis scabra	65
		Carex spp.	6
		Danthonia spicata	25
		Halenia recurva	2
		Prunella vulgaris	2
		Ranunculus peruvianus	4
A	*14*		
		Achillea millefolium var. occidentalis	2
		Agrostis scabra	95
		Danthonia spicata	5
		Halenia recurva	2
		Prunella vulgaris	15
		Ranunculus peruvianus	12
		Senecio toluccanus	0.001

97SW002 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	***15***		
		Achillea millefolium var. occidentalis	1
		Agrostis scabra	40
		Danthonia spicata	40
		Halenia recurva	4
A	***16***		
		Agrostis scabra	17
		Carex spp.	0.001
		Danthonia spicata	55
		Ranunculus peruvianus	4
A	***17***		
		Agrostis scabra	30
		Danthonia spicata	60
		Prunella vulgaris	1
		Ranunculus peruvianus	1
A	***18***		
		Achillea millefolium var. occidentalis	1
		Agrostis scabra	30
		Danthonia spicata	50
		Prunella vulgaris	8
		Ranunculus peruvianus	2
A	***19***		
		Agrostis scabra	0.001
		Danthonia spicata	83
		Muhlenbergia montana	4
		Panicum bulbosum	8
		Senecio toluccanus	17
A	***20***		
		Danthonia spicata	95
		Prunella vulgaris	10
A	***21***		
		Danthonia spicata	72
		Ranunculus peruvianus	1
A	***22***		
		Agrostis scabra	6
		Bromus polyanthus	1
		Danthonia spicata	24
		Halenia recurva	3
		Muhlenbergia montana	24
		Ranunculus peruvianus	0.001
		Senecio toluccanus	18
A	***23***		
		Agrostis scabra	4
		Danthonia spicata	1
		Halenia recurva	1
		Muhlenbergia montana	90

97SW002 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	***24***		
		Agrostis scabra	14
		Bromus polyanthus	1
		Danthonia spicata	1
		Erigeron spp.	0.001
		Halenia recurva	4
		Muhlenbergia montana	60
A	***25***		
		Agrostis scabra	65
		Halenia recurva	1
		Muhlenbergia montana	2
		Ranunculus peruvianus	2
A	***26***		
		Agrostis scabra	75
		Halenia recurva	9
		Muhlenbergia montana	20
		Prunella vulgaris	1
A	***27***		
		Agrostis scabra	30
		Danthonia spicata	65
		Erigeron modestus	2
A	***28***		
		Agrostis scabra	95
		Danthonia spicata	5
A	***29***		
		Agrostis scabra	15
		Danthonia spicata	80
		Erigeron modestus	4
A	***30***		
		Agrostis scabra	95
		Danthonia spicata	1
		Prunella vulgaris	4
		Senecio toluccanus	1
A	***31***		
		Agrostis scabra	20
		Bromus polyanthus	4
		Danthonia spicata	15
		Gnaphalium oxyphyllum	1
		Muhlenbergia montana	15
		Prunella vulgaris	1
		Senecio toluccanus	45

97SW002 Monitoring Plot cont.

Transect	Quadrat	Species	Cover
A	32		
		Achillea millefolium var. occidentalis	5
		Agrostis scabra	90
		Bromus polyanthus	2
		Carex spp.	1
		Danthonia spicata	2
		Gnaphalium oxyphyllum	2
		Ranunculus peruvianus	2
		Senecio toluccanus	3
A	33		
		Agrostis scabra	25
		Bromus polyanthus	10
		Danthonia spicata	70
		Gnaphalium oxyphyllum	3
		Ranunculus peruvianus	5
A	34		
		Danthonia spicata	75
		Erigeron modestus	2
		Gnaphalium oxyphyllum	0.001
A	35		
		Agrostis scabra	15
		Danthonia spicata	40
		Erigeron modestus	1
		Erigeron spp.	4
		Muhlenbergia montana	7
		Ranunculus peruvianus	4
A	36		
		Achillea millefolium var. occidentalis	2
		Agrostis scabra	35
		Danthonia spicata	45
		Ranunculus peruvianus	6
		Senecio toluccanus	8
A	37		
		Agrostis scabra	20
		Danthonia spicata	65
A	38		
		Danthonia spicata	55
		Prunella vulgaris	15
A	39		
		Agrostis scabra	25
		Danthonia spicata	70
		Prunella vulgaris	1
		Ranunculus peruvianus	1
A	40		
		Bromus polyanthus	2
		Danthonia spicata	100
		Prunella vulgaris	2
		Ranunculus peruvianus	2

97SW011 Monitoring Plot **Map Unit:** Pinon-Pine Juniper Woodland

GPS Coordinates: Northing 3209660 Easting 738843 taken at the northwest stake of Transect A.

Directions: Near 'El Uno' Aserradero. West of the shack, just above the dam and about 200m west into the woods.

Transect configuration: Two transects, oriented south to north (308° bearing) and read in that directions. Each is 20 meters long, approximately parallel and 7m apart from each other. The southeast stake of transect B is 7m and 26° N of the southeast stake of transect A.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Juniperus deppeana	20
		Muhlenbergia emersleyi	60
		Quercus arizonica	15
A	*2*		
		Muhlenbergia emersleyi	45
		Quercus arizonica	80
A	*3*		
		Piptochaetium pringlei	30
		Quercus arizonica	90
A	*4*		
		Bouteloua curtipendula	13
		Piptochaetium pringlei	5
		Quercus arizonica	95
A	*5*		
		Muhlenbergia emersleyi	3
		Piptochaetium pringlei	60
		Quercus arizonica	95
A	*6*		
		Muhlenbergia emersleyi	3
		Pinus cembroides	20
		Piptochaetium pringlei	10
		Quercus arizonica	90
		Schizachyrium neomexicanum	25
A	*7*		
		Panicum bulbosum	2
		Pinus cembroides	5
		Piptochaetium pringlei	50
		Quercus arizonica	60
A	*8*		
		Panicum bulbosum	2
		Pinus cembroides	50
		Piptochaetium pringlei	70
		Quercus arizonica	50
A	*9*		
		Pinus cembroides	50
		Piptochaetium pringlei	80
		Quercus arizonica	50

97SW011 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*10*		
		Bouteloua curtipendula	2
		Pinus cembroides	60
		Piptochaetium pringlei	85
		Quercus arizonica	50
A	*11*		
		Bouteloua curtipendula	38
		Grindelia havardii	5
		Quercus arizonica	25
A	*12*		
		Bouteloua curtipendula	10
		Eragrostis intermedia	3
		Muhlenbergia emersleyi	20
		Notholaena aschenborniana	5
A	*13*		
		Bouteloua curtipendula	5
		Quercus arizonica	60
		Schizachyrium neomexicanum	10
A	*14*		
		Lycurus setosus	17
		Muhlenbergia emersleyi	23
		Panicum bulbosum	3
		Quercus arizonica	50
		Schizachyrium neomexicanum	5
A	*15*		
		Lycurus setosus	17
		Panicum bulbosum	3
		Quercus arizonica	3
		Schizachyrium neomexicanum	8
A	*16*		
		Carex spp.	0.001
		Lycurus setosus	10
		Schizachyrium neomexicanum	32
A	*17*		
		Bouteloua gracilis	23
		Panicum bulbosum	7
		Schizachyrium neomexicanum	3
A	*18*		
		Bouteloua gracilis	4
		Eragrostis intermedia	8
		Lycurus setosus	13
		Pellaea ternifolia	3
A	*19*		
		Bouteloua curtipendula	35
		Eragrostis intermedia	25
		Juniperus deppeana	2

97SW011 Monitoring Plot cont.

Transect	Quadrat	Species	Cover
A	20		
		Eragrostis intermedia	50
		Juniperus deppeana	16
B	1		
		Bouteloua curtipendula	10
		Pinus cembroides	80
		Piptochaetium pringlei	7
B	2		
		Desmodium psilophyllum	1
		Grindelia havardii	1
		Muhlenbergia emersleyi	40
		Pinus cembroides	25
		Piptochaetium pringlei	30
B	3		
		Annual	1
		Eragrostis intermedia	55
		Grindelia havardii	1
		Pinus cembroides	40
B	4		
		Annual	3
		Bouteloua gracilis	7
		Eragrostis intermedia	3
		Juniperus deppeana	15
		Lycurus setosus	27
		Piptochaetium pringlei	7
B	5		
		Bouteloua curtipendula	45
		Grindelia havardii	3
		Juniperus deppeana	25
B	6		
		Bouteloua curtipendula	32
		Juniperus deppeana	50
		Piptochaetium pringlei	8
B	7		
		Bouteloua curtipendula	55
		Juniperus deppeana	27
		Piptochaetium pringlei	3
B	8		
		Bouteloua curtipendula	40
		Eragrostis intermedia	5
		Grindelia havardii	7
		Juniperus deppeana	30
		Piptochaetium pringlei	17
B	9		
		Bouteloua gracilis	30
		Eragrostis intermedia	25
		Juniperus deppeana	10
		Mimosa aculeaticarpa var. biuncifera	13

97SW011 Monitoring Plot cont.

Transect	Quadrat	Species	Cover
B	10		
		Bouteloua curtipendula	50
		Grindelia havardii	1
B	11		
		Eragrostis intermedia	30
		Juniperus deppeana	2
		Muhlenbergia emersleyi	20
B	12		
		Agave havardiana	35
		Bouteloua curtipendula	35
		Grindelia havardii	3
		Juniperus deppeana	10
		Oxalis spp.	0.001
B	13		
		Annual	5
		Eragrostis intermedia	32
		Grindelia havardii	3
		Juniperus deppeana	7
		Muhlenbergia emersleyi	32
B	14		
		Bouteloua gracilis	6
		Eragrostis intermedia	65
		Grindelia havardii	2
		Juniperus deppeana	45
		Piptochaetium pringlei	5
B	15		
		Bouteloua curtipendula	20
		Eragrostis intermedia	17
		Grindelia havardii	5
		Juniperus deppeana	40
		Panicum bulbosum	3
B	16		
		Annual	2
		Bouteloua curtipendula	30
		Eragrostis intermedia	10
		Juniperus deppeana	5
		Pellaea ternifolia	20
B	17		
		Eragrostis intermedia	30
		Eriogonum spp.	4
		Grindelia havardii	3
		Juniperus deppeana	20
		Muhlenbergia emersleyi	5
		Notholaena aschenborniana	1
		Pellaea ternifolia	8

97SW011 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*18*		
		Bouteloua curtipendula	45
		Juniperus deppeana	50
B	*19*		
		Eragrostis intermedia	16
		Juniperus deppeana	30
		Pellaea ternifolia	8
		Piptochaetium pringlei	4
B	*20*		
		Juniperus deppeana	15
		Pinus cembroides	15
		Piptochaetium pringlei	80

97SW015 Monitoring Plot Map Unit: Mixed Conifer Forest

GPS Coordinates: Northing 3211966 Easting 732327 taken at south stake of Transect A.

Directions: From main camp, head north to Mesa Bonita and take road to end, then follow ridge to the northwest. Site is an old-growth stand in a steep northwest facing canyon off this ridge.

Transect Configuration: Two transects, each 20m long, oriented north to south (downslope to upslope at a compass bearing of 188°) and read in that direction. Transects are approximately 7m apart and endstakes are at a bearing of 94° from each other. Transect A is east of Transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Pseudotsuga menziesii	100
		Thalictrum fendleri	10
		Viola spp	3
A	*2*		
		Cornus sericea	70
		Galium spp.	10
		Oxalis spp.	5
		Pseudotsuga menziesii	50
A	*3*		
		Cornus sericea	80
		Lichen	7
		Pseudotsuga menziesii	40
		Rock	55
A	*4*		
		Cornus sericea	60
		Galium spp.	3
		Lichen	4
		Osmorhiza mexicana	5
		Pseudotsuga menziesii	10
		Rock	12
A	*5*		
		Bromus lanatipes	3
		Cornus sericea	50
		Galium spp.	4
		Lichen	10
		Pseudotsuga menziesii	50
		Senecio toluccanus	25
A	*6*		
		Cornus sericea	100
		Osmorhiza mexicana	4
		Oxalis spp.	1
		Pseudotsuga menziesii	50
		Rock	8
		Thalictrum fendleri	4
A	*7*		
		Cornus sericea	100
		Pseudotsuga menziesii	10
		Rock	3
		Thalictrum fendleri	2

97SW015 Monitoring Plot con't.

