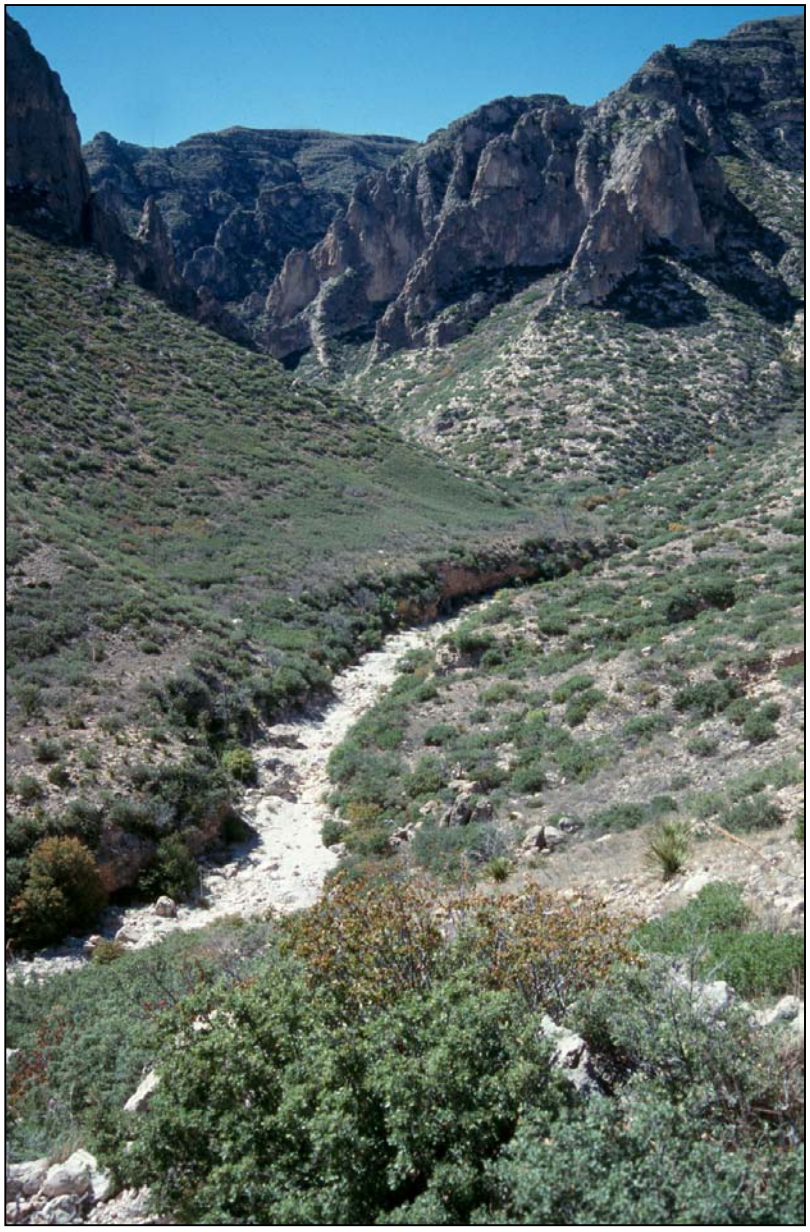
A Vegetation Map of Carlsbad Caverns National Park, New Mexico



New Mexico Natural Heritage Program

The University of New Mexico

2003

A Vegetation Map of Carlsbad Caverns National Park, New Mexico [1]

Esteban Muldavin, Paul Neville, Paul Arbetan, Yvonne Chauvin, Amanda Browder, and Teri Neville[2]

ABSTRACT

A vegetation classification and high resolution vegetation map was developed for Carlsbad Caverns National Park, New Mexico to support natural resources management, particularly fire management and rare species habitat analysis. The classification and map were based on 400 field plots collected between 1999 and 2002. The vegetation communities of Carlsbad Caverns NP are diverse. They range from desert shrublands and semi-grasslands of the lowland basins and foothills up through montane grasslands, shrublands, and woodlands of the highest elevations. Using various multivariate statistical tools, we identified 85 plant associations for the park, many of them unique in the Southwest. The vegetation map was developed using a combination of automated digital processing (supervised classifications) and direct image interpretation of high-resolution satellite imagery (Landsat Thematic Mapper and IKONOS). The map is composed of 34 map units derived from the vegetation classification, and is designed to facilitate ecologically based natural resources management at a 1:24,000 scale with 0.5 ha minimum map unit size (NPS national standard). Along with an overview of the vegetation ecology of the park in the context of the classification, descriptions of the composition and distribution of each map unit are provided. The map was delivered both in hard copy and in digital form as part of a geographic information system (GIS) compatible with that used in the park. The GIS allows flexibility to update the map as new information becomes available or as major vegetation changes occur in the park, such as fire or other impacts.

[1] Final report submitted in June, 2003 in partial fulfillment of Coop Agreement No. Ca-7170-99-004 between the New Mexico Natural Heritage Program (Natural Heritage New Mexico) at the University of New of New Mexico and Carlsbad Caverns National Park.

[2] Esteban Muldavin (Senior Ecologist), Paul Arbetan (Ecologist), Yvonne Chauvin (Botanist), Amanda Browder (Ecological Technician), and Teri Neville (GIS Specialist) are with the New Mexico Natural Heritage Program of the Museum of Southwestern Biology at the University of New Mexico (UNM); Paul Neville is with the Earth Data Analysis Center (EDAC) at UNM.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Carlsbad Caverns National Park not only harbors world-renowned caves, it also supports on its surface one of the more complex and unique ecosystems in the arid Southwest. The same unusual Permian limestone reefs that house the caverns give rise to diverse vegetation communities that provide habitat and forage for a plethora of w wildlife. Accordingly, National Park Service has sought to manage these surface resources with the same care and attention as that given to those below ground. Along with comprehensive biological inventories and monitoring, a key to effective management is the development of a high-resolution vegetation map that can support such activities as flora and fauna habitat modeling, recreation planning, fire management, and broad scale facilities planning.

To meet this objective, the New Mexico Natural Heritage Program (NMNHP), in cooperation with the staff at Carlsbad Caverns National Park (CCNP), set out to develop a vegetation map that meets or exceeds National Park Service standards[3] (1:24,000 scale and 0.5 ha minimum map unit size). The map was based on high-resolution satellite imagery and extensive ground sampling. Beginning in the fall of 1999, we conducted surveys of the vegetation communities throughout the park and developed a preliminary vegetation classification for use in the vegetation mapping process (and that could be used in future long-term ecological monitoring and biological surveys). Then, using the vegetation classification and associated ground control points, we generated a vegetation map at the 1:12,000 scale using a combination of automated image analysis and direct image interpretation of satellite imagery (Landsat Thematic Mapper and IKONOS). Map units were designed to support ecologically based natural resources management with an emphasis on uses in fire management and rare species habitat analysis.

We provide here the details on how the map was constructed, an overview of the classification and ecology of the vegetation communities of the park, and the vegetation map itself with associated map unit descriptions. The map is presented in both paper form and digitally as part of a geographic information system (GIS) compatible with that used in the park. The GIS allows flexibility to update the map as new information becomes available or as major vegetation changes that occur in the park as a result of fire or other impacts.

ACKNOWLEDGEMENTS

This project was supported through funds provided by Carlsbad Caverns National Park, Division of Resources, Stewardship and Management, and the New Mexico Natural Heritage Program at the University of New Mexico. Steven Yanoff, Elizabeth Milford, Jackie Smith, Dena Odell contributed to the fieldwork efforts; Rebecca Keeshen provided editorial review. Cover photo: mouth of Double Canyon by Paul Arbetan .

[3] See http://biology.usgs.gov/npsveg/standards.html

STUDY AREA

Location and history

Carlsbad Caverns National Park (NP) is located in Eddy County in southeastern New Mexico, about 20 Miles (32 km) southwest of Carlsbad, NM and 150 miles (241 km) east of El Paso, Texas (Figure 1). The main park entrance near White's city is accessible from U.S. Highway 62-180.

.

President Calvin Coolidge established Carlsbad Caverns National Monument on October 15, 1923 (presidential proclamation No. 1679), under the provisions of the Antiquities Act (34 Stat. 225; June 8, 1906), to protect scenic Carlsbad Cave. Additional public lands were withdrawn by executive order on April 2, (1924 (No. 3984) and May 3, 1928 (No. 4870) for consideration for future national park status. On May 14, 1930, Congress established Carlsbad Caverns National Park (46 Stat. 279). The park was enlarged by executive order on June 17, 1930 (No. 5370), 1933, and 1939. In 1963, boundary adjustments were authorized to acquire Rattlesnake Springs (77 Stat. 818) and in 1978, Congress designated 71% of the park's surface area as Wilderness. Carlsbad Caverns NP was designated as a World Heritage Site in 1995, for protection of "physical and biological formations and groups, which are of universal world-wide value and interest."

The park is currently 46,766 acres (19,926 ha), of which 33,125 acres (13,406 ha) are wilderness backcountry with little water. Primarily Bureau of Land Management lands lie along the boundary of the park except for US Forest Service land along the west side. There are also smaller private and state properties adjacent to the park, particularly along the southern boundary. Adjacent use is a mix of cattle ranching, oil and gas development, and irrigated agriculture.

Climate

The climate of Carlsbad Caverns NP is semi-arid with an average rainfall of 14.91 in (378.7 mm) and a mean annual temperature of 64.4°F (16.8°C). The majority of the precipitation (71%) falls during the summer "monsoon" rainy season (May through September), primarily derived from frontal storms off the Gulf of Mexico and to a limited degree the Gulf of California (Table 1). The remainder of precipitation comes in the form of rain and snow from storms out of the west (Figure 2). Seasonal temperature ranges can be extreme (Table 2), with daily fluxes of 30°F (16.8°C) or more (Figure 3). This, in combination with low rainfall, generates a semi-arid, continental climate throughout most of the park.

Landscape, Geology and Soils

The main physical feature of the park is the Guadalupe escarpment that extends from El Capitan in Guadalupe Mountains NP, 30 miles to the west, eastward to just past the Carlsbad Caverns NP entrance. The escarpment forms a face of the Guadalupe Mountains range that rises out of the desert floor at about 3,595 ft (1,095 m) in the southeastern part of the park and climbs gradually to a maximum elevation of 6,520 ft (1,987 m) along Guadalupe Ridge in the

northwestern corner. The mountains are cut by several deep canyon drainages that trend radically east to west, or north to south. Elevations can drop as much as 1,500 ft (450 m) in one half mile with a combination of cliffs and very steep slopes that commonly exceed >50%. This rugged terrain is particularly prevalent in the central and western portions of the park (Rattlesnake, Slaughter and Double Canyon drainages).

The geology of the park is dominated by the various limestone and dolomite formations that were part of a Permian age reef complex that was later uplifted and tilted upward from east to west to make the Guadalupe Mountains (Brand and Jacka 1979). The stratigraphy of the formations has been described in detail by Hayes (1964) and has a significant effect on vegetation patterns. In summary, the escarpment is primarily made up of the Capitan Limestone (Pcm & Pcb), which also houses the caverns of the park's fame (Figure 4). Moving away and north from the escarpment, the Capitan grades to, or is overlain by, the Seven Rivers (Pse & Psc), Yates (Pya), and Tansil (Pt) formations (Figure 5). The Tansil is prevalent in the south-central and eastern portions of the park as a dolomitic "cap rock" over the Capitan Limestone

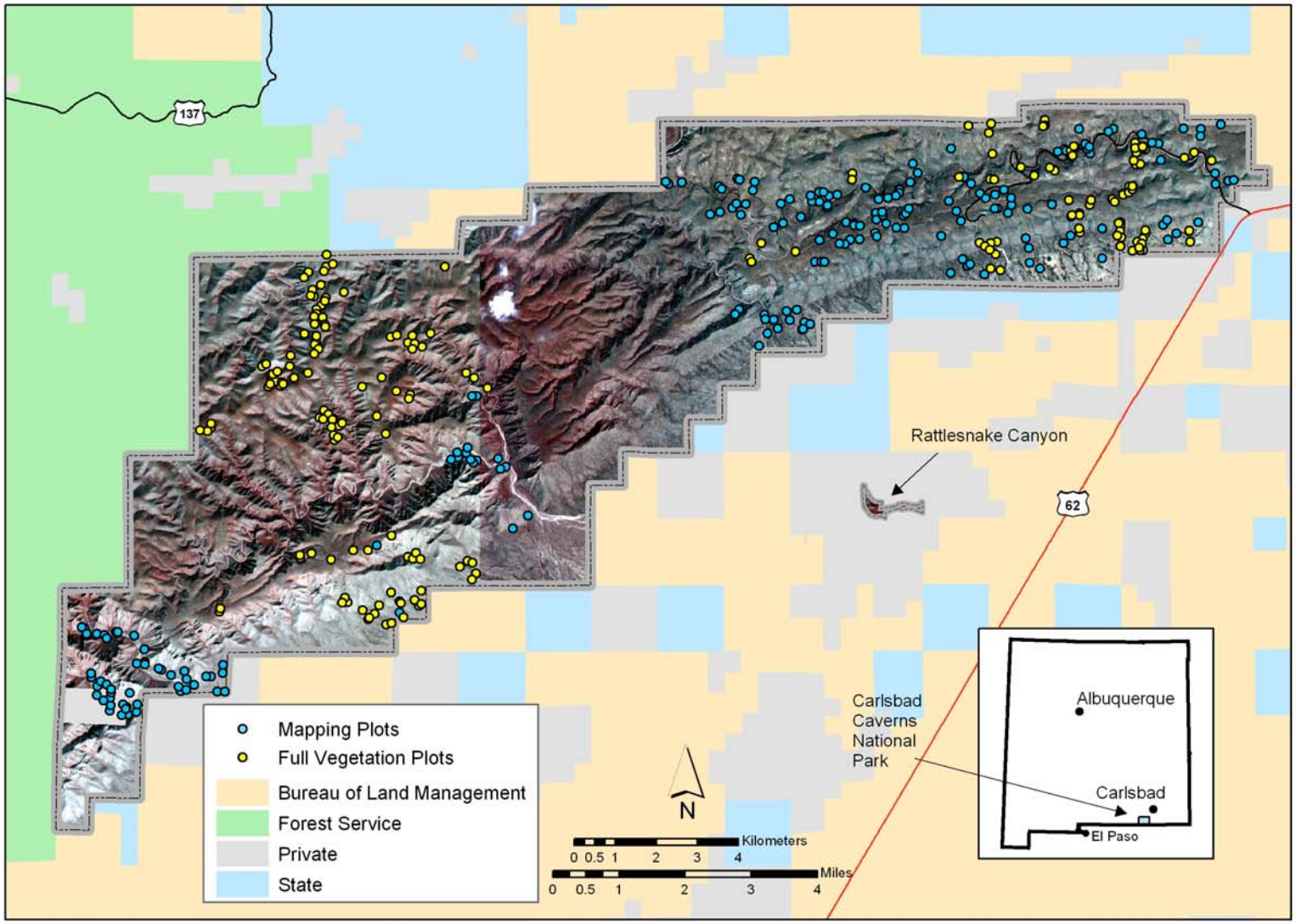


Figure 1. Carlsbad Caverns National Park vegetation map study area. Background is IKONOS satellite imagery from August 27, 2000 (east half) and September 29, 2000 (west half). Also shown is the distribution of standard vegetation and mapping plots.

Table 1. Seasonal temperature summary for Carlsbad Caverns National Park, NM from New Mexico from 1930 to 2000 at 4,441 ft (source: Western Regional Climate Center web page http://www.wrcc.dri.edu/).

	Max.	Min.	Mean	High	Date	Low	Date	Highest Mean	Year	Lowest Mean	Year	>= 90 F	<= 32 F	<= 32 F	<= 0 F
	F	F	F	F	dd/yyyy or yyyymmdd	F	dd/yyyy or yyyymmdd	F	-	F	-	# Days	# Days	# Days	
Annual	74.4	50.4	62.4	110	19940628	-4	19620111	65.6	50	59.9	79	71.0	3.7	47.0	0.1
Winter	58.2	35.1	46.6	84	19890226	-4	19620111	52.1	50	41.1	79	0.0	3.3	34.8	0.1
Spring	75.2	49.6	62.4	106	20000525	10	19480311	67.3	67	57.8	87	7.5	0.2	6.4	0.0
Summer	90.2	65.4	77.8	110	19940628	41	19640624	81.9	94	74.6	79	55.4	0.0	0.0	0.0
Fall	74.2	51.4	62.8	100	19480906	8	19761128	66.5	54	56.7	76	8.1	0.2	5.8	0.0

Table 2. Seasonal precipitation summary for Carlsbad Caverns National Park, NM from New Mexico from 1930 to 2000 at 4,441 ft (source: Western Regional Climate Center web page http://www.wrcc.dri.edu/).