Transect	*Quadrat*	*Species*	*Cover*
A	***8***		
		Cornus sericea	100
		Pseudotsuga menziesii	20
		Rock	11
		Thalictrum fendleri	27
A	***9***		
		Bromus lanatipes	3
		Cornus sericea	70
		Galium spp.	2
		Osmorhiza mexicana	15
		Oxalis spp.	1
		Pseudotsuga menziesii	15
		Rock	27
		Thalictrum fendleri	10
A	***10***		
		Bromus lanatipes	1
		Cornus sericea	100
		Oxalis spp.	2
		Pseudotsuga menziesii	10
		Senecio cardamine	4
A	***11***		
		Bromus lanatipes	0.001
		Cornus sericea	100
		Cystopteris fragilis	4
		Osmorhiza mexicana	1
		Oxalis spp.	13
		Pinus strobiformis	2
		Pseudotsuga menziesii	3
		Rock	30
A	***12***		
		Cornus sericea	5
		Galium spp.	2
		Oxalis spp.	2
		Pinus strobiformis	10
		Rock	50
		Viola spp	1
A	***13***		
		Galium spp.	3
		Holodiscus discolor	30
		Oxalis spp.	7
		Pinus strobiformis	15
		Pseudotsuga menziesii	60

97SW015 Monitoring Plot con't.

Transect	*Quadrat*	*Species*	*Cover*
A	*14*		
		Bromus lanatipes	2
		Cornus sericea	80
		Osmorhiza mexicana	1
		Oxalis spp.	1
		Pinus strobiformis	10
		Pseudotsuga menziesii	30
		Senecio toluccanus	17
		Thalictrum fendleri	23
A	*15*		
		Cornus sericea	50
		Pinus strobiformis	60
		Pseudotsuga menziesii	80
A	*16*		
		Pinus strobiformis	15
		Pseudotsuga menziesii	100
A	*17*		
		Chimaphila menziesii	8
		Osmorhiza mexicana	2
		Pseudotsuga menziesii	90
		Thalictrum fendleri	15
A	*18*		
		Bromus lanatipes	3
		Pseudotsuga menziesii	50
		Rock	10
		Thalictrum fendleri	45
A	*19*		
		Cornus sericea	35
		Pseudotsuga menziesii	90
		Rock	60
A	*20*		
		Bromus lanatipes	1
		Chimaphila menziesii	2
		Senecio cardamine	40
		Thalictrum fendleri	18
B	*1*		
		Bromus lanatipes	1
		Pinus strobiformis	50
		Pseudotsuga menziesii	50
		Thalictrum fendleri	17
B	*2*		
		Cornus sericea	2
		Pinus strobiformis	70
		Rock	8
		Thalictrum fendleri	15

97SW015 Monitoring Plot con't.

Transect	*Quadrat*	*Species*	*Cover*
B	*3*		
		Chimaphila menziesii	2
		Holodiscus discolor	12
		Oxalis spp.	3
		Pinus strobiformis	70
		Pseudotsuga menziesii	2
		Thalictrum fendleri	5
B	*4*		
		Oxalis spp.	17
		Pinus strobiformis	60
		Rock	17
B	*5*		
		Oxalis spp.	5
		Pinus strobiformis	60
		Rock	30
B	*6*		
		Oxalis spp.	2
		Pinus strobiformis	40
		Pseudotsuga menziesii	20
		Thalictrum fendleri	12
B	*7*		
		Oxalis spp.	5
		Pinus strobiformis	10
		Pseudotsuga menziesii	90
B	*8*		
		Oxalis spp.	3
		Pseudotsuga menziesii	90
		Rock	17
		Senecio toluccanus	3
B	*9*		
		Pseudotsuga menziesii	100
B	*10*		
		Pseudotsuga menziesii	100
		Rock	40
B	*11*		
		Pseudotsuga menziesii	100
		Rock	17
B	*12*		
		Pseudotsuga menziesii	100
B	*13*		
		Chimaphila menziesii	1
		Pseudotsuga menziesii	100
B	*14*		
		Pseudotsuga menziesii	100
B	*15*		
		Maianthemum stellatum	0.001
		Pseudotsuga menziesii	100

97SW015 Monitoring Plot con't.

Transect	*Quadrat*	*Species*	*Cover*
B	*16*		
		Chimaphila menziesii	1
		Maianthemum stellatum	2
		Pseudotsuga menziesii	80
		Senecio cardamine	45
B	*17*		
		Bromus lanatipes	1
		Chimaphila menziesii	3
		Galium spp.	3
		Maianthemum stellatum	6
		Pseudotsuga menziesii	75
		Senecio cardamine	30
		Thalictrum fendleri	6
		Viola spp	3
B	*18*		
		Bromus lanatipes	1
		Fragaria spp	3
		Galium spp.	3
		Maianthemum stellatum	16
		Oxalis spp.	3
		Pseudotsuga menziesii	40
		Thalictrum fendleri	14
B	*19*		
		Bromus lanatipes	1
		Fragaria spp	0.001
		Pinus strobiformis	10
		Senecio cardamine	15
		Thalictrum fendleri	6
		Viola spp	7
B	*20*		
		Chimaphila menziesii	10
		Galium spp.	1
		Maianthemum stellatum	8
		Pinus strobiformis	40

97SW021 Monitoring Plot Map Unit: Mesa Pine Forest

GPS Coordinates: Northing 3209537 Easting 733709 taken at east stake of Transect A.

Directions: Climb east up the mountain from the main camp in Canon Moreno until you top out on a mesa. Head northeast about ½ km.

Transect Configuration: Two transects, 20m long, parallel to each other and about 7m apart, are oriented east to west (264°) and read in that direction. Transect B is south of Transect A.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Achillea millefolium var. occidentalis	4
		Pinus arizonica	60
		Piptochaetium pringlei	35
		Ranunculus peruvianus	2
A	*2*		
		Annual	1
		Festuca arizonica	1
		Muhlenbergia montana	2
		Piptochaetium pringlei	1
		Ranunculus peruvianus	1
A	*3*		
		Piptochaetium pringlei	8
A	*4*		
		Pinus arizonica	90
		Piptochaetium pringlei	35
A	*5*		
		Campanula rotundifolia	0.001
		Festuca arizonica	8
		Muhlenbergia montana	3
		Pinus arizonica	90
		Piptochaetium pringlei	3
A	*6*		
		Pinus arizonica	90
		Piptochaetium pringlei	2
		Quercus hypoleucoides	10
		Ranunculus peruvianus	1
A	*7*		
		Achillea millefolium var. occidentalis	2
		Annual	3
		Festuca arizonica	4
		Pinus arizonica	70
		Quercus hypoleucoides	40
		Senecio millelobatus	2
		Sisyrinchium convolutum	8
A	*8*		
		Achillea millefolium var. occidentalis	2
		Panicum bulbosum	3
		Pinus arizonica	85
		Piptochaetium pringlei	3
		Sisyrinchium convolutum	3

97SW021 Monitoring Plot con't.

Transect	Quadrat	Species	Cover
A	9		
		Achillea millefolium var. occidentalis	4
		Annual	1
		Chaptalia texana	11
		Muhlenbergia montana	3
		Panicum bulbosum	8
		Pinus arizonica	90
		Piptochaetium pringlei	8
		Psathyrotes spp.	4
A	10		
		Achillea millefolium var. occidentalis	2
		Hieracium fendleri	65
		Pinus arizonica	60
		Piptochaetium pringlei	15
A	11		
		Achillea millefolium var. occidentalis	4
		Danthonia spicata	11
		Festuca arizonica	7
		Muhlenbergia montana	6
		Panicum bulbosum	1
		Pinus arizonica	65
		Senecio millelobatus	10
A	12		
		Achillea millefolium var. occidentalis	4
		Annual	2
		Panicum bulbosum	2
		Pinus arizonica	70
		Piptochaetium pringlei	4
		Senecio millelobatus	2
A	13		
		Annual	4
		Festuca arizonica	30
		Pinus arizonica	100
A	14		
		Muhlenbergia montana	1
		Pinus arizonica	45
A	15		
		Pinus strobiformis	70
		Piptochaetium pringlei	37
A	16		
		Hieracium fendleri	12
		Pinus strobiformis	40
		Piptochaetium pringlei	25
A	17		
		Annual	0.001
		Piptochaetium pringlei	4
		Senecio millelobatus	4
		Sisyrinchium convolutum	3

97SW021 Monitoring Plot con't.

Transect	Quadrat	Species	Cover
A	18		
		Festuca arizonica	0.001
		Muhlenbergia montana	8
		Panicum bulbosum	2
		Pinus strobiformis	3
		Piptochaetium pringlei	22
		Ranunculus peruvianus	4
		Sisyrinchium convolutum	9
A	19		
		Muhlenbergia montana	5
		Panicum bulbosum	6
		Pinus arizonica	5
		Pinus strobiformis	10
A	20		
		Annual	2
		Muhlenbergia montana	5
		Panicum bulbosum	7
		Pinus arizonica	20
		Pinus strobiformis	3
B	1		
		Chaptalia texana	3
		Hieracium fendleri	25
		Pinus arizonica	80
		Piptochaetium pringlei	21
		Senecio millelobatus	2
B	2		
		Hieracium fendleri	13
		Pinus arizonica	100
		Piptochaetium pringlei	6
B	3		
		Achillea millefolium var. occidentalis	3
		Annual	2
		Chaptalia texana	3
		Festuca arizonica	5
		Hieracium fendleri	12
		Piptochaetium pringlei	12
		Ranunculus peruvianus	100
B	4		
		Achillea millefolium var. occidentalis	2
		Pinus arizonica	95
		Piptochaetium pringlei	13
B	5		
		Annual	2
		Campanula rotundifolia	50
		Festuca arizonica	0.001
		Pinus arizonica	100
		Piptochaetium pringlei	15

97SW021 Monitoring Plot con't.

Transect	*Quadrat*	*Species*	*Cover*
B	*6*		
		Festuca arizonica	0.001
		Piptochaetium pringlei	21
		Ranunculus peruvianus	40
B	*7*		
		Campanula rotundifolia	1
		Piptochaetium pringlei	11
		Sisyrinchium convolutum	7
		Viguiera cordifolia	5
B	*8*		
		Piptochaetium pringlei	60
		Psathyrotes spp.	2
		Quercus hypoleucoides	50
B	*9*		
		Piptochaetium pringlei	2
		Quercus hypoleucoides	65
		Sisyrinchium convolutum	4
		Viguiera cordifolia	11
B	*10*		
		Achillea millefolium var. occidentalis	5
		Festuca arizonica	2
		Muhlenbergia montana	12
		Piptochaetium pringlei	27
		Quercus hypoleucoides	100
B	*11*		
		Festuca arizonica	15
		Muhlenbergia montana	15
		Panicum bulbosum	1
		Quercus hypoleucoides	75
		Viguiera cordifolia	10
B	*12*		
		Muhlenbergia montana	2
		Panicum bulbosum	13
		Piptochaetium pringlei	17
		Quercus hypoleucoides	10
B	*13*		
		Muhlenbergia montana	11
		Pinus arizonica	5
		Piptochaetium pringlei	1
B	*14*		
		Pinus arizonica	90
		Piptochaetium pringlei	55
B	*15*		
		Achillea millefolium var. occidentalis	1
		Pinus arizonica	100
		Piptochaetium pringlei	57
B	*16*		
		Pinus strobiformis	15
		Piptochaetium pringlei	4

97SW021 Monitoring Plot con't.

Transect	*Quadrat*	*Species*	*Cover*
B	*17*		
		Achillea millefolium var. occidentalis	2
		Annual	2
		Festuca arizonica	25
		Pinus arizonica	70
		Piptochaetium pringlei	22
B	*18*		
		Achillea millefolium var. occidentalis	1
		Annual	2
		Chaptalia texana	2
		Piptochaetium pringlei	35
		Senecio millelobatus	2
		Viguiera cordifolia	17
B	*19*		
		Festuca arizonica	35
		Piptochaetium pringlei	25
		Senecio millelobatus	2
B	*20*		
		Pinus arizonica	12
		Piptochaetium pringlei	9

97SW022 Monitoring Plot Map Unit: Mixed Conifer Forest

GPS Coordinates: Northing 3208298 Easting 732353 taken at east stake of Transect A.

Directions: Take road heading south from main camp for about 1.2 km. Transect is approximately 50 meters south of the road up the hillside

Transect Configuration: Two transects, 20m long, parallel to each other and about 7m apart, are oriented north to south and read in that direction. Transect B is west of Transect A.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Achillea millefolium var. occidentalis	8
		Erigeron flagellaris	5
		Koeleria macrantha	3
		Pseudotsuga menziesii	60
		Quercus gambelii	40
A	*2*		
		Erigeron flagellaris	10
		Koeleria macrantha	7
		Pseudotsuga menziesii	10
		Quercus gambelii	13
A	*3*		
		Achillea millefolium var. occidentalis	4
		Artemisia ludoviciana	2
		Erigeron flagellaris	10
		Lichen	2
		Pinus strobiformis	65
		Rock	1
		Senecio cardamine	60
A	*4*		
		Achillea millefolium var. occidentalis	12
		Bromus ciliatus	0.001
		Erigeron flagellaris	7
		Fragaria spp	10
		Koeleria macrantha	1
		Pinus strobiformis	100
		Piptochaetium pringlei	3
A	*5*		
		Achillea millefolium var. occidentalis	14
		Erigeron flagellaris	16
		Fragaria spp	4
		Monotropa hypopithys	8
		Pinus arizonica	30
		Pinus strobiformis	70
A	*6*		
		Annual	2
		Erigeron flagellaris	1
		Moss	3
		Pinus strobiformis	100
		Rock	12
		Senecio cardamine	1

97SW022 Monitoring Plot

Transect	*Quadrat*	*Species*	*Cover*

A	***7***		
		Erigeron flagellaris	14
		Fragaria spp	2
		Koeleria macrantha	8
		Pinus arizonica	50
		Pinus strobiformis	50
		Viguiera cordifolia	31
A	***8***		
		Annual	2
		Erigeron flagellaris	6
		Fragaria spp	4
		Koeleria macrantha	2
		Pinus arizonica	75
		Pseudotsuga menziesii	5
		Senecio cardamine	20
A	***9***		
		Fragaria spp	5
		Monarda pringlei	2
		Monotropa hypopithys	2
		Pinus arizonica	90
		Pseudotsuga menziesii	60
		Senecio cardamine	40
		Viguiera cordifolia	3
A	***10***		
		Artemisia ludoviciana	2
		Bromus ciliatus	3
		Monotropa hypopithys	22
		Pinus arizonica	40
		Pseudotsuga menziesii	90
		Quercus hypoleucoides	2
		Viguiera cordifolia	7
A	***11***		
		Artemisia ludoviciana	4
		Fragaria spp	1
		Pseudotsuga menziesii	100
		Senecio cardamine	10
A	***12***		
		Artemisia ludoviciana	3
		Fragaria spp	6
		Monarda pringlei	2
		Pseudotsuga menziesii	100
		Viguiera cordifolia	6
A	***13***		
		Annual	1
		Bromus ciliatus	2
		Monarda pringlei	4
		Monotropa hypopithys	22
		Pseudotsuga menziesii	75

97SW022 Monitoring Plot

Transect	***Quadrat***	***Species***	***Cover***

A	***14***		
		Fragaria spp	3
		Koeleria macrantha	1
		Monotropa hypopithys	22
		Pseudotsuga menziesii	45
		Viguiera cordifolia	80
A	***15***		
		Bromus ciliatus	1
		Moss	2
		Muhlenbergia glauca	3
		Pinus arizonica	8
		Pseudotsuga menziesii	8
		Quercus carmenensis	40
		Rock	30
A	***16***		
		Muhlenbergia glauca	1
		Quercus carmenensis	30
		Rock	20
A	***17***		
		Pinus arizonica	20
		Pseudotsuga menziesii	5
		Rock	65
		Viguiera cordifolia	10
A	***18***		
		Monotropa hypopithys	1
		Pinus arizonica	70
		Quercus hypoleucoides	5
		Rock	12
		Viguiera cordifolia	3
A	***19***		
		Monotropa hypopithys	2
		Muhlenbergia glauca	3
		Pinus arizonica	80
		Quercus hypoleucoides	25
		Rock	5
A	***20***		
		Koeleria macrantha	1
		Monotropa hypopithys	4
		Pinus arizonica	70
		Quercus carmenensis	3
B	***1***		
		Bromus lanatipes	1
		Fragaria spp	4
		Monarda pringlei	2
		Muhlenbergia glauca	9
		Pseudotsuga menziesii	5
		Quercus rugosa	90
		Rock	5
		Viguiera cordifolia	60

97SW022 Monitoring Plot

Transect	*Quadrat*	*Species*	*Cover*
B	*2*		
		Erigeron flagellaris	4
		Monarda pringlei	12
		Panicum bulbosum	6
		Quercus rugosa	60
B	*3*		
		Achillea millefolium var. occidentalis	2
		Erigeron flagellaris	6
		Fragaria spp	7
		Lichen	8
		Pseudotsuga menziesii	0.001
		Quercus rugosa	5
		Rock	32
B	*4*		
		Bromus lanatipes	2
		Erigeron flagellaris	2
		Fragaria spp	4
		Muhlenbergia glauca	15
		Pseudotsuga menziesii	0.001
		Quercus rugosa	30
		Senecio cardamine	0.001
B	*5*		
		Achillea millefolium var. occidentalis	3
		Erigeron flagellaris	9
		Fragaria spp	4
		Moss	4
		Piptochaetium pringlei	3
		Pseudotsuga menziesii	60
		Quercus rugosa	85
		Rock	12
		Vicia spp.	6
B	*6*		
		Achillea millefolium var. occidentalis	10
		Erigeron flagellaris	5
		Monotropa hypopithys	8
		Piptochaetium pringlei	2
		Pseudotsuga menziesii	45
		Quercus rugosa	8
		Rock	21
B	*7*		
		Achillea millefolium var. occidentalis	3
		Erigeron flagellaris	7
		Lichen	2
		Moss	2
		Panicum bulbosum	32
		Quercus rugosa	0.001
		Rock	3
		Vicia spp.	5

97SW022 Monitoring Plot

Transect	*Quadrat*	*Species*	*Cover*
B	*8*		
		Achillea millefolium var. occidentalis	6
		Erigeron flagellaris	13
		Fragaria spp	4
		Koeleria macrantha	6
		Lichen	4
		Monotropa hypopithys	11
		Moss	22
		Quercus arizonica	1
		Quercus hypoleucoides	2
B	*9*		
		Erigeron flagellaris	7
		Fragaria spp	5
		Koeleria macrantha	6
		Lichen	6
		Quercus arizonica	10
		Quercus hypoleucoides	30
		Ranunculus peruvianus	2
		Senecio cardamine	35
B	*10*		
		Achillea millefolium var. occidentalis	3
		Campanula rotundifolia	1
		Fragaria spp	12
		Koeleria macrantha	17
		Lichen	30
		Monarda pringlei	1
		Pseudotsuga menziesii	5
		Quercus arizonica	5
		Quercus hypoleucoides	30
		Vicia spp.	1
B	*11*		
		Achillea millefolium var. occidentalis	2
		Annual	1
		Fragaria spp	5
		Lichen	35
		Moss	5
		Panicum bulbosum	1
		Pseudotsuga menziesii	8
		Quercus hypoleucoides	20
		Rock	6
		Rubus idaeus	14
B	*12*		
		Achillea millefolium var. occidentalis	4
		Artemisia ludoviciana	13
		Fragaria spp	1
		Muhlenbergia glauca	2
		Pseudotsuga menziesii	30
		Rubus idaeus	17

97SW022 Monitoring Plot

Transect	*Quadrat*	*Species*	*Cover*
B	*13*		
		Achillea millefolium var. occidentalis	2
		Fragaria spp	3
		Geranium spp	4
		Monarda pringlei	14
		Rubus idaeus	25
		Senecio cardamine	50
B	*14*		
		Achillea millefolium var. occidentalis	1
		Erigeron flagellaris	2
		Fragaria spp	7
		Muhlenbergia glauca	4
		Piptochaetium pringlei	45
		Vicia spp.	5
B	*15*		
		Fragaria spp	3
		Monarda pringlei	3
		Pinus arizonica	6
		Piptochaetium pringlei	14
		Rock	6
		Rubus idaeus	7
		Vicia spp.	20
B	*16*		
		Achillea millefolium var. occidentalis	2
		Erigeron flagellaris	3
		Fragaria spp	4
		Pinus arizonica	40
		Pinus strobiformis	30
		Rock	22
B	*17*		
		Monotropa hypopithys	10
		Muhlenbergia glauca	4
		Pinus strobiformis	70
		Piptochaetium pringlei	8
		Rock	25
		Vicia spp.	4
B	*18*		
		Achillea millefolium var. occidentalis	2
		Erigeron flagellaris	9
		Monotropa hypopithys	17
		Pinus strobiformis	80
		Rock	13
B	*19*		
		Achillea millefolium var. occidentalis	23
		Monarda pringlei	8
		Quercus arizonica	70
		Rock	4
		Senecio cardamine	9

97SW022 Monitoring Plot

Transect	*Quadrat*	*Species*	*Cover*
B	*20*		
		Achillea millefolium var. occidentalis	4
		Monarda pringlei	14
		Muhlenbergia glauca	1
		Pinus strobiformis	7
		Quercus hypoleucoides	8
		Rock	45

97SW023 Monitoring Plot Map Unit: Pine-Oak Forest

GPS Coordinates: Northing 3209818 Easting 731521 taken at east stake of Transect A.

Directions: Stand is in a north-south running drainage immediately to the west of main camp. Transects are about 40-50m from ridgetop.

Transect Configuration: Two transects, 20m long, parallel and approximately 7m apart, are oriented across the drainage from west to east and read in that direction. Stakes are labelled with a red sharpie. Transect A is north (uphill) of Transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Koeleria macrantha	6
		Pinus arizonica	60
		Rock	11
A	*2*		
		Pinus arizonica	60
A	*3*		
		Monotropa hypopithys	10
		Pinus arizonica	30
A	*4*		
		Pinus arizonica	40
A	*5*		
		Monotropa hypopithys	10
		Pinus arizonica	50
A	*6*		
		Koeleria macrantha	35
		Monotropa hypopithys	17
		Pinus arizonica	35
A	*7*		
		Annual	1
		Koeleria macrantha	22
		Pinus arizonica	100
A	*8*		
		Cologania angustifolia	2
		Pinus arizonica	95
A	*9*		
		Pinus arizonica	90
A	*10*		
		Cologania angustifolia	1
		Pinus arizonica	75
		Rock	8
A	*11*		
		Cologania angustifolia	2
		Pinus arizonica	20
A	*12*		
		Koeleria macrantha	30
		Pinus arizonica	25
		Rock	15

97SW023 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*13*		
		Koeleria macrantha	10
		Pinus arizonica	20
		Rock	21
A	*14*		
		Koeleria macrantha	8
		Pinus arizonica	40
A	*15*		
		Hieracium carneum	2
		Koeleria macrantha	1
		Pinus arizonica	65
A	*16*		
		Pinus arizonica	90
A	*17*		
		Pinus arizonica	100
		Piptochaetium pringlei	45
A	*18*		
		Koeleria macrantha	4
		Pinus arizonica	100
		Piptochaetium pringlei	7
A	*19*		
		Pinus arizonica	100
A	*20*		
		Pinus arizonica	100
B	*1*		
		Pinus strobiformis	5
		Rock	25
B	*2*		
		Cologania angustifolia	1
		Koeleria macrantha	5
		Monotropa hypopithys	3
		Pinus strobiformis	70
B	*3*		
		Koeleria macrantha	4
		Pinus strobiformis	100
		Rock	5
B	*4*		
		Pinus strobiformis	100
B	*5*		
		Koeleria macrantha	10
		Pinus strobiformis	100
B	*6*		
		Pinus strobiformis	50
B	*7*		
		Cologania angustifolia	3
		Monotropa hypopithys	9
		Pinus strobiformis	65

97SW023 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*8*		
		Pinus arizonica	20
		Pinus strobiformis	40
B	*9*		
		Pinus arizonica	80
B	*10*		
		Koeleria macrantha	8
		Monotropa hypopithys	23
		Pinus arizonica	75
B	*11*		
		Monotropa hypopithys	5
		Pinus arizonica	80
B	*12*		
		Koeleria macrantha	4
		Pinus arizonica	80
B	*13*		
		Koeleria macrantha	5
		Monotropa hypopithys	35
		Pinus arizonica	60
B	*14*		
		Koeleria macrantha	12
		Pinus arizonica	50
B	*15*		
		Pinus arizonica	50
B	*16*		
		Monotropa hypopithys	3
		Pinus arizonica	0.001
B	*17*		
		Pinus strobiformis	60
		Quercus rugosa	55
B	*18*		
		Pinus arizonica	60
		Quercus rugosa	60
		Rock	13
B	*19*		
		Pinus arizonica	70
		Quercus rugosa	10
		Rock	5
B	*20*		
		Pinus arizonica	85
		Rock	10

97SW024 Monitoring Plot Map Unit: Montane Woodland

GPS Coordinates: Northing 3207976 Easting 735838 taken at south stake of Transect A.