	Precipitation										Total Snowfall			
	Mean	High	Year	Low	Year	1 Day Max.	>= 0.01 in.	>= 0.10 in.	>= 0.50 in.	>= 1.00 in.	Mean	High	Year	Mean
	in.	in.	-	in.	-	in.	dd/yyyy or yyyymmdd	# Days	# Days	# Days	# Days	in.	in.	-
Annual	14.91	43.23	41	4.47	51	8.41	19860624	55	30	9	3	5.4	25.3	87
Winter	1.43	4.50	32	0.08	67	1.20	19680121	9	4	1	0	4.2	26.0	88
Spring	2.45	16.28	41	0.17	100	4.55	19540425	11	6	1	0	0.8	9.5	69
Summer	6.18	19.61	86	1.36	51	8.41	19860624	20	12	4	1	0.0	0.0	48
Fall	4.85	15.52	41	0.25	56	5.63	19800926	15	8	3	1	0.5	12.0	76

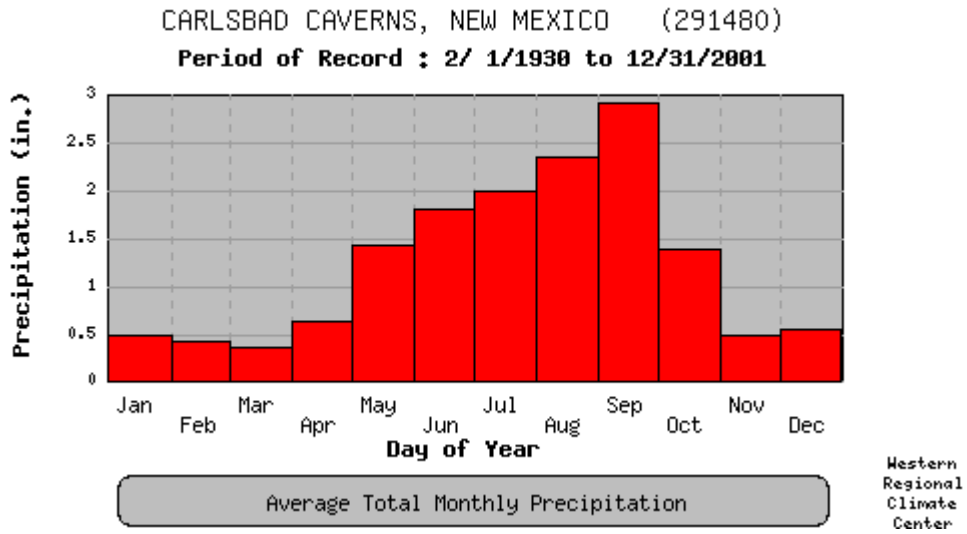


Figure 2. Monthly average precipitation at Carlsbad Caverns National Park over the period of record (station 291480). Source: Western Regional Climate Center at http://www.wrcc.dri.edu/.

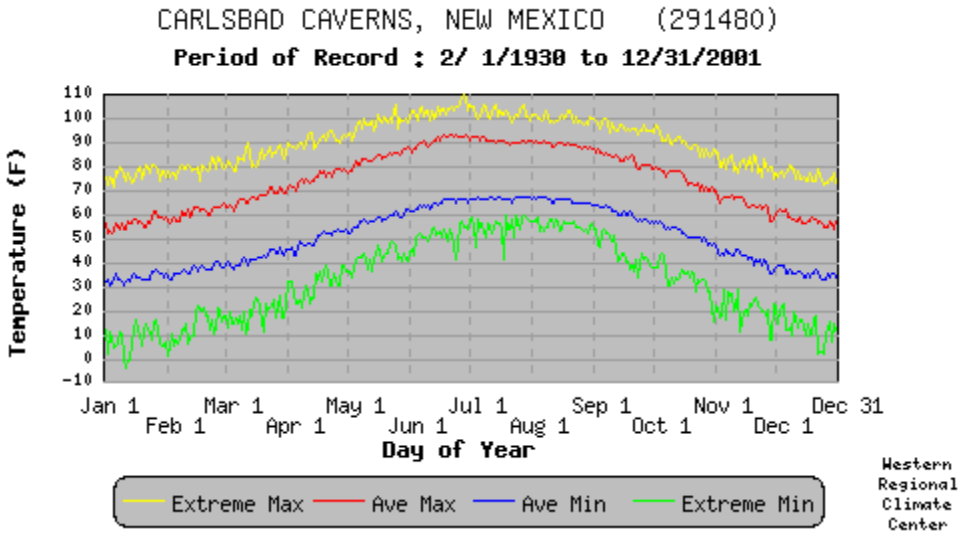


Figure 3. Daily mean temperatures at Carlsbad Caverns National Park over the period of record (station 291480). Source: Western Regional Climate Center at http://www.wrcc.dri.edu/.

and Yates formation. The nearly horizontal contact between the Tansil and the Yates is particularly recognizable because of the development of conspicuous horizontal banding of more mesic vegetation along canyon slopes driven the accumulation of moisture and occasional springs along the contact. In addition to dolomite, the Yates contains significant amounts of siltstone and sandstone beds that weather to slopes between the dolomitic cliffs and ledges. The Seven Rivers lies below Yates and becomes the dominant exposed formation to the north and west, both along slopes and on ridges (it too grades to Capitan Limestone towards the southern escarpment). The Queen formation underlies the Seven Rivers in the extreme northwestern corner of the park (Putman Canyon). To the south, the Guadalupe escarpment drops to the floor of the Delaware Basin where sediments have accumulated throughout the Quaternary to generate alluvial fan piedmonts (bajadas) and basin fill (Qal). Significant Recent alluvial gravel deposits also occur within in the drainages (Qg).

Vegetation

The park straddles a northern boundary of the Chihuahuan Desert region as defined by Johnston (1979) and Henrickson and Johnston (1997), but contains several elements of Sierra Madrean, Rocky Mountain and Great Plains affinity. Hence, following the biome definitions of Brown et al. (1979) and Brown et al. (1998), vegetation ranges from Chihuahuan Desert Scrub and Semi-Desert Grassland of the desert basin up through Interior Chaparral, Madrean Evergreen Woodland, and Rocky Mountain Montane Conifer Forest and Woodland at the higher elevations. Similarly, Dick-Peddie (1993) refers to these elements as Chihuahuan Desert Scrub, Desert Grassland, Montane Scrub, Mixed Woodland, and Lower Montane Forest, respectively.

Gehlbach (1967 & 1979) outlined the composition of five similar formations or "hypothetical biomes" for the Guadalupe Mountains (encompassing both Carlsbad Caverns NP and Guadalupe Mountains NP). Briefly, they are: 1) a Shrub Desert Formation dominated by creosotebush (*Larrea tridentata*), tarbush (*Flourensia cernua*), and viscid acacia (*Acacia neovernicosa*); 2) Succulent Desert characterized by lechuguilla (*Agave lechuguilla*) along with Pinchot juniper (*Juniperus pinchotii*) and goldeneye (*Viguiera stenoloba*); 3) Evergreen Woodland dominated by gray oak (*Quercus grisea*), alligator juniper (*Juniperus deppeana*), Texas madrone (*Arbutus xalapensis*), and pinyon pine (*Pinus edulis*); 4) Coniferous Forest characterized by ponderosa pine (*Pinus ponderosa*), and 5) a Deciduous Woodland dominated by riparian and semi-riparian species such as little walnut (*Juglans microcarpa*) and bigtooth maple (*Acer grandidentatum*). An anonymous generalized vegetation map was produced for the park with eight broad vegetation classes that more or less reflect those described by Gehlbach (1967 & 1979). Northington and Burgess (1979) also provided a review of the basic composition of vegetation in the Guadalupe Mountains that reiterates these patterns, but in addition, they noted that rock outcrops supported a unique set of taxa warranting attention.

Bunting (1978) conducted a detailed analysis of vegetation and soils of the Guadalupe Mountains, primarily in Guadalupe Mountains National Park (10 of his 195 plots were located in CCNP). He grouped 65 plant communities into eight broad "associations": Bolson, Gypsum, Quartz Sand, Creosotebush, Grassland, Mountain Shrub, Forest, and Canyon Terrace (see Table 7 for details).

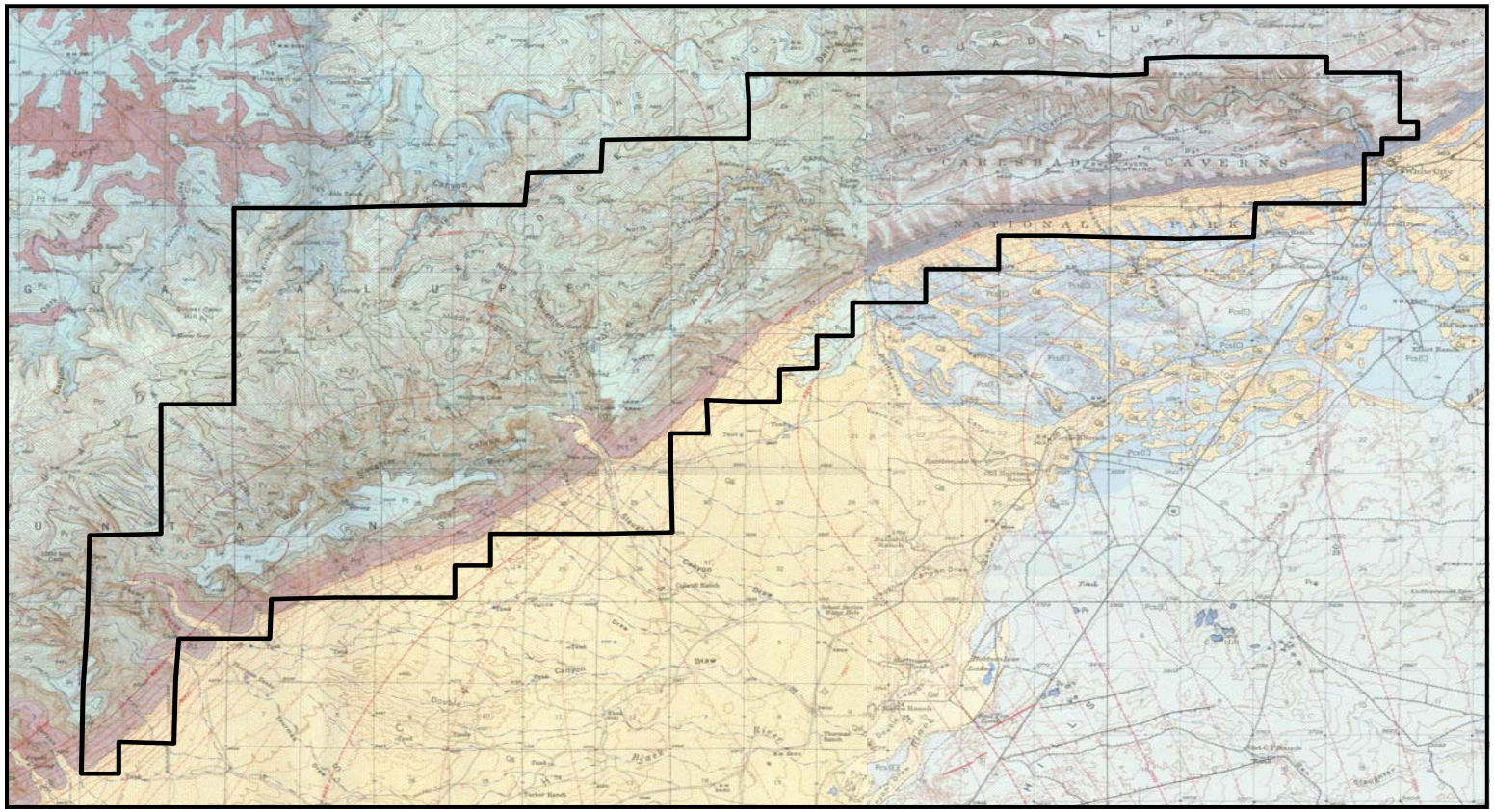


Figure 4. The geology of Carlsbad Caverns National Park as delineated by Hayes (1957 & 1958). The formations within the park are Capitan (Pcm, Pcb), Tansil (Pt), Yates (Pya), Seven Rivers (Pse, Psc), Queen (Pq), Alluvium (Qal), and Gravel (Qg).

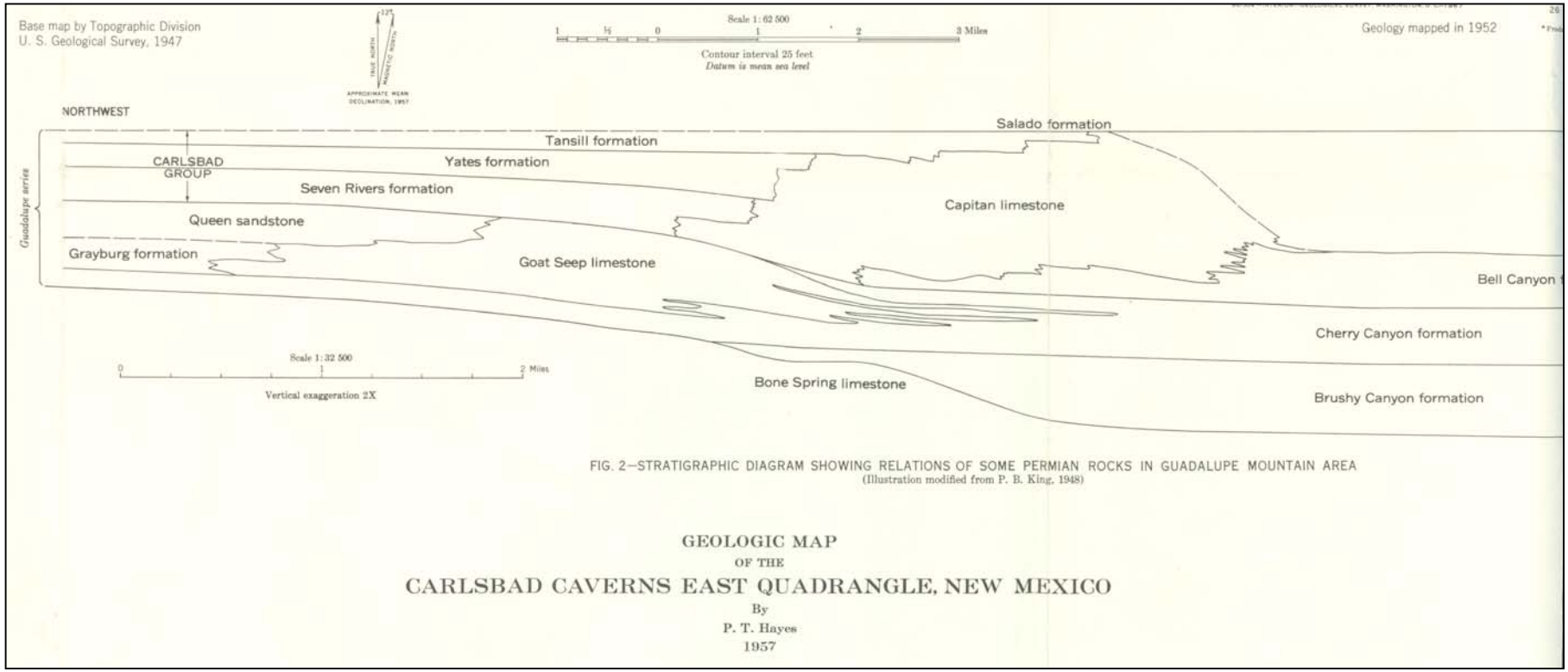


FIG. 2—STRATIGRAPHIC DIAGRAM SHOWING RELATIONS OF SOME PERMIAN ROCKS IN GUADALUPE MOUNTAIN AREA
(Illustration modified from P. B. King, 1948)

Figure 5. Example of the generalized vertical stratigraphy from north to south in the eastern portion of the park (source: Hayes 1957).

The park also potentially contains an estimated 27 sensitive plants[4] of which three are of particular interest: shining coral root (*Hexalectris nitida*) (State Endangered; NMNHP Rank G3S1), Sneed pincushion cactus (*Escobaria sneedii* var. *sneedii*) (State Endangered; NMNHP G2S2), and Lee pincushion cactus (*E. sneedii* var. *leei*) (State Endangered; NMNHP G2S2).

Cultural Heritage

Paleo Indian occupation is estimated to have begun around 12,000 B.C. Archaic hunters and gathers followed from about 6000 B.C. to 800 A.D. Pictographs left by the latter are found in several park caves. The period from 800 A.D. and 1541 was one of adaptation. Pottery shards and metates, found at several of the park's 125 archaeological sites, indicate that Indians living within the Guadalupe Mountains region were influenced by other cultures such as the Jornada Mogollon to the west[5]. The Mescalero Apache arrived in the area around 1400 and remained there until the Spanish conquest (beginning in 1536) and Anglo-European settlement (up until around 1880) drove them on to reservations to the north.

The Spanish and Anglo-Europeans extensively grazed the area with sheep, cattle and horses. In addition, commercial mining of gold and bat guano for fertilizer led to the development of an extensive trail and road system leading out of the main cavern area at the east end of the park. At establishment in 1923, the park was fenced and closed to grazing and other uses including guano extraction (grazing continued intermittently for approximately another decade).

MATERIALS AND METHODS

Sampling Strategy

Over the course of three field seasons, 400 vegetation plots were collected to serve the purposes of vegetation classification and map building (a list of plots and locations is provided in Appendix A). Plots were distributed in such a way as to maximize the coverage of as many habitats as possible but within the logistical constraints of the park's rugged terrain and wilderness areas (Figure 1). Using available aerial photography and satellite imagery, sampling zones representing typical vegetation patterns of a given area were identified that were reasonably accessible by roads and trails and within a day's hike of water. Since geology plays a key role in the pattern of vegetation communities, samplings were distributed among as many geologic units as possible to ensure broad coverage of different landscape types (see Figure 4). Plots were most commonly located in "landscape clusters" whereby plots would be optimally distributed in such a way as to represent the local vegetation pattern and geomorphic configuration. For example, within a watershed patches of homogenous vegetation on north versus south slopes might be sampled along with that in the drainages or the ridgelines.

Initially, a brief reconnaissance survey was conducted in September 1999 to provide a starting point for the development of a preliminary vegetation classification, and to guide map development and future sampling. The 1999 survey focused on Walnut Canyon and the eastern portion of the park with forays into Slaughter Canyon and along Guadalupe Ridge in the west (logistical constraints limited sampling to 16 vegetation plots total). In 2000, 175 full vegetation

[4] Personal communication Diane Dobos-Budno, CCNP botanist.
[5] information from Carlsbad Caverns National Park web page at http://www.nps.gov/cave/

plots (see below) were collected with extensive sampling in the wilderness area of the western portion of the park (Guadalupe Ridge, in Slaughter Canyon, Rattlesnake Canyon, Yucca Canyon and mesa, and in the southwestern corner in Double Canyon and surroundings), as well as throughout the eastern portion, and along the main escarpment and at the Rattlesnake Springs unit. These plots formed the core data set for the development of vegetation classification and a provisional vegetation map. The 2001 field season focused on gathering in additional ground control for the mapping process and for map validation and resulted in the collection of 208 mapping plots. Additional informal reconnaissance surveys were conducted in 2002 to further ground truth the map.