Directions: Plot is located on westernmost mesa that is south of Canon Moreno. Walk northeast from road about 1.5 km to reach plot.

Transect Configuration: Two transects, 20m long, parallel and approximately 7m apart, are oriented from south to north and read in that direction. Transect A is east of Transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Muhlenbergia emersleyi	10
		Rock	24
		Schizachyrium neomexicanum	5
A	*2*		
		Muhlenbergia emersleyi	30
		Rock	10
		Schizachyrium neomexicanum	10
A	*3*		
		Rock	8
		Schizachyrium neomexicanum	45
A	*4*		
		Arctostaphylos pungens	8
		Moss	5
		Muhlenbergia emersleyi	8
		Schizachyrium neomexicanum	28
A	*5*		
		Arctostaphylos pungens	25
		Muhlenbergia emersleyi	43
		Ranunculus peruvianus	2
		Schizachyrium neomexicanum	22
A	*6*		
		Muhlenbergia emersleyi	32
		Piptochaetium fimbriatum	10
		Schizachyrium neomexicanum	18
A	*7*		
		Muhlenbergia emersleyi	35
		Piptochaetium fimbriatum	6
		Quercus arizonica	5
		Ranunculus peruvianus	0.001
		Schizachyrium neomexicanum	20
A	*8*		
		Muhlenbergia emersleyi	14
		Piptochaetium fimbriatum	17
		Quercus arizonica	60
		Ranunculus peruvianus	3
A	*9*		
		Arctostaphylos pungens	15
		Muhlenbergia emersleyi	3
		Piptochaetium fimbriatum	18
		Schizachyrium neomexicanum	13

97SW024 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*10*		
		Arctostaphylos pungens	100
		Piptochaetium fimbriatum	10
		Rock	8
		Schizachyrium neomexicanum	2
A	*11*		
		Arctostaphylos pungens	20
		Muhlenbergia emersleyi	12
		Piptochaetium fimbriatum	9
		Quercus arizonica	90
A	*12*		
		Muhlenbergia emersleyi	11
		Quercus arizonica	90
		Salvia regla	50
		Schizachyrium neomexicanum	5
A	*13*		
		Arctostaphylos pungens	82
		Muhlenbergia emersleyi	4
		Piptochaetium fimbriatum	3
		Quercus arizonica	60
		Ranunculus peruvianus	1
		Schizachyrium neomexicanum	4
A	*14*		
		Arctostaphylos pungens	45
		Piptochaetium fimbriatum	2
		Rock	22
		Schizachyrium neomexicanum	10
A	*15*		
		Arctostaphylos pungens	20
		Galium spp.	0.001
		Piptochaetium fimbriatum	35
		Ranunculus peruvianus	3
		Schizachyrium neomexicanum	9
A	*16*		
		Arctostaphylos pungens	85
		Muhlenbergia emersleyi	15
		Piptochaetium fimbriatum	7
		Ranunculus peruvianus	5
		Schizachyrium neomexicanum	10
A	*17*		
		Rock	45
		Schizachyrium neomexicanum	18
A	*18*		
		Muhlenbergia emersleyi	22
		Rock	13

97SW024 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*19*		
		Lycurus setosus	0.001
		Muhlenbergia emersleyi	12
		Rock	43
		Schizachyrium neomexicanum	8
A	*20*		
		Annual	2
		Arctostaphylos pungens	65
		Lycurus setosus	3
		Schizachyrium neomexicanum	25
B	*1*		
		Arctostaphylos pungens	70
		Muhlenbergia emersleyi	6
		Schizachyrium neomexicanum	12
B	*2*		
		Annual	2
		Arctostaphylos pungens	52
		Muhlenbergia emersleyi	8
		Piptochaetium fimbriatum	10
B	*3*		
		Arctostaphylos pungens	25
		Muhlenbergia emersleyi	10
B	*4*		
		Arctostaphylos pungens	35
		Muhlenbergia emersleyi	50
		Piptochaetium fimbriatum	10
B	*5*		
		Muhlenbergia emersleyi	30
		Piptochaetium fimbriatum	17
B	*6*		
		Muhlenbergia emersleyi	10
		Piptochaetium fimbriatum	8
		Schizachyrium neomexicanum	95
B	*7*		
		Muhlenbergia emersleyi	8
		Piptochaetium fimbriatum	10
		Rock	17
		Schizachyrium neomexicanum	14
B	*8*		
		Muhlenbergia emersleyi	37
		Piptochaetium fimbriatum	13
		Schizachyrium neomexicanum	12
B	*9*		
		Arctostaphylos pungens	55
		Muhlenbergia emersleyi	25
		Rock	15
		Schizachyrium neomexicanum	4

97SW024 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*10*		
		Arctostaphylos pungens	60
		Muhlenbergia emersleyi	8
		Piptochaetium fimbriatum	6
		Schizachyrium neomexicanum	2
B	*11*		
		Arctostaphylos pungens	5
		Muhlenbergia emersleyi	13
		Piptochaetium fimbriatum	2
B	*12*		
		Arctostaphylos pungens	75
		Muhlenbergia emersleyi	18
		Piptochaetium fimbriatum	4
		Rock	10
B	*13*		
		Arctostaphylos pungens	100
		Piptochaetium fimbriatum	1
		Quercus arizonica	30
		Rock	2
		Schizachyrium neomexicanum	4
B	*14*		
		Arctostaphylos pungens	50
		Piptochaetium fimbriatum	2
		Quercus arizonica	70
		Schizachyrium neomexicanum	7
B	*15*		
		Muhlenbergia emersleyi	3
		Piptochaetium fimbriatum	13
		Quercus arizonica	60
		Schizachyrium neomexicanum	1
B	*16*		
		Piptochaetium fimbriatum	27
		Quercus arizonica	100
		Ranunculus peruvianus	3
		Schizachyrium neomexicanum	13
B	*17*		
		Arctostaphylos pungens	37
		Muhlenbergia emersleyi	2
		Piptochaetium fimbriatum	8
		Quercus arizonica	15
		Schizachyrium neomexicanum	6
B	*18*		
		Arctostaphylos pungens	100
		Juniperus deppeana	20
		Koeleria macrantha	2
		Schizachyrium neomexicanum	2

97SW024 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*19*		
		Arctostaphylos pungens	100
		Juniperus deppeana	70
		Piptochaetium fimbriatum	12
B	*20*		
		Arctostaphylos pungens	50
		Muhlenbergia emersleyi	8
		Piptochaetium fimbriatum	8
		Rock	25
		Schizachyrium neomexicanum	8

97SW025 Monitoring Plot Map Unit: Pinon-Pine-Juniper Woodland

GPS Coordinates: Northing 3205054 Easting 730045 taken at east stake of Transect A.

Directions: Travel on the road from 'El Cinco' to 'El Uno' Aserradero. At the point where the road turns north down the canyon, take the horse trail east over the saddle.

Transect Configuration: Two transects, 20m long, parallel and approximately 7m apart, are oriented from west to east and read in that direction. Transect B is south of Transect A.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Bouteloua curtipendula	2
		Commelina erecta	2
		Desmodium psilophyllum	1
		Muhlenbergia emersleyi	2
		Notholaena aschenborniana	30
		Rock	50
		Senna spp.	1
A	*2*		
		Rock	100
A	*3*		
		Bouteloua curtipendula	1
		Commelina erecta	2
		Echinocereus pectinatus	3
		Notholaena aschenborniana	25
		Quercus arizonica	10
		Rock	45
A	*4*		
		Echinocereus pectinatus	1
		Muhlenbergia emersleyi	5
		Rock	40
		Senna spp.	1
		Wedelia acapulcensis var. hispida	10
A	*5*		
		Bouteloua curtipendula	2
		Dichondra brachypoda	1
		Quercus arizonica	100
		Rock	45
		Salvia regla	0.001
		Schizachyrium neomexicanum	1
		Senna spp.	1
A	*6*		
		Dichondra brachypoda	4
		Eriogonum jamesii	2
		Muhlenbergia glauca	2
		Quercus arizonica	100
		Rock	51
		Sedum spp.	9

97SW025 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*7*		
		Bommeria hispida	5
		Bouteloua curtipendula	5
		Dichondra brachypoda	15
		Quercus arizonica	100
		Rock	20
A	*8*		
		Aristida orcuttiana	7
		Artemisia ludoviciana	2
		Bommeria hispida	2
		Brickellia betonicifolia	1
		Eragrostis intermedia	12
		Notholaena aschenborniana	15
		Quercus arizonica	100
		Rock	12
		Senna spp.	2
		Wedelia acapulcensis var. hispida	1
A	*9*		
		Bouteloua curtipendula	8
		Muhlenbergia emersleyi	8
		Notholaena aschenborniana	22
		Rock	15
		Wedelia acapulcensis var. hispida	1
A	*10*		
		Aristida orcuttiana	3
		Bouteloua curtipendula	8
		Lycurus setosus	0.001
		Muhlenbergia emersleyi	22
		Quercus arizonica	10
		Rock	55
		Senna spp.	2
A	*11*		
		Bommeria hispida	8
		Brickellia betonicifolia	8
		Notholaena aschenborniana	4
		Opuntia engelmannii	31
		Quercus arizonica	80
		Rock	31
		Senna spp.	1
A	*12*		
		Bouteloua curtipendula	0.001
		Muhlenbergia emersleyi	4
		Quercus arizonica	100
		Rock	73
		Schizachyrium neomexicanum	4
		Stevia salicifolia	8

97SW025 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*13*		
		Muhlenbergia emersleyi	10
		Notholaena aschenborniana	5
		Rock	74
		Schizachyrium neomexicanum	0.001
A	*14*		
		Pinus cembroides	40
		Rock	76
		Schizachyrium neomexicanum	1
		Wedelia acapulcensis var. hispida	2
A	*15*		
		Muhlenbergia emersleyi	25
		Pinus cembroides	100
		Rock	36
		Senna spp.	7
A	*16*		
		Artemisia ludoviciana	10
		Muhlenbergia emersleyi	17
		Pinus cembroides	100
		Rock	25
		Senna spp.	8
A	*17*		
		Muhlenbergia emersleyi	1
		Pinus cembroides	100
		Rock	69
A	*18*		
		Muhlenbergia emersleyi	9
		Pinus cembroides	100
		Piptochaetium fimbriatum	37
		Rock	10
		Senna spp.	6
A	*19*		
		Muhlenbergia emersleyi	22
		Notholaena aschenborniana	17
		Pinus cembroides	100
		Rock	37
		Senna spp.	1
A	*20*		
		Muhlenbergia emersleyi	42
		Pinus cembroides	100
		Rock	14

97SW025 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*1*		
		Muhlenbergia emersleyi	27
		Notholaena aschenborniana	3
		Pinus cembroides	100
		Rock	25
		Wedelia acapulcensis var. hispida	2
B	*2*		
		Artemisia ludoviciana	1
		Bouteloua curtipendula	18
		Commelina erecta	5
		Muhlenbergia emersleyi	7
		Notholaena aschenborniana	12
		Pinus cembroides	100
		Rock	7
		Schizachyrium neomexicanum	7
B	*3*		
		Astrolepis sinuata	6
		Bommeria hispida	5
		Brickellia betonicifolia	2
		Muhlenbergia emersleyi	35
		Pinus cembroides	5
B	*4*		
		Muhlenbergia emersleyi	32
		Rock	18
		Schizachyrium neomexicanum	6
B	*5*		
		Muhlenbergia emersleyi	20
		Rock	37
		Schizachyrium neomexicanum	33
B	*6*		
		Bouteloua curtipendula	13
		Muhlenbergia emersleyi	17
		Rock	14
		Schizachyrium neomexicanum	6
		Senna spp.	1
B	*7*		
		Bommeria hispida	6
		Commelina erecta	2
		Lotus oroboides	22
		Muhlenbergia emersleyi	1
		Rock	32
		Schizachyrium neomexicanum	20
B	*8*		
		Bouteloua curtipendula	6
		Muhlenbergia emersleyi	23
		Rock	58

97SW025 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*9*		
		Bommeria hispida	7
		Muhlenbergia emersleyi	1
		Rock	60
		Schizachyrium neomexicanum	5
B	*10*		
		Muhlenbergia emersleyi	73
		Quercus arizonica	70
B	*11*		
		Commelina erecta	2
		Lotus oroboides	5
		Muhlenbergia emersleyi	6
		Notholaena aschenborniana	27
		Quercus arizonica	40
		Rock	22
		Schizachyrium neomexicanum	14
B	*12*		
		Bommeria hispida	6
		Brickellia betonicifolia	7
		Rock	12
		Schizachyrium neomexicanum	10
		Senna spp.	2
B	*13*		
		Annual	3
		Notholaena aschenborniana	17
		Rock	16
		Schizachyrium neomexicanum	13
		Senna spp.	4
B	*14*		
		Muhlenbergia emersleyi	25
		Quercus arizonica	40
		Rock	6
		Schizachyrium neomexicanum	15
		Senna spp.	4
B	*15*		
		Muhlenbergia emersleyi	13
		Pinus cembroides	25
		Rock	8
		Schizachyrium neomexicanum	8
B	*16*		
		Bommeria hispida	4
		Brickellia betonicifolia	25
		Pinus cembroides	100
		Rock	48
		Schizachyrium neomexicanum	6

97SW025 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*17*		
		Bommeria hispida	5
		Brickellia betonicifolia	8
		Commelina erecta	2
		Muhlenbergia emersleyi	2
		Notholaena aschenborniana	10
		Opuntia engelmannii	7
		Pinus cembroides	100
		Rock	53
		Senna spp.	3
B	*18*		
		Commelina spp.	2
		Desmodium psilophyllum	20
		Muhlenbergia emersleyi	2
		Pinus cembroides	100
		Rock	12
		Schizachyrium neomexicanum	9
B	*19*		
		Artemisia ludoviciana	3
		Bouteloua curtipendula	6
		Brickellia betonicifolia	11
		Pinus cembroides	40
		Rock	49
		Schizachyrium neomexicanum	4
B	*20*		
		Bouteloua curtipendula	2
		Bouteloua gracilis	3
		Muhlenbergia emersleyi	37
		Rock	5
		Schizachyrium neomexicanum	4

97SW 026 Monitoring Plot Map Unit: Oak Forest

GPS Coordinates: Northing 3206308 Easting 737273 taken at north stake of Transect A.

Directions: Travel the road from 'El Cinco' Aserradero to 'El Uno' Aserradero approximately 1.3 miles. Climb up slope to the west about 100m.

Transect Configuration: Two transects, 20m long, parallel and approximately 7m apart, are oriented from south to north and read in that direction. Transect A is east of Transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Desmodium psilophyllum	1
		Muhlenbergia glauca	8
		Pinus strobiformis	60
		Piptochaetium fimbriatum	3
		Piptochaetium pringlei	10
		Quercus gravesii	50
		Rock	45
		Stevia salicifolia	6
A	*2*		
		Cirsium pringlei	6
		Desmodium psilophyllum	4
		Piptochaetium pringlei	3
		Quercus gravesii	70
		Rock	42
A	*3*		
		Bromus ciliatus	1
		Desmodium psilophyllum	14
		Lotus oroboides	2
		Pinus strobiformis	60
		Piptochaetium pringlei	1
		Quercus gravesii	5
		Rock	28
A	*4*		
		Pinus strobiformis	70
		Piptochaetium pringlei	1
		Quercus arizonica	10
		Rock	22
A	*5*		
		Pinus strobiformis	100
		Piptochaetium pringlei	7
A	*6*		
		Chimaphila menziesii	2
		Pinus strobiformis	90
		Piptochaetium pringlei	3
		Rock	10
		Stevia salicifolia	2
A	*7*		
		Pinus strobiformis	40
		Piptochaetium pringlei	1
		Quercus arizonica	40
		Rock	70

97SW 026 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*8*		
		Desmodium psilophyllum	4
		Juniperus deppeana	20
		Pinus strobiformis	5
		Piptochaetium pringlei	20
		Quercus arizonica	65
		Stevia salicifolia	8
A	*9*		
		Desmodium psilophyllum	8
		Juniperus deppeana	30
		Piptochaetium pringlei	8
		Quercus arizonica	30
		Quercus gravesii	5
		Rock	17
A	*10*		
		Piptochaetium pringlei	8
		Quercus arizonica	10
		Quercus gravesii	40
		Viguiera cordifolia	8
A	*11*		
		Lotus oroboides	1
		Muhlenbergia emersleyi	2
		Muhlenbergia montana	1
		Piptochaetium fimbriatum	2
		Piptochaetium pringlei	1
		Quercus gravesii	80
		Rock	10
A	*12*		
		Muhlenbergia montana	22
		Piptochaetium pringlei	8
		Quercus arizonica	10
		Quercus gravesii	80
A	*13*		
		Desmodium psilophyllum	2
		Piptochaetium pringlei	30
		Quercus arizonica	40
		Quercus gravesii	20
		Quercus hypoleucoides	0.001
A	*14*		
		Achillea millefolium var. occidentalis	2
		Desmodium psilophyllum	3
		Phaseolus filiformis	13
		Piptochaetium pringlei	12
		Quercus arizonica	10
		Quercus hypoleucoides	80

97SW 026 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*15*		
		Desmodium psilophyllum	2
		Muhlenbergia montana	13
		Piptochaetium pringlei	16
		Quercus hypoleucoides	100
		Viguiera cordifolia	2
A	*16*		
		Desmodium psilophyllum	3
		Piptochaetium pringlei	17
		Quercus hypoleucoides	100
A	*17*		
		Desmodium psilophyllum	12
		Muhlenbergia montana	1
		Piptochaetium pringlei	12
		Quercus arizonica	10
		Quercus hypoleucoides	100
A	*18*		
		Artemisia ludoviciana	4
		Desmodium psilophyllum	12
		Lotus oroboides	1
		Muhlenbergia montana	4
		Piptochaetium pringlei	1
		Quercus arizonica	90
		Quercus hypoleucoides	60
A	*19*		
		Desmodium psilophyllum	10
		Muhlenbergia montana	8
		Piptochaetium pringlei	12
		Quercus arizonica	55
A	*20*		
		Lotus oroboides	5
		Muhlenbergia montana	52
		Quercus arizonica	40
B	*1*		
		Desmodium psilophyllum	8
		Pinus strobiformis	20
		Quercus gravesii	90
		Rock	40
B	*2*		
		Desmodium psilophyllum	6
		Muhlenbergia emersleyi	3
		Pinus strobiformis	10
		Quercus gravesii	80
		Viguiera cordifolia	3

97SW 026 Monitoring Plot cont.

Transect	Quadrat	Species	Cover
B	3		
		Muhlenbergia emersleyi	2
		Pinus strobiformis	10
		Piptochaetium pringlei	1
		Quercus gravesii	40
		Viguiera cordifolia	12
B	4		
		Pinus arizonica	20
		Piptochaetium pringlei	6
		Quercus gravesii	0.001
		Quercus hypoleucoides	50
B	5		
		Bromus ciliatus	1
		Moss	1
		Pinus arizonica	20
		Piptochaetium pringlei	1
		Quercus hypoleucoides	5
B	6		
		Pinus arizonica	50
		Quercus hypoleucoides	100
B	7		
		Artemisia ludoviciana	2
		Desmodium psilophyllum	1
		Pinus arizonica	30
		Piptochaetium pringlei	9
		Quercus gravesii	0.001
		Quercus hypoleucoides	20
		Rock	17
		Rubus idaeus	4
B	8		
		Quercus gravesii	100
		Viguiera cordifolia	15
B	9		
		Pinus arizonica	5
		Piptochaetium pringlei	3
		Quercus gravesii	100
		Stevia salicifolia	20
		Viguiera cordifolia	2
B	10		
		Pinus arizonica	10
		Pinus strobiformis	70
		Piptochaetium pringlei	11
		Quercus gravesii	80
		Viguiera cordifolia	7
B	11		
		Pinus arizonica	60
		Pinus strobiformis	60
		Piptochaetium pringlei	6
		Quercus gravesii	70

97SW 026 Monitoring Plot cont.

Transect	Quadrat	Species	Cover
B	12		
		Pinus arizonica	80
		Piptochaetium pringlei	1
		Quercus arizonica	30
		Quercus gravesii	40
		Rock	37
B	13		
		Pinus arizonica	60
		Piptochaetium pringlei	1
		Pseudotsuga menziesii	40
		Quercus arizonica	40
B	14		
		Desmodium psilophyllum	6
		Juniperus deppeana	20
		Pinus arizonica	90
		Piptochaetium pringlei	6
		Quercus arizonica	80
B	15		
		Juniperus deppeana	50
		Quercus arizonica	50
		Quercus hypoleucoides	65
		Rock	20
B	16		
		Juniperus deppeana	10
		Piptochaetium pringlei	14
		Quercus arizonica	50
		Quercus hypoleucoides	90
B	17		
		Lotus oroboides	6
		Quercus arizonica	20
		Quercus hypoleucoides	100
B	18		
		Desmodium psilophyllum	14
		Piptochaetium pringlei	17
		Quercus arizonica	90
		Quercus hypoleucoides	90
		Rock	10
B	19		
		Desmodium psilophyllum	3
		Piptochaetium pringlei	8
		Quercus arizonica	100
		Quercus hypoleucoides	100
B	20		
		Piptochaetium pringlei	3
		Quercus arizonica	90
		Quercus hypoleucoides	50

97SW027 Monitoring Plot Map Unit: Mixed Conifer Forest

GPS Coordinates: Northing 3206276 Easting 736010 taken in the general vicinity of the transects.

Directions: From 'El Cinco' Aserradero travel west. At crossroads where road turns towards southwest, go up ridge to southeast about 60 m on the northwest facing slope.

Transect Configuration: Two transects, 20m long, parallel to each other and approximately 7m apart, are oriented from west to east and read in that direction. Transect A is north of Transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Bromus ciliatus	1
		Bromus lanatipes	1
		Fragaria spp	1
		Oxalis spp.	3
		Pseudotsuga menziesii	100
		Viguiera cordifolia	12
A	*2*		
		Pseudotsuga menziesii	50
		Quercus hypoleucoides	50
A	*3*		
		Bromus ciliatus	1
		Frangula betulifolia ssp. betulifolia	30
		Pinus strobiformis	100
		Viguiera cordifolia	27
A	*4*		
		Annual	2
		Bromus lanatipes	6
		Cologania pallida	2
		Pinus strobiformis	100
		Piptochaetium pringlei	1
		Quercus hypoleucoides	5
A	*5*		
		Cologania pallida	2
		Pinus strobiformis	100
		Piptochaetium pringlei	4
		Rock	40
		Viguiera cordifolia	8
A	*6*		
		Abies coahuilensis	15
		Annual	1
		Bromus lanatipes	4
		Panicum bulbosum	8
		Pinus strobiformis	10
		Quercus hypoleucoides	0.001
		Salvia spp.	3

97SW 027 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*7*		
		Bromus lanatipes	16
		Piptochaetium pringlei	9
		Salvia spp.	27
		Senecio cardamine	25
A	*8*		
		Bromus lanatipes	8
		Piptochaetium pringlei	13
		Rock	5
		Salvia spp.	25
		Senecio cardamine	2
		Viguiera cordifolia	8
A	*9*		
		Bromus lanatipes	2
		Ipomoea spp.	2
		Pinus strobiformis	60
		Salvia spp.	10
		Senecio cardamine	50
A	*10*		
		Bromus lanatipes	8
		Cologania pallida	2
		Ipomoea spp.	2
		Pinus strobiformis	100
A	*11*		
		Bromus lanatipes	10
		Ipomoea spp.	12
		Pinus strobiformis	90
		Piptochaetium pringlei	10
		Quercus hypoleucoides	30
		Rosa woodsii	10
		Viguiera cordifolia	28
A	*12*		
		Bromus lanatipes	0.001
		Cologania pallida	6
		Ipomoea spp.	6
		Pinus strobiformis	100
		Vicia spp.	8
A	*13*		
		Pinus strobiformis	100
		Senecio cardamine	1
A	*14*		
		Bromus lanatipes	0.001
		Pinus strobiformis	90
		Piptochaetium pringlei	4
		Senecio cardamine	3
		Viguiera cordifolia	21