Field Techniques

Of the 400 plots, 192 were standard NMNHP plots that were usually 400 m^2 and square, with other sizes occasionally used to fit the structure of a community, especially along drainages where vegetation stands conform to the channel shape. Plots were established in the center of large homogeneous stands or patches (at least 2,500 square meters). A list of all vascular plant species, stratified by lifeform (tree, shrub, subshrub, grass and forb layers) was compiled for each plot and aerial cover determined for each species using a modified Domin-Krajina Scale (Table 3). In addition, several site attributes were recorded including slope percent, aspect, slope shape, surface rock type, and ground cover (percent rock, gravel, bare soil and litter), along with detailed narratives on species composition and site conditions. The 208 mapping control and validation plots were also approximately 400 m^2, but only the dominant species were recorded with their cover estimates, and a limited set of environmental characteristics is described. All plot locations were established with handheld Garmin GPS units and determined from a raw running average over one minute or more. Accuracy is estimated to be +_/- 10 m or less (see Data Addendum for examples of sampling forms and detailed survey methods).

A total of 651 plant voucher specimens for 244 species were collected to confirm field identifications and were deposited at the University of New Mexico Herbarium. Specimens were identified to lowest level possible given the material at hand (typically to the species and lower) and with nomenclature following the PLANTS database (USDA-NRCS 2002). An additional 191 common species were not vouchered. A species list derived from the plot data is provided in Appendix B.

All plots have at least one reference photograph, barring exposure problems. The compass direction and focal length of each shot was logged for future reference. Most photographs were taken on Ektachrome 200 slide film, but some landscape panorama shoots were shot with Kodachrome 200 print film. A subset of slides were scanned and placed on a separate data CD along with a selection of landscape and other shots of interest.

All vegetation and site data were entered into a Microsoft Access 2000 database and quality controlled through error checking computer routines and manual read-backs. The complete records for all plots are provided in the Data Addendum. Each record contains the comprehensive documentation of the plot location, dimensions, vegetation composition, tree stand structure, site characteristics, vegetation classification, and photo points. In addition, the computerized ASCII dataset and database are provided on a separate data CD.

Table 3. Modified Domin-Krajina Vegetation Cover Scale from Mueller-Dombois and Ellenberg (1974). Cover Class is the scalar value assigned in the field; Percent Canopy Cover is the range of cover the class represents; m2/ 400 m^2 is the actual area represented by the cover class within the 400 m^2 plot; and Midpoint % Cover is the midpoint canopy cover value used in data analysis.

Cover Class	Percent Canopy Cover	m^2 / 400 m^2	Midpoint % Cover
+0	[Undefined]	[Outside plot]	[0.001]
+	< .05	<0.04 m	0.01
1	< 0.1	≥ 0.04 & < 0.5	0.05
2	< 1	≥ 0.5 & < 4	0.5
3	1 – 4	≥ 5 & < 20	2.5
4	5 – 10	≥ 20 & < 40	7.5
5	10 - 25	≥ 40 & <100	17.5
6	25 - 33	≥ 100 & <132	29.0
7	33 - 50	≥ 132 & <200	41.5
8	50 - 75	≥ 200 & <300	62.5
9	> 75	≥ 300 m	87.5

Vegetation Analysis

To develop a preliminary vegetation classification, the plot data was subjected to multivariate cluster analysis (Ludwig and Reynolds 1988), and standard tabular comparison techniques (Mueller-Dombois and Ellenberg 1974). The cluster analysis was performed using PCORD (McCune and Mefford. 1997) cluster analysis and Twinspan (Hill 1979) routines. The cluster analysis used a flexible-beta strategy with the beta coefficient set at –0.25. Tree, shrubs and grasses were included in the analysis, but forbs were excluded due to memory constraints of PCORD. Abundance scalar values were converted to percent cover mid-point values. Twinspan, which uses a combination of reciprocal averaging and divisive clustering techniques, was computed with the top 75 species and three divisions. The resulting classification dendrograms and two-way tables are provided in the Data Addendum. The dendrograms provided the foundation for the vegetation classification that was then refined by tabular comparison where plots were initially grouped into vegetation units following the hierarchy and protocols of the International Classification of Ecological Communities and U.S. National Vegetation Classification System (Grossman et al. 1998), which is the U.S. geographic data standard. In general, each plot was classified into an Alliance based on dominant or indicator species, and then to a particular Plant Association (PA) based on codominance and/or other groups of differential species. Phases of associations were assigned as necessary to further define the character of the plant community.

Since the National Vegetation Classification (NVC) is intended to be part of a universal international system, it, by design, lacks regional categories such as "Chihuahuan Desert Scrub" or "Rocky Mountain Pinyon-Juniper Woodland," which are part of regional and state

classifications such as Brown et al. (1998), Dick-Peddie (1993) or the U.S. Fish and Wildlife Gap Analysis Project classification for New Mexico (Thompson et al. 1996). These regional "biomes" or "zones" are essentially floristically based and can be very useful for general analysis and planning. They conceptually reflect regional knowledge of broad vegetation types and serve as effective categories for communication among scientists, managers and the public in the Southwest. Recently, a new national classification of "ecological systems" has been developed by NatureServe to help addresses these regional entities (NatureServe 2003). Accordingly, the NMNHP has also attempted to incorporate the regional concepts of vegetation in the development of a comprehensive state classification (Table 4). The state system keeps the alliance and association levels of the national classification but attempts to integrate regional formation and biome concepts from the above authors plus the NMNHP wetland classification of Muldavin et al. (2000). It is this classification that is presented here with a crosswalk to the national classification.

The plant associations are the fundamental unit of the classification. Ecologists use the concept of plant association to help describe and recognize patterns in the way vegetation occurs in the landscape. By grouping land areas based on the ability to support similar associations, general management observations and recommendations can be made for each grouping. In the past 30 years, resource managers have found that the classification of vegetation into plant associations has provided insight and the ability to predict vegetation changes in response to various disturbance processes. In addition, plant associations are used to define map unit components in the mapping process—providing the information linkage between vegetation spatial distribution and its ecology.

Table 4. NMNHP state vegetation classification hierarchy.

Level	Definition	Example
I	Formation type: growth form and structure of vegetation	Woodland
II	Primarily climate zones	Warm Temperate Woodland
III	Biomes, biotic communities, ecological systems (in part)	Madrean Evergreen Woodland
IV	Regional floristically and environmentally related Alliances	Madrean Oak Woodland
V	Alliance (series): a group of plant associations characterized by a common dominant(s) and/or a diagnostic species	Gray Oak (*Quercus grisea*) Woodland Alliance
IV.	Plant Association: fundamental unit of vegetation characterized by a set of dominant and/or diagnostic species from any stratum.	Gray Oak/Texas Mountain Laurel Woodland (*Quercus grisea/Sophora secundiflora* PA)

Vegetation plant associations were also ranked with respect to rarity on a state and global basis. The network of natural heritage programs under NatureServe evaluates status of biological elements, either species or natural communities, using a ranking system that considers rarity, vulnerability and imperilment (Grossman et al. 1998). The ranking system is used by all network data centers including the New Mexico Natural Heritage Program (NMNHP), as well as by various government agencies and other organizations to support the planning of conservation strategies. Global ranks are based on factors such as quality, condition and viability, size, and identifiable threats that face the community. Each element is assigned a single global (G) rank to indicate its relative degree of imperilment on a five-point scale (e.g., 1 = critically imperiled because of extreme rarity, 5 = demonstrably secure). The primary criteria for ranking community elements is the number of occurrences (the number of known distinct localities) and extant acreage. Also of importance are the size of the geographic range, trends in distribution, and the number of already protected occurrences. However, the emphasis remains on the number of occurrences, such that ranks are, in effect, an index of known biological rarity. State ranks are similar, but the evaluation is based on ranges and distributions within New Mexico.

Map Development

Spatial Data Acquisition and Processing

The vegetation map was developed using a strategy that combined and automated digital image classification of satellite imagery with direct analog image interpretation. Two sets of satellite imagery were used for mapping: SpaceImaging®'s IKONOS and Landsat Enhanced Thematic Mapper$^+$ (ETM$^+$). IKONOS was the primary imagery used because of its high-resolution 1 m panchromatic (Pan— a black and white panchromatic band) and 4 m Multi-Spectral (MS—three visible and one infrared band) data (Figure 6 and Table 5). Variations in plant reflection and absorption due to biochemical composition will vary within and among bands and generate distinct spectral "signatures" for various elements of interest (Lillesand and Kiefer, 1987). In this case, the signature of each picture element (pixel) in the image provides a quantitative measure of reflectance at specific wavelengths that can then be statistically analyzed to generate a vegetation map of spectrally similar vegetation communities. In addition, the high resolution of both the Pan and MS imagery enabled the visual differentiation of trees and shrubs from one another along with various physical features that allow the enhancement of the statistically generated map during the interpretation phase (Figure 7).

There were some unforeseen complications in using the IKONOS imagery. Contrary to expectations, two separate IKONOS images were acquired by SpaceImaging® to cover the park (the original order had been for one uniform image). One image covered the eastern half of the park and was acquired on August 27, 2000; the other was acquired on September 29, 2000 and covered the western half. Although the two images were only a month apart, the differences in viewing geometries, solar illumination geometries, and vegetative phenologies were sufficient such that, for classification purposes, they had to be analyzed separately, leading to the development of two maps rather than one (Table 6). In addition, the eastern image had cloud and shadow coverage, which was well within the 20% or less cloud coverage guaranteed by SpaceImaging®, but it still obscured a north-central portion of the park (see Appendix C for details).

Table 5. IKONOS and LANDSAT satellite spectral bands, spatial resolution and spectral ranges (from http://www.spaceimaging.com/ and http://landsat7.usgs.gov/).

Band	Spatial Resolution	Wavelength (microns)	Spectral Location
IKONOS			
Pan	1m (3 ft)	0.45-0.52	Visible/Near-Infrared
MS1	4m (13 ft)	0.51-0.60	Visible Blue
MS2	4m (13 ft)	0.51-0.60	Visible Green
MS3	4m (13 ft)	0.63-0.70	Visible Red
MS4	4m (13 ft)	0.76-0.85	Near-Infrared
LANDSAT			
ETM^+1	30m (98 ft)	0.45-0.52	Visible Blue
ETM^+2	30m (98 ft)	0.52-0.60	Visible Green
ETM^+3	30m (98 ft)	0.63-0.69	Visible Red
ETM^+4	30m (98 ft)	0.76-0.90	Near-infrared
ETM^+5	30m (98 ft)	1.55-1.75	Mid-infrared
ETM^+6	60m (197 ft)	10.4-12.5	Thermal Infrared
ETM^+7	30m (98 ft)	2.08-2.35	Mid-infrared

Table 6. Differences in viewing and solar geometry for two different dates IKONOS imagery were acquired.

	August 27, 2000	September 29, 2000
Viewing Geometry		
Azimuth	36°	0°
Elevation	86°	83°
Solar Geometry		
Azimuth	132°	150°
Elevation	86°	51°

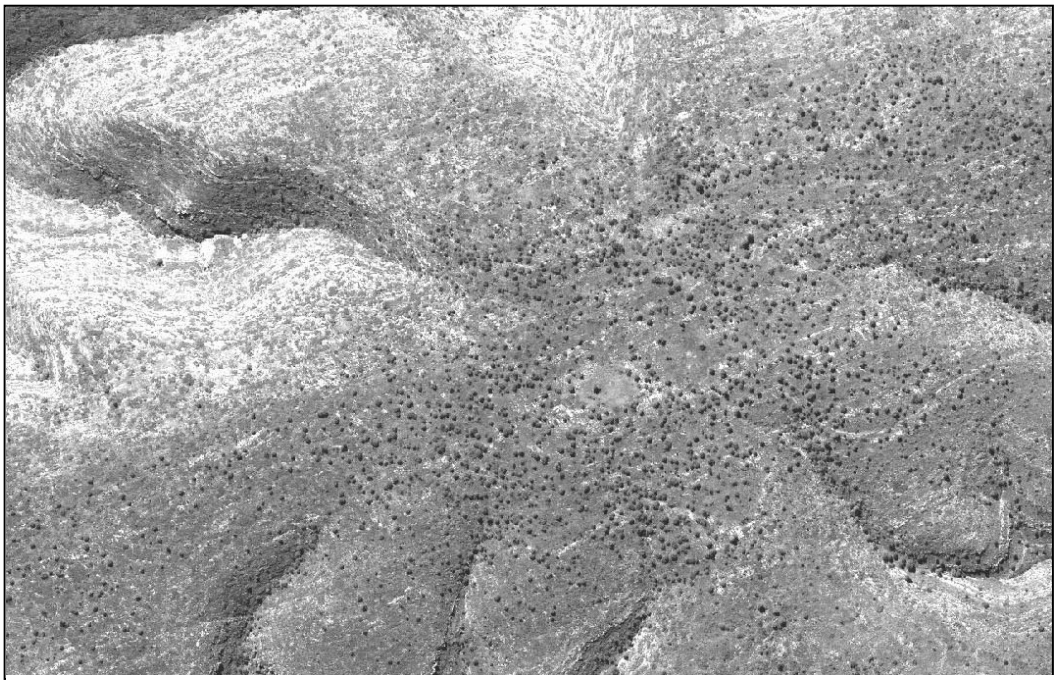
To address the problems of temporal differences and cloud cover, ETM^+ satellite imagery was used to provide data continuity over the two separate images and to infill clouded areas. While ETM^+ covers more of the spectrum than the IKONOS data with seven bands stretching from blue to far-infrared, it is coarser at a resolution of 30 m versus 4 m and 1 m. The first four bands of ETM^+ data are almost identical to the MS data (see Table 5), but the last three cover spectral and emissive responses in the mid-infrared and thermal infrared wavelengths. The mid-infrared bands are useful for detecting variations in surface geology and soil discrimination which are important in developing mapping units of the vegetation communities in sparsely vegetated areas that occur within the study area. The thermal infrared response is recorded at the coarsest spatial resolution, but these wavelengths directly measure surface temperature and indirectly the moisture content, which can be important for discriminating between different plant and soil types (Elachi 1987).

The ETM^+ scene used for the project was acquired over the area on April 16, 2000, by the Landsat 7 platform, and was of good quality with no clouds, cirrus or scan line defects. A spring scene was purposely chosen to help further differentiate among vegetation communities by detecting seasonal differences between evergreen and deciduous plant species.

a) IKONOS Panchromatic 1 m resolution

b) IKONOS Multispectral 4 m resolution

Figure 6. Examples of IKONOS imagery from over the park headquarters. North is down.



a) Individual trees are readily discernable in this IKONOS Pan closeup over Yucca Canyon mesa.

b) An NDVI level-slice IKONOS MS data helps isolate trees spectrally for analysis over the same area.

Figure 7. Examples of the uses of IKONOS imagery at 1>12,000 scale over Yucca Canyon mesa. North is down.

In addition to the above image data sources, several other data sets were created to aid in map development. Road and land status coverages were created from the 2000 US Geological Survey (USGS) TIGER dataset and the BLM 1:100,000 series ownership maps respectively - both available from the New Mexico RGIS website (http://rgis/). Raster data sets such as the USGS 1:24,000 Digital Raster Graphics (DRG) datasets – scanned topographic map sheets – and the National Elevation Dataset (NED) Digital Elevation Model (DEM) with a spatial resolution of 30 m (96 ft) was also clipped to the area and used for this study. In addition, the park provided Digital Ortho-photo Quads (DOQs) at 1 m spatial resolution; these were mosaicked together and used as a geographic reference for the satellite images. The DOQs were in a Universal Transverse Mercator projection, Zone 13, 1983 North American Datum, 1980 Geodetic Reference System.

ERDAS Imagine, Version 8.5, was the principal software used in a PC environment throughout the mapping process (ERDAS 1997). All digital imagery and GIS coverages were processed, manipulated, and used as overlays for analysis within the Imagine environment. Arc/Info 8.0 and ArcView 3.2 were used to create, import, and manipulate vector coverages. Microsoft Excel 9.0 was used to store and manipulate all field data.

The satellite imagery was processed in various ways to enhance spatial and spectral characteristics (see Appendix C for technical details). Initially, the images were geometrically corrected to within one meter using the USGS DOQ's as the reference. Then, to conform all images spatially for subsequent analysis, they were resampled to 1 m resolution of the IKONOS Pan image. A normalized difference vegetation index (NDVI) was computed using the red and infrared bands to enhance the vegetation response, and a texture filter developed from the Pan to help detect trees and shrubs. The NDVI was also used in a level-slice algorithm to generate images to help portray the density of trees or shrubs (Figure 7).

Image Classification

The indices, along with the raw spectral bands, were used in a supervised image classification strategy that was based on the ground data gathered during the vegetation survey. In this approach vegetation plots with known vegetation characteristics and locations are used to develop classification "seeds" whereby the spectral characteristics of an image pixel at a given plot location is gathered along with similar contiguous pixels to create a statistically valid model that can subsequently be used to classify the other pixels in the image. Seed shapes and locations were checked against field notes and maps, and by direct interpretation of the seeds in the imagery in conjunction with the terrain models. Each seed therefore represents a particular plant association on the ground, and the intent is to generate as many seeds as possible to represent the spectral range of a given plant association in the imagery. Not all plots will generate valid seeds because of local idiosyncrasies in the imagery, while others are redundant spectrally for same vegetation association and thus not used. Each initially valid 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.

Statistics gathered for each seed are then used to perform a supervised classification of the other pixels in the image using a Bayesian maximum likelihood decision rule. Each pixel is

assigned to a seed class representing a particular plant association based on spectral distance (as the minimum distance decision rule) and the variance of each of the signature models. The variance is important when comparing a pixel to a signature representing, for example, a shrubland community which might be fairly heterogeneous, to a grassland class, which is more homogeneous. Informal accuracy checking based on field data, air photos, personal knowledge of a site and other ancillary data was used to detect distribution problems. If a problem with a seed was detected, the seed was rechecked to insure it was properly modeling the vegetation type and landscape. If not, it was discarded or replaced and the classification repeated. Through this iterative process an optimized solution was reached and a preliminary map developed with as many map classes as seeds used to develop it.

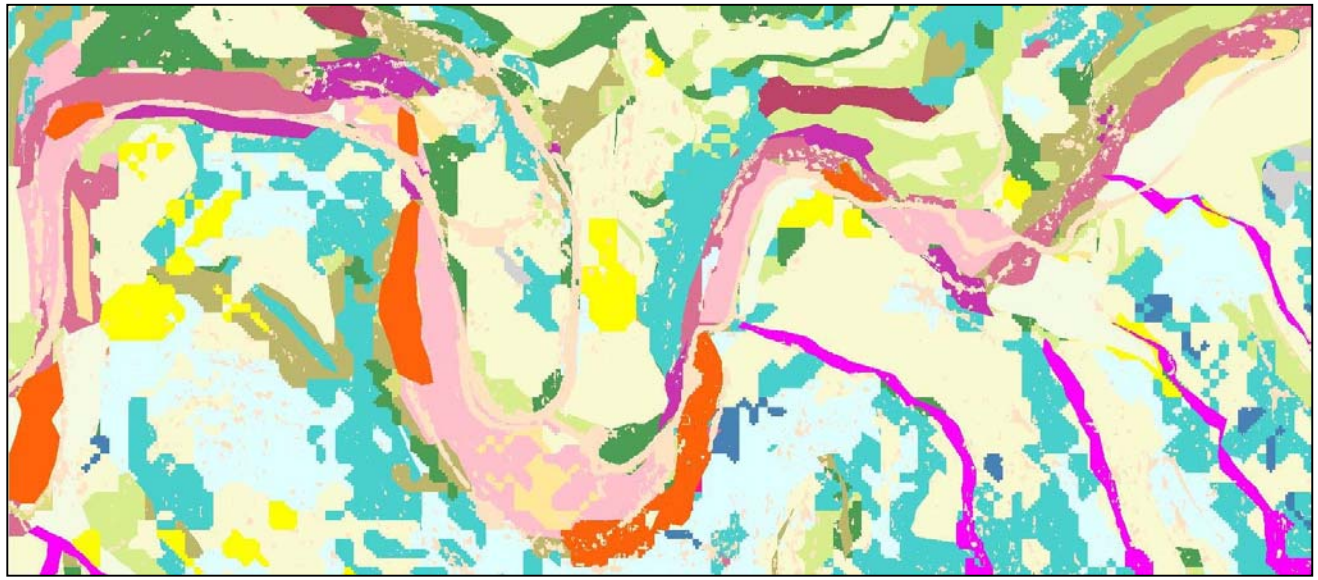
Final Map Units and Fine-scale Image Interpretation

Once the image was classified, the seed classes representing the various plant associations of the park were grouped into operational map units based on two criteria. Either they were grouped ecologically into map units that were appropriate for land management at the target scale of 1:24,000, or they were grouped because they were spatially or spectrally so similar that they were not differentiable with confidence at the target scale. Hence, most map units were represented by sets of plant associations that are separated into primary components (dominant plant associations comprising the majority of a map unit), secondary components (other plant associations with significant coverage), and potential inclusions (plant associations estimated to have less than 10% coverage within the unit). Map unit descriptions were then developed describing the composition and distribution of each unit.

Mapping in areas of high relief and with a complex vegetation mosaic such as that at CCNP can pose significant mapping problems, particularly in areas of deep shadows and narrow linear features (narrow bands of vegetation and rock are a common occurrence on CCNP). In addition, while the supervised approach was suitable for analyzing large homogeneous patches of relatively uniform spectral response, the one-meter resolution of the imagery often led to small patches and a rather heterogeneous classification pattern driven by small differences in spectral response, e.g., individual trees or shrubs might be classified as one thing while the intervening grassland matrix might be classified as another. Therefore, using the supervised classification as a foundation, the map was refined using direct image interpretation of the Pan and MS imagery supported by the special analysis layers (NDVI and level slicing) and ancillary information such as ground-based mapping and photos. The final map and associated image and shape files were incorporated into an ArcGIS project file for delivery to the park

With respect to accuracy, the initial target was at least 80% overall accuracy at a target user scale of 1:24,000 and a minimum map unit delineation size of 0.5 ha. Given the high resolution of imagery, the actual minimum delineation often approached 0.25 ha or finer at an operational scale of 1:12,000 (Figure 8). An independent validation dataset was developed from the CCNP fire monitoring plots and used to determine the accuracy of those map units represented in the dataset.

a) IKONOS 4 m Multispectral (MS) imagery



b) Final vegetation map.

Figure 8. An example at approximately 1:12,000 scale of the vegetation map pattern that results from a combination of automated supervised classification and direct image interpretation (See map for map unit definitions). North is down.

RESULTS AND DISCUSSION

Vegetation Communities of Carlsbad Caverns National Park

The vegetation communities of Carlsbad Caverns NP are diverse and in several cases unique. We identified 85 plant associations ranging from desert shrublands and semi-grasslands of the lowland basins and foothills up through montane grasslands, shrublands and woodlands of the highest elevations (Table 7). Of these, 20 were considered well established associations described elsewhere in the Southwest; 37 were considered provisional types with more limited documentation (3-4 plots), and the remaining 28 are new associations represented by one or two plots and that had not been previously described elsewhere. We have indicated in Table 7 those plant communities described by Bunting (1978) that are similar to ours. In the following, we summarize the information on composition, structure, and environments of these communities within their respective formation types and regional biomes. Floristic summary tables for each association are provided in the Data Addendum.

Forest and Woodland

Upland forests and woodlands are found at the highest elevations and include associations of both Madrean and Rocky Mountain affinity, i.e., communities that are characterized by floristic elements with the center of their distribution in either the Sierra Madre of northern Mexico or the southern Rocky Mountains, respectively. Hence, we have grouped woodland plant associations into four biome types: cold temperate Madrean Montane Forest, Rocky Mountain Conifer Woodland, Rocky Mountain Deciduous Woodland, and warm temperate Madrean Evergreen Woodlands (Evergreen Woodlands and Deciduous Woodlands of Gehlbach (1967 &1979).

Madrean Montane Forests are represented by the **Ponderosa Pine (*Pinus ponderosa*) Madrean Forest Alliance** (Figure 9). They occur in small patches predominantly on ridge tops and north facing slopes at elevations above 5,000 ft (1,525 m), or in protected sites of canyon bottoms. They are represented here by two provisional associations (Table 7). The Ponderosa Pine/ Sandpaper Oak/New Mexico Muhly Plant Association (PA) is characterized by an open to moderate canopy of ponderosa pine with a matrix of shrubby sandpaper oak (*Quercus pungens*) patches and grasses (*Muhlenbergia pauciflora, Piptochaetium fimbriatum,* and *Bouteloua curtipendula*) in the undergrowth. It is typically found on the wide flat summits of ridges or upper slopes above 6,000 ft (1,830 m) and is usually associated with Tansil or Yates Formation cap rocks. The Ponderosa Pine/Chinkapin Oak/Pinyon Ricegrass PA

Figure 9. An example of the Ponderosa Pine/Chinkapin Oak/Pinyon Ricegrass PA at Able Seep in canyon off of Guadalupe Ridge.

Table 7. Carlsbad Caverns National Park Vegetation Classification, 2003. Vegetation units follow the New Mexico Natural Heritage Program New Mexico vegetation classification system (see Table 4). Status refers to classification confidence at the plant association level: 1 = established type, well documented (5 or more plots); 2= provisional type, limited documentation (3-4 plots); 3 = new type with minimal documentation (1-2 plots). Associations similar to those described by Bunting (1978) are marked with an "* ". S-Rank is the rarity ranks assigned for the state and G-Rank is the global rarity rank. A "?" after the rank is used for new and occasionally for provisional associations where ranking data is limited (see Methods).

Vegetation Unit	Status	S-Rank	G-Rank
I. Forest			
II. Cold Temperate Forest			
III. Madrean Montane Forest			
IV. Madrean Pine-Oak Forest			
Ponderosa Pine (*Pinus ponderosa*) Forest Alliance			
Ponderosa Pine-Chinkapin Oak/Pinyon Ricegrass Forest (*Pinus ponderosa-Quercus muehlenbergii/Piptochaetium fimbriatum* PA)	2	S1?	G2?
Ponderosa Pine/Sandpaper Oak/New Mexico Muhly Forest* (*Pinus ponderosa/Quercus pungens*/*Muhlenbergia pauciflora* PA)	2	S3S4	G4?
I. Woodland			
II. Cold Temperate Woodland			
III. Rocky Mountain Conifer Woodland			
IV. Rocky Mountain Pinyon-Juniper Woodland			
Pinyon Pine (Pinus edulis) Woodland Alliance			
Pinyon Pine-Sandpaper Oak Woodland* (*Pinus edulis-Quercus pungens* PA)	2	S?	G?
III. Rocky Mountain Deciduous Woodland			
IV. Rocky Mountain Broad-leaved Deciduous Woodland			
Bigtooth Maple (*Acer grandidentatum*) Woodland Alliance			
Bigtooth Maple/New Mexico Muhly Woodland (*Acer grandidentatum/Muhlenbergia pauciflora* PA)	3	S?	G?
Bigtooth Maple-Chinkapin Oak Woodland (*Acer grandidentatum-Quercus muehlenbergii* PA)	2	S1S2	G3
II. Warm Temperate Woodland			
III. Madrean Evergreen Woodland			
IV. Madrean Oak Woodland			
Gray Oak (*Quercus grisea*) Woodland Alliance			
Gray Oak/Texas Mountain Laurel Woodland (*Quercus grisea/Sophora secundiflora* PA)	2	S2	G3
Gray Oak-Bigtooth Maple Woodland (*Quercus grisea-Acer grandidentatum* PA)	2	S2	G2?
Gray Oak-Texas Madrone Woodland* (*Quercus grisea-Arbutus xalapensis* PA)	2	S2	G2?
IV. Madrean Juniper Savanna Woodland			
Alligator Juniper (*Juniperus deppeana*) Woodland Alliance			
Alligator Juniper/Sideoats Grama Woodland (*Juniperus deppeana/Bouteloua curtipendula* PA)	2	S4	G5
Alligator Juniper/Sandpaper Oak/Pine Muhly Woodland* (*Juniperus deppeana/Quercus pungens/Muhlenbergia dubia* PA)	3	S?	G?
Alligator Juniper/Sandpaper Oak/Bullgrass Woodland (*Juniperus deppeana/Quercus pungens/Muhlenbergia emersleyi* PA)	2	S4	G5
Alligator Juniper/Canyon Grape Woodland	3	S?	G?

(*Juniperus deppeana/Vitis arizonica* PA)

Table 7. Carlsbad Caverns National Park Vegetation Classification, 2003 (continued).

Vegetation Unit	Status	S-Rank	G-Rank
I. Mesophytic Shrubland			
II. Cold Temperate Shrubland			
III. Madrean Montane Scrub			
IV. Broadleaved Deciduous Madrean Montane Scrub			
Shaggy Mountain Mahogany (*Cercocarpus montanus* var. *paucidentatus*) Shrubland Alliance			
Shaggy Mountain Mahogany/Little Awn Needlegrass Shrubland (*Cercocarpus montanus* var. *paucidentatus/Achnatherum lobatum* PA)	3	S3	G4
Shaggy Mountain Mahogany/Bullgrass Shrubland (*Cercocarpus montanus* var. *paucidentatus/Muhlenbergia emersleyi* PA)	1	S4	S4
Shaggy Mountain Mahogany/New Mexico Muhly Shrubland* (*Cercocarpus montanus* var. *paucidentatus/Muhlenbergia pauciflora* PA)	1	S5	G5
Shaggy Mountain Mahogany/Curlyleaf Muhly Shrubland* (*Cercocarpus montanus* var. *paucidentatus/Muhlenbergia setifolia* PA)	1	S4	G4
II. Warm Temperate Shrubland			
III. Chihuahuan Interior Chaparral			
IV. Broadleaved Chihuahuan Interior Chaparral			
Sandpaper Oak (*Quercus pungens*) Shrubland Alliance			
Sandpaper Oak/Littleawn Needlegrass Shrubland (*Quercus pungens/Achnatherum lobatum* PA)	2	S3	G4G5
Sandpaper Oak/Sideoats Grama Shrubland (*Quercus pungens/Bouteloua curtipendula* PA)	2	S3	G4G5
Sandpaper Oak/Shaggy Mountain Mahogany Shrubland* (*Quercus pungens/Cercocarpus montanus* var. *paucidentatus* PA)	2	S3	G4G5
Sandpaper Oak/New Mexico Muhly Shrubland* (*Quercus pungens/Muhlenbergia pauciflora* PA)	2	S3	G4G5
Sandpaper Oak/Curlyleaf Muhly Shrubland (*Quercus pungens/Muhlenbergia setifolia* PA)	2	S3	G4G5
IV. Needle-leaved Chihuahuan Interior Chaparral			
Pinchot Juniper (*Juniperus pinchotii*) Shrubland Alliance			
Pinchot Juniper/Sandpaper Oak/Sideoats Grama Shrubland (*Juniperus pinchotii/Quercus pungens/Bouteloua curtipendula* PA)	3	S?	G?
Pinchot Juniper/Sandpaper Oak/Hairy Grama Shrubland* (*Juniperus pinchotii/Quercus pungens/Bouteloua hirsuta* PA)	2	S?	G?
Pinchot Juniper/Skeletonleaf Goldeneye Shrubland (*Juniperus pinchotii/Viguiera stenoloba* PA)	3	S?	G?
Pinchot Juniper/Sideoats Grama Shrubland (*Juniperus pinchotii/Bouteloua curtipendula* PA)	2	S2	G?
Pinchot Juniper/Black Grama Shrubland (*Juniperus pinchotii/Bouteloua eriopoda* PA)	2	S2	G4
Pinchot Juniper/Curlyleaf Muhly Shrubland* (*Juniperus pinchotii/Muhlenbergia setifolia* PA)	2	S2	G3G4

Table 7. Carlsbad Caverns National Park Vegetation Classification, 2003 (continued).

Vegetation Unit	Status	S-Rank	G-Rank
I. Xerophytic Shrubland			
II. Warm Temperate Desert Shrubland			
III. Chihuahuan Desert Scrub			
IV. Chihuahuan Foothill-Piedmont Desert Scrub			
Viscid Acacia (*Acacia neovernicosa*) Shrubland Alliance			
Viscid Acacia/Black Grama Shrubland* (*Acacia neovernicosa/Bouteloua eriopoda* PA)	1	S4	G4
Viscid Acacia/Blue Grama Shrubland (*Acacia neovernicosa/Bouteloua gracilis* PA)	2	S4	G4
Viscid Acacia-Lechuguilla Shrubland (*Acacia neovernicosa-Agave lechuguilla* PA)	2	G5	G5
Viscid Acacia-Mariola Shrubland (*Acacia neovernicosa-Parthenium incanum* PA)	1	G5	G5
Viscid Acacia-Pricklyleaf Dogweed Shrubland (*Acacia neovernicosa-Thymophylla acerosa* PA)	3	G?	G?
Ocotillo (*Fouquieria splendens*) Shrubland Alliance			
Ocotillo-Lechuguilla Shrubland (*Fouquieria splendens-Agave lechuguilla* PA)	2	S3	G5
Ocotillo-Mariola Shrubland* (*Fouquieria splendens-Parthenium incanum* PA)	1	S5	G5
Catclaw Mimosa (*Mimosa aculeaticarpa*) Shrubland Alliance			
Catclaw Mimosa/Sideoats Grama Shrubland* (*Mimosa aculeaticarpa/Bouteloua curtipendula* PA)	2	S4	G4
Mariola (*Parthenium incanum*) Dwarf Shrubland Alliance			
Mariola-Lechuguilla Desert Shrubland (*Parthenium incanum-Agave lechuguilla* PA)	3	S4?	G5?
Mariola-Skeletonleaf Goldeneye Desert Shrubland (*Parthenium incanum-Viguiera stenoloba* PA)	2	S4	G5
IV. Chihuahuan Succulent Desert Scrub			
Cactus Apple (*Opuntia engelmannii*) Shrubland Alliance			
Cactus Apple-Lechuguilla Shrubland (*Opuntia engelmannii-Agave lechuguilla* PA)	2	S4	G5
Cactus Apple-Wright Beebrush Shrubland (*Opuntia engelmannii-Aloysia wrightii* PA)	2	S4	G5
Cactus Apple-Ocotillo Shrubland (*Opuntia engelmannii-Fouquieria splendens* PA)	2	S4	G5
IV. Chihuahuan Creosotebush Desert Scrub			
Creosotebush (*Larrea tridentata*) Shrubland Alliance			
Creosotebush/Sparse Undergrowth Desert Shrubland* (*Larrea tridentata/Sparse* PA)	1	S5	G5
Creosotebush-Viscid Acacia/Black Grama Desert Shrubland (*Larrea tridentata-Acacia neovernicosa/Bouteloua eriopoda* PA)	3	S?	G?
Creosotebush/Viscid Acacia/Sparse Desert Shrubland (*Larrea tridentata-Acacia neovernicosa/Sparse* PA)	2	S5	G5
Creosotebush-Mariola Shrubland (*Larrea tridentata-Parthenium incanum* PA)	1	S5	G5

Table 7. Carlsbad Caverns National Park Vegetation Classification, 2003 (continued).