97SW 027 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*15*		
		Bromus lanatipes	6
		Cologania pallida	4
		Ipomoea spp.	8
		Pinus strobiformis	20
		Piptochaetium pringlei	5
		Quercus hypoleucoides	5
		Senecio cardamine	15
		Viguiera cordifolia	2
A	*16*		
		Bromus lanatipes	10
		Pinus strobiformis	10
		Quercus hypoleucoides	40
		Rosa woodsii	8
		Salvia spp.	8
		Senecio cardamine	90
A	*17*		
		Ipomoea spp.	4
		Quercus hypoleucoides	20
		Salvia spp.	3
		Senecio cardamine	3
A	*18*		
		Bromus ciliatus	4
		Frangula betulifolia ssp. betulifolia	3
		Ipomoea spp.	8
		Senecio cardamine	35
A	*19*		
		Bromus lanatipes	5
		Ipomoea spp.	15
		Senecio cardamine	5
A	*20*		
		Bromus lanatipes	4
		Galium spp.	4
		Viguiera cordifolia	25
B	*1*		
		Abies coahuilensis	40
		Moss	2
		Pinus strobiformis	40
		Viguiera cordifolia	27
B	*2*		
		Abies coahuilensis	90
		Bromus lanatipes	30
		Ipomoea spp.	8
		Pinus strobiformis	10
		Piptochaetium pringlei	2
		Senecio cardamine	2
		Viguiera cordifolia	11

97SW 027 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*3*		
		Abies coahuilensis	100
		Bromus lanatipes	8
		Ipomoea spp.	32
		Pinus strobiformis	5
		Salvia spp.	17
B	*4*		
		Abies coahuilensis	90
		Bromus lanatipes	9
		Frangula betulifolia ssp. betulifolia	2
		Ipomoea spp.	4
		Salvia spp.	14
		Senecio cardamine	30
B	*5*		
		Abies coahuilensis	60
		Bidens spp	2
		Bromus lanatipes	5
		Piptochaetium pringlei	1
		Senecio cardamine	45
		Viguiera cordifolia	3
B	*6*		
		Abies coahuilensis	100
		Bromus lanatipes	5
		Ipomoea spp.	3
		Piptochaetium pringlei	5
		Senecio cardamine	40
		Viguiera cordifolia	12
B	*7*		
		Abies coahuilensis	100
		Pinus strobiformis	50
		Piptochaetium pringlei	2
		Senecio cardamine	10
		Viguiera cordifolia	4
B	*8*		
		Abies coahuilensis	20
		Bromus lanatipes	5
		Fragaria spp	4
		Ipomoea spp.	10
		Pinus strobiformis	60
		Viguiera cordifolia	40
B	*9*		
		Abies coahuilensis	40
		Ipomoea spp.	40
		Pinus strobiformis	50
		Piptochaetium pringlei	3
		Senecio cardamine	14

97SW 027 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*10*		
		Ipomoea spp.	20
		Pinus strobiformis	70
		Pseudotsuga menziesii	70
B	*11*		
		Bidens spp	8
		Bromus lanatipes	0.001
		Ipomoea spp.	5
		Pinus strobiformis	5
		Salvia spp.	15
		Senecio cardamine	40
B	*12*		
		Annual	3
		Bidens spp	8
		Bromus lanatipes	2
		Fragaria spp	3
		Quercus hypoleucoides	3
		Salvia spp.	12
B	*13*		
		Bromus lanatipes	3
		Cologania pallida	5
		Geranium caespitosum	6
		Lichen	10
		Quercus hypoleucoides	80
		Salvia spp.	5
		Senecio cardamine	4
		Viguiera cordifolia	25
B	*14*		
		Annual	80
		Cologania pallida	5
		Moss	22
		Viguiera cordifolia	5

97SW 027 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*15*		
		Achillea millefolium var. occidentalis	2
		Annual	1
		Bidens spp	2
		Bromus lanatipes	1
		Cologania pallida	3
		Ipomoea spp.	25
		Rosa woodsii	13
		Salvia spp.	5
		Senecio cardamine	55
B	*16*		
		Bidens spp	11
		Bromus lanatipes	16
		Oxalis spp.	1
		Quercus hypoleucoides	30
		Salvia spp.	6
		Senecio cardamine	25
B	*17*		
		Bidens spp	2
		Lichen	3
		Quercus hypoleucoides	80
		Salvia spp.	4
		Viguiera cordifolia	70
B	*18*		
		Bidens spp	22
		Bromus lanatipes	2
		Cologania pallida	14
		Quercus hypoleucoides	70
		Salvia spp.	20
B	*19*		
		Bromus lanatipes	2
		Quercus hypoleucoides	100
		Rock	13
		Salvia spp.	13
		Viguiera cordifolia	45
B	*20*		
		Annual	1
		Koeleria macrantha	32
		Salvia spp.	12
		Viguiera cordifolia	15

97SW028 Monitoring Plot Map Unit: Oak Forest

GPS Coordinates: Northing 3208545 Easting 732173 taken at west stake of Transect A.

Directions: 1.3 miles south from main camp in Canon Moreno – plot is about 60 m uphill on east facing slope in an oak woodland.

Transect Configuration: Two transects, 20m long, parallel to each other and approximately 7m apart, are oriented from east to west and read in that direction. Transect A is north of Transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Muhlenbergia glauca	4
		Quercus hypoleucoides	80
		Rock	40
A	*2*		
		Muhlenbergia emersleyi	0.001
		Muhlenbergia glauca	4
		Quercus hypoleucoides	80
		Rock	25
		Salvia spp.	4
		Viguiera cordifolia	20
A	*3*		
		Muhlenbergia glauca	14
		Quercus hypoleucoides	50
		Quercus rugosa	50
		Rock	30
		Salvia spp.	1
A	*4*		
		Cheilanthes eatonii	4
		Muhlenbergia glauca	3
		Quercus rugosa	100
		Rock	25
		Salvia spp.	6
		Viguiera cordifolia	33
A	*5*		
		Quercus rugosa	100
A	*6*		
		Quercus rugosa	100
A	*7*		
		Quercus rugosa	100
A	*8*		
		Bromus lanatipes	0.001
		Moss	8
		Quercus rugosa	100
		Salvia spp.	12
A	*9*		
		Moss	6
		Piptochaetium pringlei	2
		Quercus hypoleucoides	10
		Quercus rugosa	20

97SW028 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*10*		
		Piptochaetium pringlei	8
		Quercus hypoleucoides	100
		Salvia spp.	18
A	*11*		
		Muhlenbergia glauca	8
		Piptochaetium pringlei	17
		Quercus rugosa	100
		Salvia spp.	6
A	*12*		
		Piptochaetium pringlei	0.001
		Quercus hypoleucoides	80
		Quercus rugosa	80
		Salvia spp.	7
A	*13*		
		Muhlenbergia glauca	8
		Quercus hypoleucoides	100
		Salvia spp.	6
A	*14*		
		Muhlenbergia glauca	2
		Quercus hypoleucoides	100
A	*15*		
		Muhlenbergia glauca	18
		Quercus hypoleucoides	90
		Quercus rugosa	20
		Rubus idaeus	13
		Salvia spp.	8
A	*16*		
		Muhlenbergia glauca	6
		Quercus hypoleucoides	100
		Quercus rugosa	90
A	*17*		
		Quercus hypoleucoides	100
		Quercus rugosa	40
A	*18*		
		Annual	1
		Moss	4
		Quercus hypoleucoides	60
		Rock	10
		Salvia spp.	3
A	*19*		
		Quercus hypoleucoides	50
		Rock	15
		Salvia spp.	7
A	*20*		
		Rock	20

97SW028 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*1*		
		Quercus hypoleucoides	100
		Quercus rugosa	100
B	*2*		
		Moss	4
		Quercus hypoleucoides	100
		Quercus rugosa	100
B	*3*		
		Quercus rugosa	100
B	*4*		
		Piptochaetium pringlei	0.001
		Quercus hypoleucoides	20
		Quercus rugosa	40
		Viguiera cordifolia	18
B	*5*		
		Piptochaetium pringlei	4
		Quercus hypoleucoides	100
		Quercus rugosa	100
		Rock	40
B	*6*		
		Quercus hypoleucoides	100
		Rock	25
B	*7*		
		Quercus hypoleucoides	100
		Salvia spp.	10
B	*8*		
		Ipomoea spp.	16
		Piptochaetium pringlei	37
B	*9*		
		Arbutus xalapensis	10
		Muhlenbergia emersleyi	15
		Quercus rugosa	30
		Solidago velutina	4
B	*10*		
		Quercus rugosa	100
		Rock	50
		Salvia spp.	3
		Viguiera cordifolia	3
B	*11*		
		Muhlenbergia glauca	3
		Quercus hypoleucoides	100
		Salvia spp.	15
B	*12*		
		Quercus hypoleucoides	100
		Rock	17
		Salvia spp.	13

97SW028 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*13*		
		Quercus hypoleucoides	70
		Rock	25
B	*14*		
		Quercus hypoleucoides	10
		Rock	13
B	*15*		
		Quercus hypoleucoides	6
		Rock	8
B	*16*		
		Moss	2
		Muhlenbergia glauca	3
		Quercus hypoleucoides	10
		Rock	45
B	*17*		
		Quercus rugosa	100
		Rock	5
B	*18*		
		Arbutus xalapensis	1
		Desmodium psilophyllum	10
		Quercus hypoleucoides	100
		Rock	30
		Salvia spp.	5
B	*19*		
		Cheilanthes eatonii	1
		Piptochaetium pringlei	13
		Quercus hypoleucoides	100
		Rock	30
		Salvia spp.	3
B	*20*		
		Piptochaetium pringlei	0.001
		Rock	16
		Salvia spp.	14

97SW029 Monitoring Plot Map Unit: Mixed Conifer Forest

GPS Coordinates: Northing 3205394 Easting 733605 taken in general vicinity of plot.

Directions: Approximately 150 meters downslope (north) of the radio repeater that is on the western face of the Sierra del Carmens

Transect Configuration: Two transects, 20m long, parallel to each other and approximately 7m apart, are oriented from west to east and read in that direction Transect A is north (uphill) of transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Pinus strobiformis	90
		Piptochaetium fimbriatum	2
		Rock	15
A	*2*		
		Pinus arizonica	5
		Piptochaetium fimbriatum	6
		Rock	8
A	*3*		
		Piptochaetium fimbriatum	0.001
		Piptochaetium pringlei	11
		Rock	18
A	*4*		
		Panicum bulbosum	20
		Piptochaetium pringlei	0.001
		Rock	75
A	*5*		
		Piptochaetium fimbriatum	10
		Rock	40
A	*6*		
		Achillea millefolium var. occidentalis	0.001
		Pinus strobiformis	10
		Piptochaetium fimbriatum	7
		Piptochaetium pringlei	32
		Quercus hypoleucoides	5
		Rock	8
A	*7*		
		Achillea millefolium var. occidentalis	0.001
		Panicum bulbosum	27
		Pinus strobiformis	20
		Piptochaetium fimbriatum	0.001
		Piptochaetium pringlei	15
		Rock	10
A	*8*		
		Abies coahuilensis	70
		Pinus strobiformis	15
		Piptochaetium fimbriatum	3
		Piptochaetium pringlei	3
		Rock	7

97SW029 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*9*		
		Abies coahuilensis	95
		Pinus strobiformis	90
		Rock	8
A	*10*		
		Abies coahuilensis	85
		Panicum bulbosum	2
		Pinus strobiformis	18
		Piptochaetium fimbriatum	1
		Rock	10
A	*11*		
		Abies coahuilensis	40
		Panicum bulbosum	1
		Piptochaetium fimbriatum	2
		Rock	2
A	*12*		
		Abies coahuilensis	30
		Pinus strobiformis	50
		Piptochaetium fimbriatum	0.001
		Rock	10
A	*13*		
		Abies coahuilensis	95
		Bromus polyanthus	0.001
		Pinus strobiformis	0.001
		Rock	20
A	*14*		
		Abies coahuilensis	80
		Pinus strobiformis	10
A	*15*		
		Abies coahuilensis	95
		Pinus strobiformis	65
		Piptochaetium fimbriatum	0.001
		Rock	40
A	*16*		
		Abies coahuilensis	0.001
		Pinus strobiformis	80
		Piptochaetium fimbriatum	12
		Rock	3
A	*17*		
		Piptochaetium fimbriatum	1
		Rock	20
A	*18*		
		Abies coahuilensis	45
		Piptochaetium fimbriatum	1
		Piptochaetium pringlei	0.001
		Rock	15