Vegetation Unit	Status	S-Rank	G-Rank
IV. Chihuahuan Basin Desert Scrub			
Tarbush (*Flourensia cernua*) Shrubland Alliance			
Tarbush/Black Grama Shrubland (*Flourensia cernua/Bouteloua eriopoda* PA)	1	S4	G4
Tarbush/Tobosagrass Desert Shrubland (*Flourensia cernua/Hilaria mutica* PA)	1	S5	G5
Littleleaf Sumac (*Rhus microphylla*) Shrubland Alliance			
Littleleaf Sumac/Sideoats Grama Shrubland* (*Rhus microphylla/Bouteloua curtipendula* PA)	2	S5	G5
Littleleaf Sumac/Blue Grama Shrubland (*Rhus microphylla/Bouteloua gracilis* PA)	1	S?	G?
Littleleaf Sumac-Texas Mountain Laurel Shrubland (*Rhus microphylla-Sophora secundiflora* PA)	1	S?	G?
IV. Chihuahuan Mesquite Desert Scrub			
Prosopis glandulosa Shrubland Alliance			
Honey Mesquite/Tobosagrass Shrubland* (*Prosopis glandulosa/Hilaria mutica* PA)	1	S5	G5
I. Grassland			
II. Cold Temperate Grassland			
III. Madrean Plains-Mesa-Foothill Grassland			
IV. Madrean Foothill Grassland			
Texas Sacahuista (*Nolina texana*) Shrub Herbaceous Alliance			
Bullgrass/Texas Sacahuista Grassland (*Muhlenbergia emersleyi/Nolina texana* PA)	3	S?	G?
Curlyleaf Muhly-Sideoats Grama/Texas Sacahuista Grassland (*Muhlenbergia setifolia-Bouteloua curtipendula/Nolina texana* PA)	3	S?	G?
Sideoats Grama/Texas Sacahuista Grassland* (*Bouteloua curtipendula/Nolina texana* PA)	2	S?	G?
II. Warm Temperate Grassland			
III. Chihuahuan Semidesert Grassland			
IV. Chihuahuan Foothill-Piedmont Desert Grassland			
Lechuguilla-Green Sotol (*Agave lechuguilla-Dasylirion leiophyllum*) Shrub Herbaceous Alliance			
Black Grama/Lechuguilla-Green Sotol Grassland (*Bouteloua eriopoda/Agave lechuguilla-Dasylirion leiophyllum* PA)	3	S?	G?
Curlyleaf Muhly/Lechuguilla Grassland (*Muhlenbergia setifolia/Agave lechuguilla* PA)	2	S1S2	G3
Curlyleaf Muhly/Lechuguilla-Green Sotol Grassland (*Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum* PA)	1	S1S2	G3
Curlyleaf Muhly/Green Sotol Grassland (*Muhlenbergia setifolia/Dasylirion leiophyllum* PA)	2	S1S2	G3
Sideoats Grama/Lechuguilla-Green Sotol Grassland (*Bouteloua curtipendula/Agave lechuguilla-Dasylirion leiophyllum* PA)	2	S2S3	G3G4
Sideoats Grama/Green Sotol Grassland (*Bouteloua curtipendula/Dasylirion leiophyllum* PA)	2	S3	G3G4
Sideoats Grama-Tanglehead/Green Sotol Grassland (*Bouteloua curtipendula-Heteropogon contortus/Dasylirion leiophyllum* PA)	2	S3	G3G4
Slim Tridens/Lechuguilla Grassland (*Tridens muticus/Agave lechuguilla* PA)	3	S?	G?

Table 7. Carlsbad Caverns National Park Vegetation Classification, 2003 (continued).

Vegetation Unit	Status	S-Rank	G-Rank
IV. Chihuahuan Foothill-Piedmont Desert Grassland (continued)			
Blue Grama (*Bouteloua gracilis*) Shrub Herbaceous Alliance			
Blue Grama/Skeletonleaf Goldeneye Grassland (*Bouteloua gracilis/Viguiera stenoloba* PA)	3	S?	G?
Blue Grama-Tobosagrass/Catclaw Mimosa Grassland (*Bouteloua gracilis-Hilaria mutica/Mimosa aculeaticarpa* PA)	3	S?	G?
Black Grama (*Bouteloua eriopoda*) Herbaceous Alliance			
Black Grama-Blue Grama Grassland* (*Bouteloua eriopoda-Bouteloua gracilis* PA)	1	S2	G2
Black Grama-Sideoats Grama Grassland (*Bouteloua eriopoda-Bouteloua curtipendula* PA)	1	S2	G2
Curlyleaf Muhly (*Muhlenbergia setifolia*) Herbaceous Alliance			
Curlyleaf Muhly-Sideoats Grama Grassland (*Muhlenbergia setifolia-Bouteloua curtipendula* PA)	1	S1S2	G3
Curlyleaf Muhly-Hairy Tridens Grassland (*Muhlenbergia setifolia-Erioneuron pilosum* PA)	3	S?	G?
Curlyleaf Muhly/Skeletonleaf Goldeneye Grassland (*Muhlenbergia setifolia/Viguiera stenoloba* PA)	3	S?	G?
Panicgrass (*Panicum hallii*) Herbaceous Alliance			
Hall's Panicgrass-Hairy Tridens Grassland (*Panicum hallii-Erioneuron pilosum* PA)	2	S?	G?
IV. Chihuahuan Lowland/Swale Semidesert Grassland			
Tobosagrass (*Hilaria mutica*) Herbaceous Alliance			
Tobosagrass-Burrograss Grassland (*Hilaria mutica-Scleropogon brevifolius* PA)	1	S5	G5
Riparian/Wetland			
I. Forested Riparian/Wetland			
II. Broadleaved Deciduous Riparian/Wetland Forest and Woodland			
III. Lowland Interior Southwest Broad-leaved Deciduous Riparian Forest and Woodland			
IV. Southwest Arroyo Riparian Woodland (intermittently flooded)			
Netleaf Hackberry (*Celtis laevigata* var. *reticulata*) Arroyo Woodland Alliance			
Netleaf Hackberry-Little Walnut Arroyo Woodland (*Celtis laevigata var. reticulata-Juglans microcarpa* PA)	3	S?	G?
Netleaf Hackberry-Littleleaf Sumac Arroyo Woodland (*Celtis laevigata var. reticulata-Rhus microphylla* PA)	3	S?	G?
Little Walnut (*Juglans microcarpa*) Arroyo Woodland Alliance			
Little Walnut/Sideoats Grama Arroyo Woodland (*Juglans microcarpa/Bouteloua curtipendula* PA)	2	S2S3	G2G3
IV. Southwest Lowland Riparian Forest and Woodland (Temporarily Flooded)			
Rio Grande Cottonwood (*Populus fremontii*) Riparian Forest Alliance			
Rio Grande Cottonwood-Goodding Willow Riparian Forest (*Populus deltoides* var. *wislizenii -Salix gooddingii* PA)	1	S2	G2
Rio Grande Cottonwood-Netleaf Hackberry-Goodding Willow Riparian Forest (*Populus deltoides* var. *wislizenii -Celtis laevigata var. reticulata- Salix gooddingii* PA)	3	S?	G?
Rio Grande Cottonwood-Russian Olive Riparian Forest (*Populus deltoides* var. *wislizenii -Elaeagnus angustifolia* PA)	1	SM	GM

Table 7. Carlsbad Caverns National Park Vegetation Classification, 2003 (continued).

Vegetation Unit	Status	S-Rank	G-Rank
I. Shrub Riparian/Wetland			
II. Broadleaved Deciduous Riparian/Wetland Shrubland			
III. Lowland Interior Southwest Riparian/Wetland Shrubland			
IV. Southwest Arroyo Riparian Shrubland (intermittently flooded)			
Apache Plume (*Fallugia paradoxa*) Shrubland Alliance			
Apache Plume/Wash Arroyo Shrubland (*Fallugia paradoxa*/Arroyo PA)	3	S2S3?	G?
Apache Plume/Mexican Buckeye Arroyo Shrubland (*Fallugia paradoxa*/*Ungnadia speciosa* PA)	3	S2S3?	G?
Texas Mountain Laurel (*Sophora secundiflora*) Shrubland Alliance			
Texas Mountain Laurel-Roemer Catclaw Arroyo Shrubland (*Sophora secundiflora-Acacia roemeriana* PA)	3	S2S3?	G?
Green Sotol (*Dasylirion leiophyllum*) Shrubland Alliance			
Green Sotol/Catclaw Mimosa Arroyo Shrubland (*Dasylirion leiophyllum/Mimosa aculeaticarpa* PA)	3	S?	G?
Desert Willow (*Chilopsis linearis*) Shrubland Alliance	3	S3?	G3?
Desert Willow-Texas Mountain Laurel Shrubland (*Chilopsis linearis-Sophora secundiflora* PA)			
Catclaw Acacia (*Acacia greggii*) Shrubland Alliance			
Catclaw Acacia/Bullgrass Shrubland (*Acacia greggii/Muhlenbergia emersleyi* PA)	3	S4?	G4?
Littleleaf Sumac (*Rhus microphylla*) Shrubland Alliance			
Littleleaf Sumac-Texas Mountain Laurel Shrubland (*Rhus microphylla-Sophora secundiflora* PA)	3	S?	G?
I. Emergent Herbaceous Wetland			
II. Persistent Emergent Herbaceous Wetland			
III. Lowland Western Persistent Emergent Herbaceous Wetland			
IV. Semipermanently Flooded Western Lowland Herbaceous Wetland			
Western Umbrella (*Fuirena simplex*) Herbaceous Alliance			
Western Umbrella-sedge-Sand Spikerush Herbaceous Wetland (*Fuirena simplex/Eleocharis montevidensis* PA)	3	S?	G?
Baltic Rush (*Juncus balticus*) Herbaceous Alliance			
Baltic Rush-Threesquare Bulrush (*Juncus balticus-Schoenoplectus pungens* PA)	2	S4?	G5?

also has an open canopy of ponderosa pine along with a subcanopy of chinkapin oak (*Q. muehlenbergii*) and occasionally big-tooth maple (*Acer grandidentatum*). The understory is diverse but characterized by abundant pinyon ricegrass (*Piptochaetium fimbriatum*) and other Madrean grasses (*Muhlenbergia pauciflora, Muhlenbergia dubia,* and *Muhlenbergia emersleyi*). It is commonly found on slopes or in canyon bottoms.

The most common woodland associations in the park are Madrean Juniper Savanna Woodlands belonging to the **Alligator Juniper (*Juniperus deppeana*) Woodland Alliance**. Alligator bark juniper has the center of its distribution in the southwestern U.S. extending southward into the Sierra Madre Occidental and Oriental of Mexico. It is the largest of the southwestern junipers and commonly grows to between 20 to 40 feet (6.1 to 12.2 m). Gray oak (*Q. grisea*) is an occasional canopy codominant associate. Three of the four associations identified from this alliance are open savanna woodland types (typically 10% to 25 % canopy cover) that primarily occur on the flat ridge summits and upper slopes above 5,900 ft (1,800 m). The Alligator Juniper/Sideoats Grama PA lacks significant shrub undergrowth, and, while Madrean grasses are present, the association is actually dominated by grasses with Great Plains affinity (sideoats grama, plains lovegrass or *Eragrostis intermedia*, and purple threeawn or *Aristida purpurea*). In contrast, the Alligator Juniper/Sandpaper Oak/Pine Muhly and Alligator Juniper/Sandpaper Oak/Bullgrass PAs are dominated by Madrean grasses such as pine muhly (*Muhlenbergia dubia*), bullgrass (*Muhlenbergia emersleyi*) New Mexico Muhly (*Muhlenbergia pauciflora*) and pinyon ricegrass (*Piptochaetium fimbriatum)* while scrub oaks (*Q. pungens* and *Quercus* × *pauciloba*) are usually well represented.

The Alligator Juniper/Canyon Grape PA is an association of canyon bottoms and is know from around 5,600 ft (1,700 m) and probably extends through the drainages to lower elevations. It is commonly associated with seeps and areas where enough moisture accumulates to support mesic species such as canyon grape (*Vitis arizonica*), tapered rosette grass (*Dichanthelium acuminatum* var. *acuminatum*), and if standing water is present, facultative and obligate riparian species such as Torrey rush (*Juncus torreyi*), inland rush (*J. interior*), and cardinal flower (*Lobelia cardinalis).*

The **Two-needle Pinyon Pine (*Pinus edulis*) Woodland Alliance** is represented by the Two-needle Pinyon Pine-Sandpaper Oak (*Pinus edulis-Quercus pungens*) PA (Figure 10). Two-needle pinyon (also known as Rocky Mountain or Colorado pinyon) is at the southern edge of its distribution in the Guadalupe Mountains, and hence is why the association is considered part of the Rocky Mountain Conifer woodland biome. In CCNP, stands are relatively uncommon and small, and are associated with ridge summits above 5,800 ft (1,770 m). The understory is dominated by scrub oaks and mountain mahogany (*Cercocarpus montanus*) and grass cover is low.

Figure 10. A small two-needle pinyon stand on Yucca Canyon mesa that is representative of Rocky Mountain Conifer Woodland at CCNP. (Photo: S. Yanoff)

There are also Rocky Mountain Deciduous Woodlands represented by the **Bigtooth Maple (*Acer grandidentatum*) Woodland Alliance** that occur along the drainages and slope ravines in the western portion of the park at elevations ranging from 5,750 to 6,200 ft (1,735 to 1,890 m). We have identified two associations: a Bigtooth Maple/New Mexico Muhly (*Acer grandidentatum/Muhlenbergia pauciflora*) PA and a Bigtooth Maple-Chinkapin Oak (*Acer grandidentatum-Quercus muehlenbergii*) PA. The former is characterized by scattered shrubs and the dominance of New Mexico muhly and bullgrass grasses. The latter association is co-dominated by chinkapin oak, a widespread oak in the eastern U.S., but near the western edge of its distribution in the Guadalupe Mountains. The canopy can be diverse and include Texas madrone (*Arbutus xalapensis*), along with scattered alligator juniper, Rocky Mountain juniper, two-needled pinyon and ponderosa pine. Because canopy cover can approach 80%, the undergrowth can be sparse, but still diverse with 67 species recorded for the association. This is a rather unique association of Trans-Pecos Texas and southern New Mexico and has been tentatively ranked as globally "imperiled" (NMNHP Rank G2?).

At lower elevations, the deciduous woodlands give way to Madrean Evergreen Woodlands of the **Gray Oak (*Quercus grisea*) Woodland Alliance**. The Gray Oak-Bigtooth Maple (*Quercus grisea-Acer grandidentatum*) PA and Gray Oak-Texas Madrone (*Quercus grisea-Arbutus xalapensis*) PA are known from elevations below 4,200 ft (1,280 m). They are typically found in horizontal bands associated with the contact between the Tansil and Yates geological formations. At this contact, water accumulates, often creating seeps and springs, and more mesic conditions for the development of woodlands. The stands are particularly prevalent in the headslope "coves" of drainages (hence we refer to them as "band-cove woodlands"). The canopies can reach 85% or more cover and can include Mohr shin oak (*Quercus mohriana*) and netleaf hackberry (*Celtis laevigata* var. *reticulata*) as canopy associates. The shrub layers are diverse and include mesic species such as Texas mulberry (*Morus microphylla*), Texas Mountain Laurel (*Sophora secundiflora*), evergreen sumac (*Rhus virens* var. *choriophylla*), and Southwestern chokecherry (*Prunus serotina* var. *virens*). Although grass and forb cover are low, these band-cove woodlands are important wildlife corridors that provide cover and browse at lower elevations where they are imbedded in a matrix of semi-desert grasslands and desert grasslands. As with the upper elevation bigtooth maple communities, these associations are uncommon in the Trans-Pecos region and hence and have been tentatively ranked as globally "imperiled" (G2?).

The Gray Oak/Texas Mountain Laurel Woodland (*Quercus grisea/Sophora secundiflora*) PA is more of an arroyo-riparian type found along canyon drainages at lower elevations. Accordingly, arroyo riparian species such as Mexican buckeye (*Ungnadia speciosa*) and little walnut (*Juglans microcarpa*) are common. Arroyo riparian communities in the Southwest that have not been impacted by grazing are rare. Accordingly, this association has been ranked at G3 and is considered vulnerable throughout its range.

Fire, or the lack of it, has likely played a significant role in the distribution and maintenance of forest and woodland communities in CCNP (Ahlstrand 1979, 1981, & 1982). While these woodlands are at their natural lower elevation limits (and hence prone to regeneration problems), the extent of woodlands was probably significantly larger in the past than it is currently, due to the impacts of 20th century fires. Large landscape-scale fires have swept through these areas during the past 50 years and likely eliminated or fragmented the larger

stands leaving behind the very open and small stands we see today. This is likely a function, in part, of fire suppression policies of the earlier part of the 20th century that typically dramatically altered fire regimes of southwestern pine forests (Grissino-Mayer 1995; Swetnam and Baisan 1996). There has been a shift from frequent, mostly low-intensity, often small, surface fires and only occasional large landscape-scale crown fires to regimes where large, high-intensity crown fires have become the dominant mode. This, in combination of a lack of favorable years for germination and survival of conifer seedlings in these marginal habitats, has likely limited succession back to woodlands, and favored the establishment and maintenance of semi-permanent montane shrublands dominated by scrub oaks and mountain mahogany. Additional research is still needed on the fire history of the park's woodlands in the context of climate and the autecology of the conifer and shrub species in order to determine effective management strategies.

Mesophytic Shrubland

Mesophytic shrublands of Madrean Montane Scrub and Chihuahuan Interior Chaparral dominate the vegetation of the park from mid to upper elevations (3,800 to 6,300 ft; 1,160 to 1,920 m) (Figure 11). Associations of the **Shaggy Mountain Mahogany (*Cercocarpus montanus* var. *paucidentatus*) Shrubland Alliance** are found at the highest elevations and represent cool-temperate Madrean montane deciduous scrub communities. Shaggy mountain mahogany (also known as hairy mountain mahogany) is a southwestern and northern Mexico variation of a species that is found throughout much of the western U.S. (hence the Madrean classification). The leaves are smaller and there is some suggestion, based on the habitats it occupies, that it may be a more drought-tolerant variation than the species as a whole. The four associations found within the park are typified by a shrub layer dominated by patches of shaggy mountain mahogany ranging in cover from 10 to 50% in a mosaic with various grasses (Table 7). Sandpaper oak (*Quercus pungens*), wavyleaf oak (*Q. x pauciloba*), Texas sacahuista (*Nolina texana*), and green sotol (*Dasylirion leiophyllum*) are common shrub associates, but never dominate. Three of the associations are well-established types known elsewhere in the southern New Mexico and are dominated respectively by bullgrass (*Muhlenbergia emersleyi)*, New Mexico muhly (*Muhlenbergia pauciflora*), and curlyleaf muhly (*Muhlenbergia setifolia*). The Shaggy Mountain Mahogany/Little Awn Needlegrass Shrubland (*Cercocarpus montanus* var. *paucidentatus/Achnatherum lobatum* PA) has not been described elsewhere but is probably closely related to Shaggy Mountain Mahogany/Scribner Needlegrass Shrubland (*Cercocarpus montanus /Achnatherum scribneri* PA known from south-central New Mexico. All the grass species are indicators of different habitats, but these are definite shrublands where grass cover seldom exceeds 15%.