97SW029 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*19*		
		Abies coahuilensis	1
		Achillea millefolium var. occidentalis	0.001
		Muhlenbergia emersleyi	0.001
		Pinus arizonica	90
		Pinus strobiformis	95
A	*20*		
		Achillea millefolium var. occidentalis	1
		Pinus strobiformis	45
		Piptochaetium fimbriatum	10
		Rock	17
B	*1*		
		Abies coahuilensis	10
		Pinus strobiformis	70
		Rock	10
B	*2*		
		Abies coahuilensis	80
		Pinus strobiformis	5
		Rock	45
B	*3*		
		Pinus arizonica	95
B	*4*		
		Pinus arizonica	90
		Pinus strobiformis	80
		Piptochaetium pringlei	0.001
B	*5*		
		Pinus arizonica	90
		Pinus strobiformis	95
		Piptochaetium pringlei	0.001
		Rock	30
B	*6*		
		Panicum bulbosum	50
		Pinus strobiformis	80
B	*7*		
		Abies coahuilensis	0.001
		Panicum bulbosum	0.001
		Pinus strobiformis	80
		Piptochaetium fimbriatum	2
		Piptochaetium pringlei	1
		Rock	18
B	*8*		
		Bromus polyanthus	1
		Pinus arizonica	5
		Pinus strobiformis	10
		Rock	40

97SW029 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*9*		
		Pinus arizonica	60
		Pinus strobiformis	5
		Piptochaetium fimbriatum	3
		Rock	60
B	*10*		
		Pinus arizonica	90
		Pinus strobiformis	20
B	*11*		
		Pinus strobiformis	5
B	*12*		
		Rock	90
B	*13*		
		Piptochaetium fimbriatum	0.001
		Rock	80
B	*14*		
		Achillea millefolium var. occidentalis	1
		Pinus strobiformis	10
		Rock	90
B	*15*		
		Rock	100
B	*16*		
		Panicum bulbosum	13
		Rock	20
B	*17*		
		Abies coahuilensis	50
		Bromus ciliatus	1
		Piptochaetium fimbriatum	0.001
		Piptochaetium pringlei	40
		Rock	18
B	*18*		
		Bromus polyanthus	80
		Rock	95
B	*19*		
		Abies coahuilensis	95
		Bromus polyanthus	0.001
		Piptochaetium fimbriatum	0.001
B	*20*		
		Abies coahuilensis	95

97SW033 Monitoring Plot **Map Unit:** Creosotebush-Whitethorn Acacia Shrubland

GPS Coordinates: Northing 3193982 Easting 733803 taken at southeast stake of Transect B.

Directions: Go east from Pilares on airstrip road three miles. Plot is about 50 m off road to north.

Transect Configuration: Two transects, 20m long, parallel to each other and approximately 7m apart, are oriented from southeast to northwest and read in that direction Transect A is north of Transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Agave lechuguilla	12
		Jatropha dioica	5
		Parthenium incanum	20
		Rock	50
		Sida abutifolia	2
A	*2*		
		Agave lechuguilla	7
		Flourensia cernua	10
		Panicum hallii	3
		Rock	37
		Sida abutifolia	8
A	*3*		
		Parthenium incanum	40
		Rock	38
		Sida abutifolia	7
A	*4*		
		Flourensia cernua	18
		Parthenium incanum	40
		Rock	44
A	*5*		
		Parthenium incanum	10
		Rock	75
		Sida abutifolia	2
A	*6*		
		Larrea tridentata	5
		Parthenium incanum	45
		Rock	77
		Sida abutifolia	6
A	*7*		
		Jatropha dioica	70
		Rock	80
A	*8*		
		Jatropha dioica	30
		Panicum hallii	10
		Prosopis glandulosa	15
		Rock	57
		Sida abutifolia	8
A	*9*		
		Jatropha dioica	15
		Prosopis glandulosa	35

		Rock	35

97SW033 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	***10***		
		Rock	64
		Sida abutifolia	6
A	***11***		
		Larrea tridentata	5
		Parthenium incanum	40
		Rock	40
A	***12***		
		Larrea tridentata	35
		Rock	72
		Sida abutifolia	2
A	***13***		
		Parthenium incanum	17
		Rock	56
		Sida abutifolia	13
A	***14***		
		Panicum hallii	2
		Parthenium incanum	12
		Rock	81
		Sida abutifolia	6
A	***15***		
		Parthenium incanum	60
		Rock	72
		Sida abutifolia	15
A	***16***		
		Parthenium incanum	30
		Rock	90
A	***17***		
		Flourensia cernua	40
		Panicum hallii	3
		Rock	80
		Sida abutifolia	2
A	***18***		
		Parthenium incanum	50
		Rock	50
		Sida abutifolia	5
A	***19***		
		Erioneuron pulchellum	3
		Rock	79
		Sida abutifolia	10
A	***20***		
		Agave lechuguilla	40
		Jatropha dioica	22
		Parthenium incanum	3
		Rock	30
		Sida abutifolia	2

97SW033 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*1*		
		Agave lechuguilla	12
		Guajacum angustifolium	17
		Jatropha dioica	4
		Parthenium incanum	45
		Rock	45
		Sida abutifolia	10
B	*2*		
		Parthenium incanum	80
		Prosopis glandulosa	8
		Rock	64
		Sida abutifolia	8
B	*3*		
		Jatropha dioica	33
		Larrea tridentata	15
		Rock	59
		Sida abutifolia	10
B	*4*		
		Flourensia cernua	5
		Jatropha dioica	20
		Larrea tridentata	43
		Parthenium incanum	50
		Rock	79
		Sida abutifolia	8
B	*5*		
		Jatropha dioica	25
		Rock	87
B	*6*		
		Rock	88
		Sida abutifolia	2
B	*7*		
		Jatropha dioica	12
		Parthenium incanum	60
		Rock	47
		Sida abutifolia	10
B	*8*		
		Parthenium incanum	20
		Rock	78
		Sida abutifolia	5
B	*9*		
		Rock	93
B	*10*		
		Jatropha dioica	20
		Parthenium incanum	3
		Rock	89

97SW033 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*11*		
		Flourensia cernua	10
		Parthenium incanum	20
		Rock	79
		Sida abutifolia	6
B	*12*		
		Erioneuron pulchellum	3
		Jatropha dioica	13
		Rock	69
		Sida abutifolia	8
B	*13*		
		Jatropha dioica	8
		Rock	79
B	*14*		
		Jatropha dioica	20
		Parthenium incanum	15
		Rock	55
B	*15*		
		Larrea tridentata	65
		Rock	25
B	*16*		
		Rock	78
B	*17*		
		Rock	95
B	*18*		
		Parthenium incanum	2
		Rock	47
B	*19*		
		Guajacum angustifolium	15
		Rock	79
B	*20*		
		Larrea tridentata	17
		Rock	64
		Sida abutifolia	2

97SW044 Monitoring Plot Map Unit: Juniper and Oak Savannah

GPS Coordinates: Northing 3198047 Easting 741187 taken at the west stake of Transect A.

Directions: Take trail from Cañon San Isidro to north end of Mesa Los Fresnos. Plot is on top of mesa, near the north end and about 40 m northwest of trail.

Transect Configuration: Two transects, 20m long, approximately parallel to each other and 7 m apart, oriented east to west and read in that direction. Transect A is north of transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Bouteloua curtipendula	37
		Linum schiedeanum	5
		Rock	15
A	*2*		
		Bouteloua curtipendula	30
		Rock	5
		Stipa tenuissima	7
		Verbena neomexicana var. neomexicana	3
A	*3*		
		Bouteloua curtipendula	73
		Notholaena aschenborniana	7
		Rock	5
		Stipa tenuissima	8
		Verbena neomexicana var. neomexicana	2
A	*4*		
		Bouteloua curtipendula	30
		Linum schiedeanum	8
		Rock	25
		Stipa tenuissima	2
A	*5*		
		Bouteloua curtipendula	56
		Calliandra humilis	2
		Lotus oroboides	12
A	*6*		
		Bouteloua curtipendula	25
		Linum schiedeanum	7
		Lotus oroboides	30
		Rock	26
A	*7*		
		Bouteloua curtipendula	30
		Lotus oroboides	20
		Rock	40
A	*8*		
		Bouteloua curtipendula	33
		Lotus oroboides	22
		Rock	25
A	*9*		
		Bouteloua curtipendula	17
		Lotus oroboides	35
		Rock	33

97SW044 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*10*		
		Bouteloua curtipendula	10
		Bouteloua gracilis	8
		Linum schiedeanum	4
		Lotus oroboides	33
		Rock	37
A	*11*		
		Bouteloua curtipendula	57
		Lotus oroboides	2
		Notholaena aschenborniana	2
		Oxalis spp.	1
		Rock	21
		Stipa tenuissima	5
		Verbena neomexicana var. neomexicana	5
A	*12*		
		Bouteloua curtipendula	84
		Lotus oroboides	1
		Rock	5
A	*13*		
		Bothriochloa barbinodis	8
		Bouteloua curtipendula	3
		Linum schiedeanum	5
		Lotus oroboides	3
		Muhlenbergia emersleyi	37
A	*14*		
		Bouteloua gracilis	33
		Lycurus setosus	14
		Rock	38
A	*15*		
		Bouteloua curtipendula	12
		Bouteloua gracilis	17
		Gaura spp.	1
		Lotus oroboides	32
		Rock	25
A	*16*		
		Bouteloua curtipendula	48
		Eragrostis intermedia	12
		Lotus oroboides	14
		Rock	13
A	*17*		
		Bouteloua curtipendula	55
		Calliandra humilis	1
		Eragrostis intermedia	6
		Lotus oroboides	7
		Rock	20

97SW044 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
A	*18*		
		Bouteloua curtipendula	50
		Linum schiedeanum	1
		Lotus oroboides	20
		Lycurus setosus	4
		Rock	25
A	*19*		
		Bouteloua curtipendula	60
		Oxalis spp.	2
		Rock	20
		Selaginella lepidophylla	1
A	*20*		
		Bouteloua curtipendula	40
		Bouteloua gracilis	23
		Lotus oroboides	6
		Rock	24
B	*1*		
		Bouteloua gracilis	22
		Calliandra humilis	2
		Lotus oroboides	15
		Muhlenbergia emersleyi	11
		Rock	30
		Verbena neomexicana var. neomexicana	1
B	*2*		
		Bouteloua curtipendula	40
		Lotus oroboides	30
		Rock	5
		Verbena neomexicana var. neomexicana	8
B	*3*		
		Bouteloua gracilis	8
		Gaura spp.	5
		Linum schiedeanum	7
		Lotus oroboides	12
		Muhlenbergia emersleyi	12
		Rock	8
		Schizachyrium neomexicanum	20
		Verbena neomexicana var. neomexicana	2
B	*4*		
		Lotus oroboides	2
		Muhlenbergia emersleyi	25
		Polygala alba	6
		Quercus arizonica	80
		Rock	17
		Stipa tenuissima	35

97SW044 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*5*		
		Bommeria hispida	4
		Cirsium spp.	5
		Muhlenbergia emersleyi	32
		Notholaena aschenborniana	5
		Quercus arizonica	1
		Rock	25
		Stipa tenuissima	14
B	*6*		
		Bouteloua curtipendula	7
		Notholaena aschenborniana	2
		Polygala alba	8
		Stipa tenuissima	43
		Tragia amblyodonta	3
		Verbena neomexicana var. neomexicana	6
B	*7*		
		Bidens spp	1
		Linum schiedeanum	1
		Muhlenbergia emersleyi	11
		Quercus arizonica	90
		Rock	10
		Stipa tenuissima	323
		Verbena neomexicana var. neomexicana	2
B	*8*		
		Achillea millefolium var. occidentalis	1
		Muhlenbergia emersleyi	20
		Notholaena aschenborniana	6
		Quercus arizonica	100
		Rock	15
		Tragia amblyodonta	10
B	*9*		
		Bouteloua curtipendula	8
		Eragrostis intermedia	23
		Linum schiedeanum	5
		Opuntia engelmannii	27
		Quercus arizonica	90
		Rock	5
B	*10*		
		Bouteloua curtipendula	10
		Bouteloua gracilis	13
		Lotus oroboides	4
		Quercus arizonica	50
		Stipa tenuissima	5

97SW044 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*11*		
		Bidens spp	4
		Bouteloua curtipendula	12
		Bouteloua gracilis	3
		Muhlenbergia emersleyi	12
		Notholaena aschenborniana	10
		Rock	20
B	*12*		
		Bouteloua curtipendula	5
		Calliandra humilis	1
		Muhlenbergia emersleyi	7
		Rock	47
B	*13*		
		Bouteloua curtipendula	25
		Hedeoma spp.	8
		Muhlenbergia emersleyi	7
		Rock	40
		Tragia amblyodonta	3
B	*14*		
		Bouteloua curtipendula	17
		Bouteloua gracilis	12
		Muhlenbergia emersleyi	47
		Quercus arizonica	100
		Verbena neomexicana var. neomexicana	2
B	*15*		
		Bouteloua gracilis	30
		Muhlenbergia emersleyi	22
		Quercus arizonica	100
B	*16*		
		Bouteloua curtipendula	10
		Bouteloua gracilis	8
		Eragrostis intermedia	11
		Muhlenbergia emersleyi	22
		Quercus arizonica	100
B	*17*		
		Bouteloua gracilis	13
		Quercus arizonica	100
		Stipa tenuissima	57
B	*18*		
		Bouteloua gracilis	20
		Muhlenbergia emersleyi	10
		Quercus arizonica	100
		Stipa tenuissima	35

97SW044 Monitoring Plot cont.