Figure 11. Madrean Montane Shrublands and Chihuahuan Interior Chaparral dominate the landscape over much of the western portion of the park. This a view of Guadalupe Ridge near Hayhurst. Note the Alligator Juniper Savanna Woodland that dots the ridge tops. (Photo: A. Browder)

Associations of the Sandpaper Oak (*Quercus pungens*) Shrubland Alliance overlap the range of mountain mahogany communities but extend to lower elevations (4,200 to 6,200 ft; 1,280 to 1,890 m). Sandpaper oak and wavyleaf oak[6] (*Quercus x pauciloba*) are evergreen (more or less) scrub oaks that form a broadleaved variant of Chihuahuan Interior Chaparral in combination with an array of other shrubs such as desert Ceanothus (*Ceanothus greggii*), Texas sacahuista, Pinchot juniper (*Juniperus pinchotii*), banana yucca (*Yucca baccata*), lechuguilla (*Agave lechuguilla*), green sotol, damiantia (*Chrysactinia mexicana*), skunkbush sumac (*Rhus trilobata*), and others (a total of 44 shrub and subshrub species). Together they form extensive brush fields on the slopes and ridge top summits in the western portion of the park, and represent the largest vegetation type within the park. We have identified five provisional associations, which, with the exception of the Sandpaper Oak/Shaggy Mountain Mahogany Shrubland, are differentiated by various grass indicators (sideoats grama, New Mexico Muhly, curlyleaf muhly and little awn needlegrass). Grasses are found primarily found in the inter-shrub spaces and cover can range from 5% to 60%, depending on the degree of shrub cover. Only the Sandpaper Oak/Shaggy Mountain Mahogany Shrubland PA has been described elsewhere in the Southwest, the other four are currently known only from CCNP (Table 7).

The **Pinchot Juniper (*Juniperus pinchotii*) Shrubland Alliance** forms the needle-leaved component of the Chihuahuan Interior Chaparral and is generally found at lower elevations of the montane zone (3,800 to 6,000 ft; 1,160 to 1,830 m). In New Mexico, Pinchot juniper's main distribution is in the Guadalupe Mountains where it grows on shallow limestone upland soils or in lowland arroyo channels as a low branching shrub the seldom exceeds 2 m in height. Accordingly, Dick-Peddie (1993) considered Pinchot juniper to be part of montane shrublands and chaparral in New Mexico rather than a significant element of woodlands or plains grasslands in New Mexico. This is in keeping with its primary habitat in the Plains country of west Texas of rocky limestone breaks, foothills and drainages (Ellis and Schuster 1968). It is only comparatively recently that Pinchot juniper is thought to have invaded plains grasslands of finer textured soils—primarily as a function of intensive grazing and the lack of fire (Ellis and Schuster 1968; Wright and Bailey 1982; McPherson et al. 1988).

We have identified six associations from the alliance, two of which are co-dominated by sandpaper oak (Table 7). Juniper cover ranges from around 10% to as much as 40%, but overall cover of the main chaparral elements is always greater than grass cover. As with oak-dominated chaparral, shrub diversity is high (60 species) in Pinchot juniper communities, but because of the generally lower elevations, they tend to have more grassland and desert associated shrub species such as skeletonleaf goldeneye (*Viguiera stenoloba*), green sotol, tulip pricklypear (*Opuntia phaeacantha*), Torrey yucca (*Yucca torreyi*), algerita (*Mahonia trifoliata*), lechuguilla, catclaw mimosa (*Mimosa aculeaticarpa* var. *biuncifera*), and Wright beebrush (Aloysia wrightii). Grass cover seldom exceeds 15%, and along with curlyleaf muhly and sideoats grama, lower-elevation species are more prevalent, e.g. black grama (*Bouteloua eriopoda*), hairy grama (*B. hirsuta*), plains lovegrass (Eragrostis intermedia), and purple threeawn (*Aristida purpurea*).

[6] *Q. x pauciloba* is a broadly defined hybrid complex that can include hybrids between *Q. pungens, Q. grisea, Q. gambelii,* and *Q. muehlenbergii*. There are a variety of forms present at CCNP that need further study to sort out. For the purposes of the vegetation classification, however, *Q. x pauciloba* has been lumped with *Q. pungens*, but remains a separate entity in the database.

As with woodlands, fire plays an important role in the establishment and maintenance of montane shrublands and chaparral. The oaks, mountain mahogany, and Pinchot juniper can be vigorous resprouters following fire and hence are integral to the dynamics of these fire adapted ecosystems (Correll and Johnston 1970; Pase and Brown 1982; Ahlstrand 1982; Wright and Bailey 1982; Bryant et al. 1983; Steuter and Britton 1983; McPherson 1992). While fire records are incomplete for CCNP, the extensive areas covered by chaparral in the western portion of the park suggest that large fires have swept through the areas repeatedly, possibly reducing woodlands and favoring the development of shrublands. Yet, this does not mean that all montane shrublands are successional types to woodlands following fire—shallow soils and steep slopes often preclude the development of woodlands and, hence, chaparral and montane shrublands are likely the "potential" natural vegetation for much of the rugged canyon country within the park.

Site conditions aside, the dynamics of fire within chaparral are still complex. In southern California, it has been suggested that the even-aged and large size of modern chaparral patches are a function of 20th century fire suppression feedbacks whereby intensive suppression has led to large fuel buildups over large areas of landscape leading to large stand-replacement fires of ever increasing size (Minnich 1983; 2001). Others contend that the large patch patterns are within that natural range of variability, and that they are driven more by climate trends, prevailing weather patterns, increased human ignition frequencies with increased population density, changes in land use, and landscape characteristics rather than suppression (Keely and Fotheringham 2001a & b; Moritz 2003). The pattern of chaparral distribution in CCNP suggests that the latter scenario might be the case here. Because of the rugged country, effective suppression has been minimal, particularly in the western portion of the park[7]. Hence, the large patches of chaparral may be representative of a more or less natural fire regime, but one possibly modified by increased human caused fires and fire suppression on neighboring forested lands. Early 20th century fire suppression in forests on USFS lands to the west of the park may have led to greater numbers of high intensity fires as a function of increased human starts (as use increased) and with more effective lightning ignitions in the now heavily wooded ponderosa pine forests. These more frequent, intense fires subsequently spread into the park more often, leading to the decline of the grassy woodland savannas on the ridge top summits and a favoring of shrublands (possibly enhanced by increased fine fuels with the cessation of livestock grazing). In this type of fire regime, Keely and Fotheringham (2001b) and Moritz (2003) contend that prescribed burning may be useless or even harmful and that fire suppression, at least in the short term, may be more appropriate for maintaining an ecosystem near its natural state. Minnich (2001) would likely argue the opposite saying it is fire suppression that generates the large patch pattern and that prescribed fire is needed to restore a small patch mosaic with imbedded natural fuel firebreaks. Detailed fire history studies that focus on chaparral patch age structure in a landscape context would be useful (and perhaps necessary) to help resolve these conflicting viewpoints and generate management options that are tailored to the montane shrublands and upper chaparral of CCNP.

At the other end of the elevation spectrum, repeated burning of chaparral, particularly Pinchot juniper, has been suggested as a way to increase grass cover in shrubland communities within CCNP (Ahlstrand 1982). Most of our understanding of how to manage of Pinchot juniper comes from the high Plains of Texas where it is seen as an invader of fine textured plains

[7] Personal communication D. Roemer, CCNP biologist

grasslands soils, and where management has focused on control and eradication to increase livestock forage. Research from the high plains indicates that the effectiveness of fire in controlling Pinchot juniper is a function of fire intensity, climatic conditions and position of the bud zone above or below the soil (Stueter and Britton 1983). Fire was particularly effective in inducing mortality in young plants with exposed buds on rocky sites, but this dropped off significantly with older plants. In addition, increased grass cover (grama grasses) can inhibit reproduction (Smith et al. 1975). As Ahlstrand (1982) has shown, fires can lead to at least short-term increases in grass cover, but because Pinchot juniper can recover 50% or more of its original cover within six or seven years of a burn, repeated prescribed fires at 10- to 15-year intervals would be needed to sustain a grassland type.

Whether this is an appropriate management perspective in the park, or for juniper woodlands in general, is open to debate (Belsky 1996). Clearly Pinchot juniper is an important element within the chaparral and upland desert grasslands of the park (see below), but is this a relatively recent phenomenon driven by historical land use, i.e., overgrazing and lack of fire, or one predicated by longer term climatic trends and soil conditions? Pinchot juniper seems to be most prevalent in soils of the Tansil Formation, particularly among its lower members and at the contact with the Yates Formations where moisture conditions favor shrub establishment (rocky sites with deep accumulations of available water). Both up and down in elevation from this contact, juniper abundance declines (although it still is present over a wide environmental range). These strong edaphic correlations with abundance in the park correspond more or less to the rocky limestone breaks and rough land associated with shrubby Pinchot juniper throughout its range (Ellis and Schuster 1968; Powell 1988). While fire at the lower ends of its distribution may help limit some establishment at the seedling stage, it may not have much effect in the heart of its distribution over the long term. There is also some evidence that increased grass cover can limit juniper establishment (Smith et al. 1975), and that there is a degree of density dependence with respect to seedling establishment under dense canopies of Pinchot juniper (Ellis and Schuster 1968). Hence, the removal of livestock from the park and the consequent increase in grass cover alone has probably helped limit the expansion of Pinchot juniper, particularly into desert grasslands. This is not to say fire is unimportant in these systems, it most certainly is, but rather the use of fire as a tool to "control" juniper may not be the best approach to management of the ecosystems as a whole. Rather, how fire is to be used should be driven by a site-specific understanding of the ecological dynamics of desert grasslands and montane shrublands in the park landscape.

Overall, caution needs to be exercised when extrapolating fire regimes beyond the local landscape setting (Keeley and Fotheringham 2001 a & b) or from one ecosystem to other (Johnson et al. 2001), particularly in the case where fire suppression has historically been weak or non-existent. Therefore, experimental studies on the establishment of juniper and other shrubs along with long-term monitoring of vegetation, both burned and unburned across many habitats, are critical to understanding how to apply fire and other management tools in an ecologically sound way within the park.

Grassland

The grasslands of the park fall into two broad categories: 1) upper elevation cold temperate Madrean Plains-Mesa-Foothill Grasslands that are intermixed among chaparral, montane shrublands and woodlands, and 2) lower elevation warm-temperate Chihuahuan Semidesert Grasslands that extend from the contact with chaparral down into the lowland desert basins (Table 7).

Figure 12. Chihuahuan Foothill-Piedmont Desert Grassland dominates much of the middle elevation landscape of the park. This a view of tanglehead- dominated grassland in the foreground and curlyleaf muhly-dominatedgrasslands in the mid ground and along the upper slopes. (Photo: E. Muldavin)

The cold temperate grasslands are represented by **Texas Sacahuista (*Nolina texana*) Shrub Herbaceous Alliance** of three associations dominated by sideoats grama, bullgrass and curlyleaf muhly, respectively. These associations tend to occur at elevations above 5,800 ft (1,700 m) along the ridge top summits, typically in a mosaic with montane shrublands. Texas sacahuista is the shrub dominant and can reach up to 15% cover, and occasionally a chaparral element such as sandpaper oak, shaggy mountain mahogany and Pinchot juniper are well represented, but shrubs on the whole seldom exceed 10%. In contrast, grass cover can run 30% or more, and is typified along with association dominants by more mesic species such as hairy grama, New Mexico muhly, plains lovegrass, and bristly wolfstail (*Lycurus setosus*).

The warm temperate Chihuahuan Semidesert Grasslands are a complex group made up of two major Alliance Groups—Chihuahuan Foothill-Piedmont Desert Grassland of moderate elevations and Chihuahuan Lowland/Swale Desert Grassland of the desert floor. Chihuahuan Foothill-Piedmont Desert Grasslands are the dominant grasslands in CCNP and are most prominently represented by the **Lechuguilla-Green Sotol Shrub Herbaceous Alliance** (Figure 12). We have subsequently defined seven associations based on the dominance of curlyleaf muhly, sideoats grama, black grama or slim tridens (*Tridens muticus*), and their respective shrub element(s). Besides lechuguilla and green sotol, over 72 other shrub and dwarf species have been recorded for the alliance, of which skeletonleaf goldeneye, featherplume (*Dalea formosa*), silver prairieclover (*Dalea bicolor* var. *argyraea*), roundflower catclaw (*Acacia roemeriana*) and tulip pricklypear are most common and indicative. While shrubs can make up a significant portion of these communities (anywhere from 1% to 20% tall shrub cover), grasses still dominate with covers ranging as high as 65%, and they are the key to the dynamics of these communities, particularly with respect to fire (see below).

The grasslands of this alliance that are most common are dominated by curlyleaf muhly (Curlyleaf muhly/Green Sotol, Curlyleaf muhly/ Lechuguilla, and Curlyleaf muhly/Lechuguilla/Green Sotol plant associations). They give the mid-elevation slopes their distinctive character and are part of what sets the landscape of CCNP apart from most others in the Southwest. Curlyleaf is almost entirely restricted to the Chihuahuan Desert where it occurs

sporadically and mostly on rocky, limestone slopes (Hendrickson and Johnston 1997). While similar curlyleaf muhly-dominated communities are found occasionally throughout the range, none are known to dominate their respective landscapes as those on CCNP do. Again, this may be driven by the unusual geology that makes this a unique landscape, and as a result, these associations have been ranked as S1S2 on a statewide basis and globally as G3.

We know little about the ecology of curlyleaf muhly except for its propensity for rocky limestone hills and elevations between 4,000 and 5,800 ft (1,220 and 1,770 m). It, like other bunchgrass muhlys, may be susceptible to grazing, and hence the absence of livestock on CCNP has likely led to increased abundance and coincidentally to increased fine fuels for fires. The direct effects of fire on curlyleaf muhly are not known at this time, but Ahlstrand (1982) reported that there was no difference in cover between selected burned and unburned sites in CCNP after six to seven years. Fire likely reduces curlyleaf muhly cover in the short term, along with succulents and rosette shrubs such as lechuguilla and sotol. Accordingly, it appears that some burned sites may undergo a successional process whereby communities such as the Sideoats Grama/Green Sotol or Sideoats Grama/Tanglehead/Green Sotol dominate early post-fire conditions and then give way to curlyleaf muhly as they recover over the following decade. While fire can have immediate and dramatic impact on lechuguilla (Ahlstrand 1982), it is not clear, given the cyclic nature of lechuguilla lifecycles, what the long-term effects are. Similarly, green sotol and Texas sacahuista also can undergo significant mortality following fire (although not to the degree that lechuguilla does), but they generally appear to regain their coverage within five or six years.

Where lechuguilla and green sotol are minor elements, communities of the **Halls's panicgrass Herbaceous Alliance**, **Black Grama Herbaceous Alliance, Blue Grama Shrub Herbaceous Alliance** and **Curlyleaf Muhly Herbaceous Alliance** often prevail. Associations of the Curlyleaf Muhly Herbaceous Alliance typically represent recently burned extensions of their more shrubby analogs in the Lechuguilla-Green Sotol Alliance. Hall's Panicgrass-Hairy Tridens and Black Grama-Sideoats Grama grasslands are primarily associated with alluvial fans and piedmonts (also known as "bajadas") that extend out from the main escarpment to the basin bottom or along toeslopes and fans of the inner canyons. In contrast, the Black Grama-Blue Grama PA along with the Blue Grama-Tobosagrass/Catclaw Mimosa PA are usually found on older alluvial terraces of the major drainages. While relatively minor components of the CCNP grasslands, black grama grasslands are considered threatened regionally by overgrazing (S2 and G2 rankings).

The grama and panicgrass-hairy tridens grasslands of the alluvial fan piedmonts give way at lower elevations to the Chihuahuan Lowland/Swale Semidesert Grassland of the Delaware Basin floor. These are represented here by the Tobosagrass Herbaceous Alliance, and specifically the Tobosagrass-Burrograss PA. This common association of the Southwest occurs on fine-textured soils associated with basin fill alluvial deposits. It is often found in a matrix with basin desert scrub communities dominated by tarbush (*Flourensia cernua*) and littleleaf sumac (*Rhus microphylla*). The presence of burrograss commonly reflects past grazing impacts.

Xerophytic Shrubland

Figure 13. An Ocotillo-Mariola Shrubland in lower Walnut Canyon that is representative of a typical Chihuahuan Desert Scrub community on rocky south-facing limestone slopes of the park. (Photo: Y. Chauvin)

Xerophytic shrublands of CCNP are presented by a diverse collection of Chihuahuan Desert Scrub communities (Figure 13). Typically, shrubs are more abundant than grasses in aggregate, and following the national standard, any communities where tall shrubs exceed 25% cover are considered shrublands regardless of grass cover. At elevations ranging between 3,750 and 5,000 ft (1,140 and 1,525 m) and occasionally higher in the Guadalupe Mountains, Chihuahuan Foothill-Piedmont Desert Scrub represented by **Viscid Acacia (*Acacia neovernicosa*), Ocotillo (*Fouquieria splendens*), Catclaw Mimosa (*Mimosa aculeaticarpa*),** and **Mariola (*Parthenium incanum*) Shrubland Alliances** predominates. We have identified 10 associations that form a complex mosaic, often in combination with foothill-piedmont desert grasslands (particularly at the upper elevation contact). The grasslands tend to be found on the relatively cooler aspects, while the desert scrub communities are found on the warmer, often rockier sites. These are species-rich shrub communities with over 60 shrub species recorded from the group and with an expectation of 10 to 15 species at any given site. Grasses are often common in these foothill and bajada shrub communities and even occasionally dominate the understory (e.g., Viscid Acacia/Black Grama and Viscid Acacia/Blue Grama PAs), but shrubs are always well represented and diagnostic.