Transect	*Quadrat*	*Species*	*Cover*
B	*19*		
		Bouteloua gracilis	10
		Koeleria macrantha	6
		Muhlenbergia emersleyi	6
		Piptochaetium fimbriatum	16
		Quercus arizonica	100
B	*20*		
		Muhlenbergia emersleyi	7
		Opuntia engelmannii	6
		Piptochaetium fimbriatum	14
		Quercus arizonica	100
		Stipa tenuissima	13

97SW045 Monitoring Plot Map Unit: Mesa Grassland

GPS Coordinates: Northing 3197299 Easting 741064 taken at east stake of Transect A.

Directions: Take trail from Cañon San Isidro to north end of Mesa Los Fresnos. Plot is in oak savannah just before the grassy mesa top, south of second saddle, and off trail about 20 m (short distance as trail is infrequently used).

Transect Configuration: Two transects, 20m long, approximately 7m apart and parallel to each other, arranged in a west-east configuration and read in that direction (uphill). Transect A is north of Transect B.

Transect	*Quadrat*	*Species*	*Cover*
A	*1*		
		Bouteloua gracilis	30
		Lycurus setosus	35
		Stipa tenuissima	35
A	*2*		
		Bouteloua gracilis	5
		Opuntia engelmannii	5
		Stipa tenuissima	65
A	*3*		
		Amphiachryis dracunculoides	12
		Bouteloua gracilis	55
A	*4*		
		Bouteloua gracilis	65
		Grindelia spp.	8
		Oxalis corniculata	2
A	*5*		
		Bouteloua gracilis	25
		Oxalis corniculata	6
		Stipa tenuissima	60
A	*6*		
		Bouteloua gracilis	78
		Gaura calcicola	2
A	*7*		
		Aristida divaricata	70
		Bouteloua gracilis	15
A	*8*		
		Aristida divaricata	15
		Bouteloua gracilis	53
		Grindelia spp.	2
		Rock	17
A	*9*		
		Aristida divaricata	70
		Oxalis corniculata	1
		Oxytropis spp	2
		Rock	3
		Stipa tenuissima	4

Transect	*Quadrat*	*Species*	*Cover*
A	*10*		

		Aristida divaricata	10
		Bothriochloa barbinodis	2
		Bouteloua gracilis	20
		Lycurus setosus	40
		Oxalis corniculata	1
		Rock	3
A	***11***		
		Aristida divaricata	50
		Bothriochloa barbinodis	10
		Grindelia spp.	2
		Lycurus setosus	20
		Rock	10
A	***12***		
		Bothriochloa barbinodis	8
		Bouteloua gracilis	45
		Grindelia spp.	2
		Lycurus setosus	12
		Oxalis corniculata	1
		Oxytropis spp	7
		Rock	10
A	***13***		
		Aristida divaricata	10
		Bouteloua gracilis	10
		Oxalis corniculata	13
		Rock	6
		Stipa tenuissima	55
A	***14***		
		Gnaphalium pringlei	5
		Oxalis corniculata	2
		Stipa tenuissima	68
A	***15***		
		Stipa tenuissima	40
A	***16***		
		Stipa tenuissima	100
A	***17***		
		Stipa tenuissima	40
A	***18***		
		Calliandra humilis	2
		Stipa tenuissima	35
A	***19***		
		Stipa tenuissima	63
A	***20***		
		Stipa tenuissima	80

Transect	***Quadrat***	***Species***	***Cover***
B	***1***		

		Bouteloua gracilis	18
		Stipa tenuissima	80
B	*2*		
		Bothriochloa barbinodis	5
		Bouteloua gracilis	20
		Grindelia spp.	5
		Stipa tenuissima	65
B	*3*		
		Aristida divaricata	60
		Bouteloua gracilis	20
		Gnaphalium pringlei	1
		Oxalis corniculata	2
		Stipa tenuissima	10
B	*4*		
		Bouteloua gracilis	20
		Stipa tenuissima	65
B	*5*		
		Amphiachryis dracunculoides	3
		Aristida divaricata	10
		Bouteloua gracilis	23
		Grindelia spp.	8
		Stipa tenuissima	45
B	*6*		
		Bouteloua gracilis	49
		Gnaphalium pringlei	1
		Stipa tenuissima	50
B	*7*		
		Bouteloua gracilis	10
		Stipa tenuissima	70
B	*8*		
		Aristida divaricata	64
		Bothriochloa barbinodis	12
		Oxalis corniculata	1
		Stipa tenuissima	8
B	*9*		
		Aristida divaricata	35
		Bothriochloa barbinodis	50
		Carex spp.	2
		Grindelia spp.	10
B	*10*		
		Aristida divaricata	58
		Bothriochloa barbinodis	3
		Rock	15
B	*11*		
		Aristida divaricata	42
		Bothriochloa barbinodis	13
		Bouteloua gracilis	17
		Rock	5
Transect	***Quadrat***	***Species***	***Cover***
B	*12*		
		Aristida divaricata	8

		Bothriochloa barbinodis	7
		Bouteloua gracilis	37
		Oxalis corniculata	5
		Rock	28
B	***13***		
		Aristida divaricata	43
		Bouteloua gracilis	8
		Bouteloua hirsuta	3
		Oxalis corniculata	3
		Rock	33
		Stipa tenuissima	5
B	***14***		
		Aristida divaricata	25
		Bouteloua gracilis	10
		Rock	8
		Stipa tenuissima	53
B	***15***		
		Bouteloua gracilis	50
		Oxalis corniculata	1
		Rock	2
		Stipa tenuissima	25
B	***16***		
		Bouteloua gracilis	5
		Stipa tenuissima	70
B	***17***		
		Amphiachryis dracunculoides	5
		Aristida divaricata	23
		Bouteloua gracilis	40
		Rock	17
		Stipa tenuissima	3
B	***18***		
		Amphiachryis dracunculoides	2
		Aristida divaricata	87
		Oxalis corniculata	1
		Oxytropis spp	0.001
B	***19***		
		Aristida divaricata	57
		Bothriochloa barbinodis	1
		Gaura calcicola	2
		Oxalis corniculata	1
		Rock	1
		Stipa tenuissima	32
B	***20***		
		Aristida divaricata	56
		Bothriochloa barbinodis	6
		Bouteloua gracilis	5
		Lycurus setosus	18

Appendix E: Reference Plots for Map Units

Plots that were used to seed or included in each map unit are referenced here. Full descriptions of the map units can be found in Appendix D.

Map Unit 1: Mixed Conifer Forest

97GC002	97GC045	97GC144	97SW014
97GC018	97GC130	97GC145	97SW015
97GC031	97GC133	97GC146	97SW022
97GC032	97GC139	97GC150	97SW027
97GC035	97GC140	97GC151	97SW029
97GC037	97GC141	97GC156	
97GC038	97GC142	97GC157	
97GC039	97GC143	97SW013	

Map Unit 2: Mesa-Pine Forest

97GC001	97GC019	97SW020
97GC003	97GC036	97SW021
97GC004	97SW002	
97GC005		

Map Unit 3: Pine-Oak Forest

97GC016	97GC090	97SW007
97GC017	97GC129	97SW016
97GC020	97GC134	97SW018
97GC021	97GC135	97SW023
97GC028	97GC137	97SW068
97GC030	97GC149	97SW137
97GC043	97GC154	

Map Unit 4: Oak Forest

97GC013	97GC114	97GC160	97SW026
97GC014	97GC115	97GC170	97SW028
97GC023	97GC131	97GC171	97SW057
97GC027	97GC138	97SW006	97SW117
97GC042	97GC158	97SW017	
97GC058			

Map Unit 5: Pinon-Juniper Woodland

97GC006	97GC094	97GC164	97SW043
97GC007	97GC116	97GC193	97SW048
97GC008	97GC117	97GC195	97SW069
97GC009	97GC118	97SW004	97SW100
97GC012	97GC119	97SW011	97SW126
97GC024	97GC120	97SW019	
97GC026	97GC123	97SW025	

Map Unit 6: Juniper-Oak Savannah

97GC011	97GC194	97SW044	97SW136
97GC055	97SW031	97SW067	97SW156
97GC091	97SW039	97SW078	
97GC125	97SW042	97SW120	

Map Unit 7: Oak Woodland

97GC010	97GC112	97GC162	97SW030
97GC029	97GC122	97GC163	97SW032
97GC034	97GC126	97GC169	97SW049
97GC040	97GC127	97GC173	97SW050
97GC041	97GC136	97GC174	97SW066
97GC046	97GC147	97GC192	97SW083
97GC056	97GC148	97GC214	97SW090
97GC060	97GC152	97SW001	97SW101
97GC086	97GC153	97SW003	97SW131
97GC088	97GC155	97SW008	
97GC089	97GC159	97SW012	

Map Unit 8: Montane Shrubland

97GC015	97GC109	97GC215	97SW093
97GC022	97GC111	97SW005	97SW094
97GC033	97GC121	97SW024	97SW095
97GC057	97GC128	97SW041	97SW096
97GC079	97GC184	97SW047	97SW124
97GC080	97GC185	97SW058	98SW012
97GC095	97GC196	97SW074	
97GC100	97GC200	97SW084	

Map Unit 9: Mesa Grassland

97GC059	97GC176	97SW097
97GC061	97SW040	97SW140
97GC172	97SW045	
97GC175	97SW077	

Map Unit 10: Foothill Grassland

97GC069
97GC107
97GC113
97GC187
97GC203
97GC211
97GC213
97SW062
97SW064
97SW091
97SW146
97SW150
97SW151

Map Unit 11: Sotol Yucca Grassland

97GC052
97GC064
97GC065
97GC066
97GC068
97GC072
97GC078
97GC081
97GC082
97GC083
97GC084
97GC085
97GC087
97GC093
97GC104
97GC106
97GC108
97GC110
97GC161
97GC178
97GC179
97GC186
97GC188
97GC189
97GC190
97GC191
97GC197
97SW009
97SW010
97SW036
97SW046
97SW054
97SW059
97SW061
97SW073
97SW075
97SW076
97SW082
97SW089
97SW098
97SW099
97SW121
97SW123
97SW125
97SW134
97SW141
97SW154
98GC006
98GC012
98GC014
98GC016
98GC021
98GC023
98GC024
98GC027

Map Unit 12: Honey Mesquite Grassland

97GC103
97GC202
97GC204
97GC205
97SW063
97SW070
97SW079
97SW092
97SW127
97SW135
98GC004

Map Unit 13: Creosote-Acacia Shrubland

97GC062	97GC181	97SW081	98GC010
97GC067	97GC183	97SW087	98GC017
97GC070	97GC198	97SW088	98GC019
97GC073	97GC206	97SW128	98GC020
97GC076	97GC208	97SW145	98GC022
97GC096	97GC209	98GC002	98GC025
97GC098	97GC210	98GC003	98GC026
97GC105	97SW033	98GC007	98GC029
97GC177	97SW065	98GC008	98SW024
97GC180	97SW071	98GC009	

Map Unit 14: Mimosa Honey Mesquite Shrubland

97GC025	97GC168	97SW056	97SW133
97GC054	97GC199	97SW060	97SW139
97GC092	97GC201	97SW080	97SW142
97GC099	97GC207	97SW086	97SW143
97GC101	97GC212	97SW129	97SW147
97GC102	97SW055	97SW130	
97GC132			

Map Unit 15: Succulent Desert Shrubland

97GC047	97GC074	97SW035	98GC001
97GC048	97GC075	97SW037	98GC005
97GC049	97GC077	97SW038	98GC011
97GC050	97GC097	97SW051	98GC015
97GC051	97GC165	97SW052	98GC018
97GC053	97GC166	97SW053	98SW002
97GC063	97GC182	97SW072	98SW029
97GC071	97SW034	97SW085	