We have separated out a Chihuahuan Succulent Scrub represented by the Cactus Apple (*Opuntia engelmannii*) Shrubland Alliance with three associations that occurs on the extreme sites among other desert scrub communities, i.e., steep southwest slopes (>35%) at elevations below 4,100 ft (1,250 m). These associations are clearly dominated by cactus with covers that can exceed 20% on their own. While shrubs remain diverse (30 species recorded), grasses are poorly represented (less than 5% cover) and are relatively low in diversity (15 species).

Because of its prevalence, both on CCNP and in the Chihuahuan Desert as whole, we have specified a **Creosotebush (*Larrea tridentata*) Shrubland Alliance** with four associations that dominates the lower bajada slopes south of the main escarpment. Tarbush, Christmas cactus (*Opuntia leptocaulis*), mariola, and honey mesquite (*Prosopis glandulosa*) are common shrub associates, and in two of the associations, viscid acacia is a codominant (Creosotebush-Viscid Acacia/Black Grama and Creosotebush/Viscid Acacia/Sparse PAs) with creosotebush.

The desert shrubland corollaries to Chihuahuan Lowland/Swale Grassland are Chihuahuan Basin Desert Scrub communities represented by the **Tarbush Shrubland Alliance** and **Littleleaf Sumac Shrubland Alliance.** These occur on basin alluvial flats with fine-textured soils often intermixed with Tobosagrass-Burrograss Grassland, or in large arroyo

bottoms with gentle gradients. Occasionally, tarbush and littleleaf sumac communities are found in suitable upland microhabitats as patches among foothill desert scrub and grassland communities. As with creosotebush scrub, we have identified a separate Chihuahuan Mesquite Desert Scrub, but the particular association—Honey Mesquite/Tobosagrass—is typically found in a mosaic with tarbush and littleleaf sumac shrublands as well as tobosagrass grasslands.

Riparian/Wetland

Riparian and wetland communities fall into two categories: occasionally flooded Southwest Arroyo Riparian Woodland and Shrubland and Lowland Interior Southwest Broad-leaved Deciduous Forested Wetland per Muldavin et al. (2000) versus semi-permanently flooded herbaceous Lowland Persistent Emergent Wetlands (Table 7). The forested wetlands are represented by the **Rio Grande Cottonwood (*Populus fremonti*i ssp. *wislizenii*) Temporarily Flooded Forest Alliance**, and are restricted to the wetland areas downstream of springs in the Rattlesnake Springs unit of the park. While limited in distribution within the park, these are important riparian occurrences regionally where they serve as refugia for a host of animal species, particularly birds. They are considered globally threatened due to altered hydrological regimes. In fact, since the hydrological regime at Rattlesnake Springs has been significantly modified to meet water supply needs for the park and adjacent landowners, the wetland areas have been significantly reduced from their historical extent (they may have extended all the way to the Black River). Because of these hydrological modifications and the development that has taken place at Rattlesnake Spring, an in-depth ecological analysis is needed to determine the best management options to sustain this globally significant wetland oasis.

There is a small, previously undescribed upland Western Umbrella-sedge-Sand Spikerush Herbaceous Wetland (*Fuirena simplex/ Eleocharis montevidensis* PA) at Longview Spring (Figure 14). Western umbrella-sedge is an obligate wetland species known from south-central U.S. into southern New Mexico and Arizona. Other remote spring areas of the park also likely support unique wetlands.

The arroyo woodlands are represented by the **Netleaf Hackberry Woodland Alliance** and **Little Walnut Woodland Alliance** and have a scattered distribution along the arroyo washes of the park. The Netleaf Hackberry-Little Walnut and Little Walnut-Desert Willow/Sideoats Grama arroyo woodlands are found along the lower portions of the major drainages of the park (Walnut, Rattlesnake, Slaughter, and Double) where the gradients are low enough to allow the deposition of sands and gravels (as opposed to upslope mostly eroding ravine channels). They are intermixed with **Apache Plume** and **Green Sotol** arroyo shrublands communities which often occupy low lying alluvial terraces as well as the open washes (Apache Plume/Green Sotol and Green Catclaw/Catclaw Mimosa PAs).

Figure 14. Netleaf Hackberry-Little Walnut Arroyo Woodland in lower Walnut Canyon (Photo: E. Muldavin)

Vegetation Map

Map Applications and Accuracy

Using the vegetation classification as a foundation, we have developed a vegetation map containing 33 mapping units (Table 8). The map has been produced on a single sheet at the original target scale of 1:24,000. In addition, the high resolution of the imagery made it possible to produce the map on multiple sheets at 1:12,000 scale. A small-scale version of the map at approximately 1:100,000 is shown in Figure 15. While the NPS standards call for a minimum map unit delineation of 0.5 ha, to avoid the loss of subtle horizontal banding patterns, the minimum map unit was reduced here to approximately 500 sq. m (0.05 ha). In addition, the Cliff/Rock/Barren/Arroyo Wash map unit was left at its original one-meter resolution. We consider 1:24,000 ideal for natural resources management at the landscape scale, e.g., fire planning, animal and plant habitat modeling, or recreation planning. We would suggest that 1:12,000 is more appropriate for local site level needs, e.g., site-specific sensitive species habitat analysis and clearance surveys, habitat manipulations, or general facilities planning. We would caution against application at finer scales because of the limits posed by spatial error (geometric correction error of the imagery). More importantly, even though the minimum map delineation is small at 0.05 ha, the focus should remain on the large patch pattern in any analysis—the error rate increases as patch size goes down and minor local variations in reflectance generate incidental aberrant signatures. Typically, aberrant patches are recognizable because they are out of context with respect to the surrounding vegetation matrix, but a good rule of thumb is to use an operational minimum patch size of about 0.25 ha for most analyses.

Based on informal accuracy assessment from the 400 vegetation plots and field reconnaissance charting, we estimate that the map falls well within the 80% accuracy standard of the NPS from a producers point of view. Because we used all available vegetation plots for map development, the only independent data available for accuracy assessment is a set of 30 NPS fire monitoring plots that were established in the park during the past decade. Of the 29 plots tested, 23 either fell directly within the correct map unit, or within 30 m of it (one Thematic Mapper pixel equivalent), i.e., they were either primary or secondary components of the map units and within the spatial error of the map. Of the six misclassifications, five were still inclusions within respective map units. Only one plot was completely misclassified (a curlyleaf grassland was mapped as a grama terrace grassland). While limited in distribution and composition (26 were various grassland plots and three were desert shrublands), they give at least an initial indication of the accuracy of the map from a user's point of view.

Table 8. Map units for the Carlsbad Caverns National Park Vegetation Map, 2003

Map Unit	Ha	Acres	No.
Woodland			
Ponderosa Pine Woodland	52	129	11
Alligator Juniper - Pinyon Pine Woodland Savanna	276	682	15
Maple - Oak Ravine Woodland	366	903	10
Oak - Madrone Band-Cove Woodland	21	51	12
Montane Shrubland			
Dense Oak - Mountain Mahogany Shrubland	1619	4001	30
Moderate Oak - Mountain Mahogany Shrubland	3143	7766	33
Sparse Oak - Mountain Mahogany Shrubland	1010	2497	34
Pinchot Juniper - Oak Shrubland	1113	2750	31
Pinchot Juniper Shrubland	341	844	32
Grassland			
Curlyleaf Muhly Grassland	2529	6249	100
Curlyleaf Muhly Grassland with Oak and Mountain Mahogany	1358	3356	101
Curlyleaf Muhly Grassland with Pinchot Juniper	946	2338	103
Grama Grasslands	488	1206	110
Grama Grasslands with Pinchot Juniper	72	178	111
Grama Grasslands with Desert Shrubland	260	641	114
Grama Terrace Grassland	117	290	112
Tobosa Basin Grassland	133	328	120
Desert Shrubland			
Mariola - Goldeneye Desert Shrubland	1328	3282	51
Cactus - Ocotillo Desert Succulent Shrubland	857	2118	53
Viscid Acacia Desert Shrubland	1011	2497	40
Creosote Bush - Viscid Acacia Desert Shrubland	440	1088	52
Tarbush - Littleleaf Sumac Desert Shrubland	101	250	42
Catclaw Mimosa Desert Shrubland	24	60	41
Arroyo Riparian Woodland and Shrubland			
Arroyo Riparian Woodland	67	164	14
Canyon/Bajada Arroyo Riparian Shrubland	203	503	24
Green Sotol - Apache Plume Arroyo Riparian Shrubland	98	243	23
Desert Willow Arroyo Riparian Shrubland	121	300	20
Mixed Arroyo Riparian Shrubland	128	315	21
Mimosa-Acacia Arroyo Riparian Shrubland	92	228	22
Other			
Herbaceous Wetland	5	12	121
Forested Wetland	6	14	16
Cliff/Rock/Barren/Arroyo Wash	628	1553	9
Agriculture/Old Field	57	142	7
Developed/Roads	109	268	8
Total Area	19120	47247	

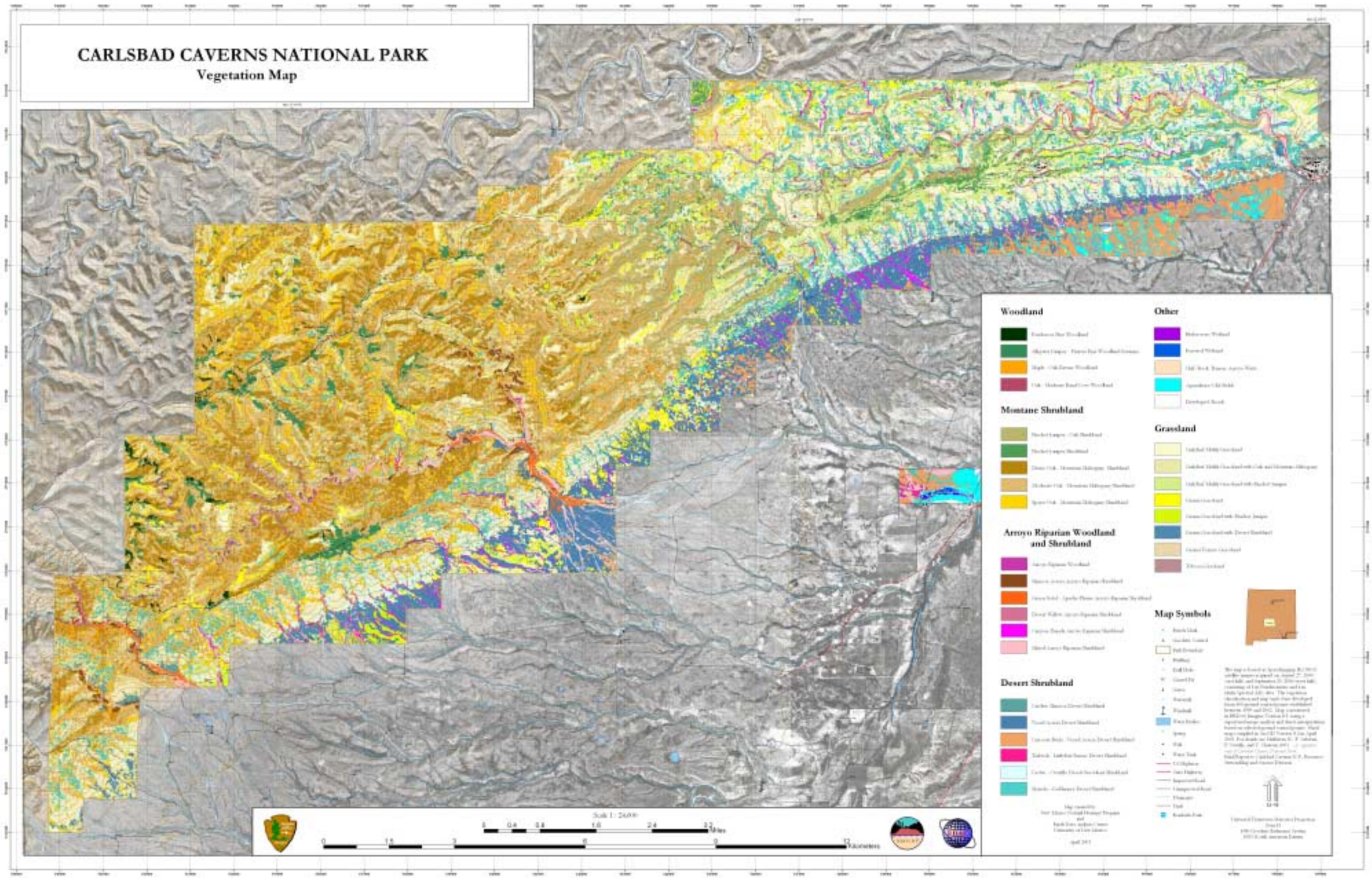


Figure 15 A reduced scale version (approximately 1:100,000) of the Carlsbad Caverns National Park vegetation map, 2003. See text for map unit descriptions..

MAP UNIT DESCRIPTIONS

Map unit descriptions for each map unit listed in Table 8 follow. For each unit, the primary and secondary components are listed along with inclusions. Primary components are those plant associations listed in Table 7 that together comprise the majority of the unit. Secondary components are minor associations that can occupy at least 10% of the unit, but are not the dominants. Inclusions are associations that occupy less than 10% of the area. The descriptions are grouped by Woodlands, Montane Shrublands and Chaparral, Grasslands, Desert Shrublands, Arroyo Riparian Woodlands and Shrublands, and other wetland and miscellaneous types. Cover criteria by strata are provided for each map unit, along with information on distribution within the park.

Woodlands

Ponderosa Pine Woodland	**11**
Trees > 10%	
Ha: 52	**Acres:** 129
Primary Components: Ponderosa Pine/Sandpaper Oak/New Mexico Muhly	
Secondary Components: Ponderosa Pine-Chinkapin Oak/Pinyon Ricegrass	
Inclusions: Pinyon Pine-Sandpaper Oak	
Distribution: minor Madrean Montane Forest and Woodland map unit that occurs as small stands (<1 ha) on ridge top summits, north-facing slopes, and as "stringers" along canyon bottoms. Mainly in the west half of the park between 5,200 and 6,400 ft.	

Figure 16. Ponderosa Pine/Sandpaper Oak/New Mexico Muhly Woodland on the west end of Yucca Mesa ridge. Fire, plus the limited potential for reproduction, keeps most stands open. (Photo: E. Muldavin)

Alligator Juniper – Pinyon Pine Woodland Savanna	**15**
Trees >10%	
Ha: 276	**Acres:** 682
Primary Components: Alligator Juniper/Sideoats Grama Alligator Juniper/Sandpaper Oak/Pine Muhly Alligator Juniper/Sandpaper Oak/Bullgrass	
Secondary Components: Alligator Juniper/Canyon Grape	
Inclusions: Sandpaper Oak/Shaggy Mountain Mahogany Ponderosa Pine/Sandpaper Oak/New Mexico Muhly Pinyon Pine-Sandpaper Oak	
Distribution: limited Rocky Mountain Conifer Woodland map unit. Occurs as small to medium sized stands on ridge top summits, north-facing slopes and as "stringers" along canyon bottoms. Mainly in the west half of the park between 5,000 and 6,400 ft.	

Figure 17. Alligator Juniper/Sideoats Grama Woodland Savanna on Yucca Mesa ridge at about 6,000 ft. Fires have helped maintain an open woodland savanna structure. (Photo: S. Yanoff)

Maple-Oak Ravine Woodland	**10**
Trees > 25%	
Ha: 366	**Acres:** 903
Primary Components: Bigtooth Maple/New Mexico Muhly Bigtooth Maple-Chinkapin Oak	
Secondary Components:	
Inclusions: Gray Oak-Bigtooth Maple Ponderosa Pine-Chinkapin Oak/Pinyon Ricegrass Alligator Juniper/Canyon Grape	
Distribution: limited Rocky Mountain Broad-leaved Deciduous Woodland map unit. The Bigtooth Maple/New Mexico Muhly PA occurs in small stands in north-facing ravines at elevations above 5,000 ft in the western portion of the park . The Bigtooth Maple-Chinkapin Oak PA is also found in ravines and as part of the "band-cove" woodlands at mid-elevations in the eastern portion of the park.	

Figure 18. Bigtooth Maple-Chinkapin Oak Woodland in a ravine near Hayhurst along Guadalupe Ridge (elevation 6,155 ft). (Photo: Y. Chauvin)

Oak- Madrone Band Cove Woodland	**12**
Trees > 25%	
Ha: 21	**Acres:** 51
Primary Components: Gray Oak-Texas Madrone Gray Oak-Bigtooth Maple	
Secondary Components: Bigfoot Maple-Chinkapin Oak	
Inclusions: Gray Oak/Texas Mountain Laurel Pinchot Juniper/Curlyleaf Muhly	
Distribution: minor Madrean Evergreen Woodland map unit. Small stands occur on north-facing slopes and in headslope coves where they commonly form bands along horizontal sedimentary rock strata, particularly at the contact between the Tansil and Yates formations. Mostly found at middle-elevations between 4,000 and 5,000 ft in the eastern portion of the park.	

Figure 19. A band of Gray Oak-Texas Madrone Woodland in a north-facing, mid-slope cove in lower Walnut Canyon (elevation 4,000 ft). Although limited in extent these are important wildlife habitats and corridors. (Photo: E. Muldavin)

Montane Shrublands and Chaparral

Dense Oak – Mountain Mahogany Shrubland	**30**
Tall shrubs >50%	
Ha: 1,619	**Acres:** 4,001
Primary Components: Sandpaper Oak/Shaggy Mountain Mahogany Shaggy Mountain Mahogany/Curlyleaf Muhly Sandpaper Oak/Curlyleaf Muhly Sandpaper Oak/Sideoats Grama Sandpaper Oak/New Mexico Muhly Shaggy Mountain Mahogany/New Mexico Muhly	
Secondary Components: Shaggy Mountain Mahogany/Little Awn Needlegrass Shaggy Mountain Mahogany/Bullgrass Sandpaper Oak/Littleawn Needlegrass	
Inclusions: Pinchot Juniper/Sandpaper Oak/Sideoats Grama Pinchot Juniper/Sandpaper Oak/Hairy Grama	
Distribution: major dense canopied Broadleaved Chihuahuan Interior Chaparral and Montane Shrubland map unit that occurs primarily on north-facing slopes at elevations from 5,000 to 6,400 ft. Mainly found in the western portion of the park.	

Figure 20. Sandpaper Oak/New Mexico Muhly Shrubland near Hayhurst along Guadalupe Ridge at 6,028 ft. (Photo: P. Arbetan)

Moderate Oak – Mountain Mahogany Shrubland	**33**
Tall shrubs >25% and <50%	
Ha: 3,143	**Acres:** 7,766
Primary Components: Sandpaper Oak/Curlyleaf Muhly Shaggy Mountain Mahogany/Curlyleaf Muhly Shaggy Mountain Mahogany/New Mexico Muhly Sandpaper Oak/New Mexico Muhly Sandpaper Oak/Sideoats Grama	
Secondary Components: Shaggy Mountain Mahogany/Bullgrass Sandpaper Oak/Shaggy Mountain Mahogany Sandpaper Oak/Littleawn Needlegrass Shaggy Mountain Mahogany/Little Awn Needlegrass	
Inclusions: Pinchot Juniper/Sandpaper Oak/Sideoats Grama Pinchot Juniper/Sandpaper Oak/Hairy Grama	
Distribution: major, moderately open Broadleaved Chihuahuan Interior Chaparral and Montane Shrubland that occurs primarily on ridge top summits and easterly and westerly slopes at elevations from 5,000 to 6,400 ft.	

Figure 21. Sandpaper Oak/Shaggy Mountain Mahogany Shrubland on a western ridge above Slaughter Canyon at 5,996 ft. (Photo: P. Arbetan)

Sparse Oak – Mountain Mahogany Shrubland	**34**
Tall shrubs >10% and <25%; grasses < shrubs	
Ha: 1,010	**Acres:** 2,497
Primary Components: Sandpaper Oak/New Mexico Muhly Shaggy Mountain Mahogany/New Mexico Muhly Sandpaper Oak/Sideoats Grama	
Secondary Components: Sandpaper Oak/Curlyleaf Muhly Shaggy Mountain Mahogany/Curlyleaf Muhly Shaggy Mountain Mahogany/Little Awn Needlegrass Sandpaper Oak/Littleawn Needlegrass Shaggy Mountain Mahogany/Bullgrass	
Inclusions: Pinchot Juniper/Sandpaper Oak/Sideoats Grama Pinchot Juniper/Sandpaper Oak/Hairy Grama Sandpaper Oak/Shaggy Mountain Mahogany	
Distribution: major, sparse canopied Broadleaved Chihuahuan Interior Chaparral and Montane Shrubland map unit that occurs primarily on steep, rocky north-facing slopes at elevations from 5,000 to 6,400 ft.	

Figure 22. Sandpaper Oak/New Mexico Muhly Shrubland on a steep rocky slope near Hayhurst at 5,714 ft along Guadalupe Ridge. (Photo: P. Arbetan)

Pinchot Juniper - Oak Shrubland	**31**
Tall shrubs >25%; oak and Pinchot Juniper co-dominants	
Ha: 1,113	**Acres:** 2,750
Primary Components: Pinchot Juniper/Sandpaper Oak/Sideoats Grama Pinchot Juniper/Sandpaper Oak/Hairy Grama	
Secondary Components: Pinchot Juniper/Sideoats Grama Pinchot Juniper/Curlyleaf Muhly	
Inclusions: Sandpaper Oak/Sideoats Grama Sandpaper Oak/New Mexico Muhly	
Distribution: major mixed Chihuahuan Interior Chaparral map unit. It occurs along the upper potion of the Loop Road extending westward along north-facing slopes between Rattlesnake Canyon and Slaughter Canyon. Elevations are typically between 4,400 and 5,500 ft.	

Figure 23. Pinchot Juniper/Sandpaper Oak/Sideoats Shrubland on a gentle upper slope along Loop Road at about 4,532 ft. (Photo: D. Odell).

Pinchot Juniper Shrubland	**32**
Tall shrubs >25%; oak <10%	
Ha: 341	**Acres:** 844
Primary Components: Pinchot Juniper/Curlyleaf Muhly Pinchot Juniper/Sideoats Grama	
Secondary Components: Pinchot Juniper/Black Grama	
Inclusions: Pinchot Juniper/Sandpaper Oak/Sideoats Grama Pinchot Juniper/Sandpaper Oak/Hairy Grama Curlyleaf Muhly/Lechuguilla-Green Sotol Sideoats grama/Lechuguilla-Green Sotol	
Distribution: limited Needle-leaved Chihuahuan Interior Chaparral map unit. It occurs along upper north-facing slopes between Rattlesnake Canyon and the mouth of Walnut Canyon. Typically occurring on ridge summits of the Tansil Formations and as bands along mid and upper slopes at elevations between 3,800 and 4,800 ft.	

Figure 24. Pinchot Juniper/Curlyleaf Muhly Shrubland on a gentle upper slope at about 4,650 ft along the Loop Road. (Photo: E. Muldavin)

Grasslands

Curlyleaf Muhly Grassland	**100**
Tall shrubs <10%	
Ha: 2,529	**Acres:** 6,249
Primary Components: Curlyleaf Muhly/Lechuguilla Curlyleaf Muhly/Lechuguilla-Green Sotol Curlyleaf Muhly/Green Sotol Curlyleaf Muhly-Sideoats Grama	
Secondary Components: Curlyleaf Muhly-Hairy Tridens	
Inclusions: Sideoats Grama/Green Sotol Sideoats Grama/Lechuguilla-Green Sotol	
Distribution: major Chihuahuan Foothill-Piedmont Desert Grassland map unit that primarily occurs on upper slopes and ridge top summits in the eastern portion of the park. Elevations range from 4,000 to 5,000 ft.	

Figure 25. Curlyleaf Muhly/Green Sotol Grassland near Rattlesnake Canyon Trailhead at 4,601 ft. (Photo: Y. Chauvin)

Curlyleaf Muhly Grassland with Oak and Mountain Mahogany	**101**
Tall Shrubs >10 and <25%; grasses dominant	
Ha: 1,358	**Acres:** 3,356
Primary Components: Curlyleaf Muhly-Sideoats Grama/Texas Sacahuista Mountain Mahogany Phase Bullgrass/Texas Sacahuista, Sandpaper Oak Phase	
Secondary Components: Sideoats Grama/Texas Sacahuista , Sandpaper Oak Phase	
Inclusions: Sandpaper Oak/Curlyleaf Muhly Shaggy Mountain Mahogany/Curlyleaf Muhly Shaggy Mountain Mahogany/New Mexico Muhly Sandpaper Oak/New Mexico Muhly Sandpaper Oak/Sideoats Grama	
Distribution: major Madrean Plains-Mesa-Foothill Grassland map unit with a shrubby component that occurs primarily on upper slopes and ridge top summits in the western portion of the park. Elevations range from 5,000 to 6,400 ft.	

Figure 26. Curlyleaf Muhly-Sideoats Grama/Texas Sacahuista, Mountain Mahogany Phase Grassland located north of Hayhurst along Guadalupe Ridge at 5,868 ft. Grasses are still dominant, and shrubs are represented by Texas sacahuista, mountain mahogany, sandpaper oak and Pinchot juniper. (Photo: Y. Chauvin)

Curlyleaf Muhly Grassland with Pinchot Juniper	**103**
Pinchot juniper >10 and <25%; grasses dominant	
Ha: 946	**Acres:** 2,338
Primary Components: Curlyleaf Muhly/Lechuguilla, Pinchot Juniper Phase Curlyleaf Muhly/Lechuguilla-Green Sotol, Pinchot Juniper Phase	
Secondary Components: Sideoats Grama/Lechuguilla-Green Sotol, Pinchot Juniper Phase	
Inclusions: Pinchot Juniper/Curlyleaf Muhly Pinchot Juniper/Sideoats Grama	
Distribution: major Chihuahuan Foothill-Piedmont Desert Grassland map unit that occurs primarily on upper slopes and ridge top summits in the eastern portion of the park. Elevations range from 4,000 to 5,000 ft.	

Figure 27. Curlyleaf Muhly/Lechuguilla, Pinchot Juniper Phase Grassland along the Juniper Trail in the northeast portion of the park. Grasses are abundant and dominant while Pinchot juniper is between 10% and 25% cover. (Photo: E. Muldavin)

Grama Grasslands	**110**
Tall shrubs <10%	
Ha: 488	**Acres:** 1,206
Primary Components: Sideoats Grama/Lechuguilla-Green Sotol Sideoats Grama/Green Sotol Sideoats Grama-Tanglehead/Green Sotol Black Grama-Sideoats Grama	
Secondary Components: Sideoats Grama/Texas Sacahuista Curlyleaf Muhly-Sideoats Grama/Texas Sacahuista Curlyleaf Muhly-Sideoats Grama Bullgrass/Texas Sacahuista Black Grama-Blue Grama	
Inclusions: Curlyleaf Muhly/Green Sotol Curlyleaf Muhly-Hairy Tridens Hall Panicgrass-Hairy Tridens	
Distribution: limited Chihuahuan Foothill-Piedmont Desert Grassland map unit that occurs on hill slopes and ridge top summits, and along upper piedmonts (bajadas). Elevations range from 4,000 to 6,000 ft.	

Figure 28. Sideoats Grama-Tanglehead/Green Sotol Grassland on a south-facing slope at 5,014 ft in middle Walnut Canyon. Tanglehead dominates this recently burned site. (Photo: Y. Chauvin).

Grama Grasslands with Pinchot Juniper	**111**
Pinchot juniper >10 and <25%; grasses dominant	
Ha: 72	**Acres:** 178
Primary Components: Sideoats Grama/Lechuguilla-Green Sotol, Pinchot Juniper Phase Sideoats Grama/Green Sotol, Pinchot Juniper Phase Sideoats Grama-Tanglehead/Green Sotol, Pinchot Juniper Phase Black Grama-Sideoats Grama, Pinchot Juniper Phase	
Secondary Components: Curlyleaf Muhly-Sideoats Grama/Texas Sacahuista Curlyleaf Muhly-Sideoats Grama Bullgrass/Texas Sacahuista Black Grama-Blue Grama, Pinchot Juniper Phase	
Inclusions: Sideoats Grama/Texas Sacahuista Sideoats Grama/Lechuguilla-Green Sotol Curlyleaf Muhly/Green Sotol Curlyleaf Muhly/Lechuguilla-Green Sotol	
Distribution: minor Chihuahuan Foothill-Piedmont Desert Grassland map unit. It occurs on piedmont slopes (bajadas) on the west side at elevations around 4,500 ft, and on occasionally on ridge top summits up to 5,000 ft.	

Figure 29. Black Grama-Blue Grama, Pinchot Juniper Phase Grassland on the south-facing Yucca Canyon bajada below the Guadalupe Escarpment. The elevation is 4,318 ft. (Photo: Y. Chauvin)

Grama Grasslands with Desert Shrubland	**114**
Tall shrubs >10 and <25%; grasses dominant	
Ha: 260	**Acres:** 640
Primary Components: Blue Grama/Skeletonleaf Goldeneye Black Grama-Blue Grama, Viscid Acacia Phase	
Secondary Components: Sideoats Grama/Lechuguilla-Green Sotol, Viscid Acacia Phase	
Inclusions: Viscid Acacia/Black Grama Viscid Acacia/Blue Grama Hall's Panicgrass-Hairy Tridens	
Distribution: limited Chihuahuan Foothill-Piedmont Desert Grassland map unit that occurs on piedmont slopes (bajadas) below the Guadalupe Escarpment to the western side of the park. Elevations are generally below 4,800 ft.	

Figure 30. Blue Grama/Skeletonleaf Goldeneye Grassland along the upper Yucca Canyon bajada at 4,490 ft. (Photo: S. Yanoff).

Grama Terrace Grasslands	**112**
Tall shrubs <25%; grasses dominant	
Ha: 117	**Acres:** 290
Primary Components: Blue Grama-Tobosagrass/Catclaw Mimosa Black Grama-Blue Grama	
Secondary Components:	
Inclusions: Catclaw Mimosa/Sideoats Grama	
Distribution: minor Chihuahuan Foothill-Piedmont Desert Grassland map unit that occurs on elevated alluvial terraces of valley bottoms. Elevations are usually below 5,200 ft.	

Figure 31. Black Grama-Blue Grama Grassland on alluvial terrace in Walnut Canyon. (Photo: E. Muldavin)

Tobosa Grasslands	**120**
Tall shrubs <10%; grasses dominant	
Ha: 133	**Acres:** 328
Primary Components: Tobosagrass-Burrograss	
Secondary Components:	
Inclusions: Tarbush/Tobosagrass Honey Mesquite/Tobosagrass	
Distribution: minor Chihuahuan Lowland/Swale Semidesert Grassland map unit that occurs on basin bottom alluvial flats of the Black River drainage at elevations below 4,000 ft.	

Figure 32. Tobosagrass-Burrograss Grassland on an alluvial flat near Whites City at an elevation of 3,661 ft. (Photo: Y Chauvin).

Desert Shrublands

Mariola - Goldeneye Desert Shrubland	**51**
Tall shrubs >25% or dominant over grasses	
Ha: 1,328	**Acres:** 3,282
Primary Components: Mariola-Lechuguilla Mariola-Skeletonleaf Goldeneye Ocotillo-Mariola	
Secondary Components:	
Inclusions: Curlyleaf Muhly/Lechuguilla-Green Sotol Cactus Apple-Lechuguilla Cactus Apple-Ocotillo Ocotillo-Lechuguilla	
Distribution: major Chihuahuan Foothill-Piedmont Desert Scrub map unit that occurs on foothill slopes and ridge top summits along the Guadalupe Escarpment and in interior canyons. It is often found in bands corresponding to horizontal sedimentary rock layers. Elevations range from 3,800 to 6,000 ft.	

Figure 33. Mariola-Skeletonleaf Goldeneye Desert Shrubland along an upper south-facing slope in Walnut Canyon at 4,152 ft. (Photo: E. Muldavin)

Cactus - Ocotillo Desert Succulent Shrubland	**53**
Tall shrubs >25% or dominant over grasses	
Ha: 857	**Acres:** 2,118
Primary Components: Cactus Apple-Lechuguilla Cactus Apple-Ocotillo Ocotillo-Lechuguilla	
Secondary Components: Cactus Apple-Wright Beebrush	
Inclusions: Mariola-Lechuguilla Mariola-Skeletonleaf Goldeneye Viscid Acacia-Lechuguilla	
Distribution: major Chihuahuan Foothill-Piedmont Desert Scrub map unit that occurs on lower foothill slopes and upper piedmonts (bajadas) of southerly aspects along the Guadalupe Escarpment and in interior canyons. Elevations are generally below 5,000 ft.	

Figure 34. Cactus Apple-Ocotillo Shrubland along a south-facing slope in lower Walnut Canyon. The elevation is 3,915 ft. (Photo: E. Muldavin)

Viscid Acacia Desert Shrubland	40
Tall shrubs >25% or dominant over grasses	
Ha: 1,011	**Acres:** 2,497
Primary Components: Viscid Acacia/Black Grama Viscid Acacia-Lechuguilla Viscid Acacia-Mariola	
Secondary Components: Viscid Acacia/Blue Grama Viscid Acacia-Pricklyleaf Dogweed	
Inclusions: Mariola-Skeletonleaf Goldeneye Creosotebush-Viscid Acacia/Black Grama Creosotebush/Viscid Acacia/Sparse	
Distribution: major Chihuahuan Foothill-Piedmont Desert Scrub map unit that occurs on lower footslopes and upper piedmonts (bajadas) below the Guadalupe Escarpment and in interior canyons. Elevations range between 3,700 and 4,700 ft.	

Figure 35. Viscid Acacia-Mariola Shrubland along the Yucca Canyon bajada at 4,404 ft. (Photo: S. Yanoff)

Creosote Bush - Viscid Acacia Desert Shrubland	52
Tall shrubs >25% or dominant over grasses	
Ha: 440	**Acres:** 1,088
Primary Components: Creosotebush/Sparse Undergrowth Creosotebush-Viscid Acacia/Black Grama Creosotebush/Viscid Acacia/Sparse	
Secondary Components: Creosotebush-Mariola Creosotebush/Sparse Undergrowth	
Inclusions: Viscid Acacia/Black Grama Viscid Acacia-Lechuguilla Viscid Acacia-Mariola	
Distribution: limited Chihuahuan Foothill-Piedmont Desert Scrub map unit that occurs on lower piedmonts (bajadas) and slopes of the Guadalupe Escarpment. Elevations are generally below 4,000 ft.	

Figure 36. Creosotebush-Viscid Acacia/Black Grama Desert Shrubland on a bajada slope near Whites City. Elevation is 3,658 ft. (Photo: A. Browder)

Tarbush - Littleleaf Sumac Desert Shrubland	**42**
Tall shrubs >25% or dominant over grasses	
Ha: 101	**Acres:** 250
Primary Components: Tarbush/Black Grama Tarbush/Tobosagrass	
Secondary Components: Littleleaf Sumac/Sideoats Grama Littleleaf Sumac/Blue Grama	
Inclusions: Tobosagrass-Burrograss Honey Mesquite/Tobosagrass	
Distribution: minor Chihuahuan Basin Desert Scrub map unit that occurs in drainages and on basin bottom flats of the Black River drainage at elevations below 4,000 ft.	

Figure 37. Tarbush/Tobosagrass Desert Shrubland in an arroyo drainage along the eastern Guadalupe Escarpment bajada at 3,630 ft. (Photo: E. Muldavin)

Catclaw Mimosa Desert Shrubland	**41**
Tall shrubs >25% or dominant over grasses	
Ha: 1,328	**Acres:** 3,282
Primary Components: Catclaw Mimosa/Sideoats Grama	
Secondary Components: Blue Grama-Tobosagrass/Catclaw Mimosa	
Inclusions: Black Grama-Sideoats Grama	
Distribution: minor Chihuahuan Foothill-Piedmont Desert Scrub map unit that occurs on lower foothill slopes and on sandstone ridges and benches at elevations from 4,600 to 5,650 ft.	

Figure 38. A Catclaw Mimosa/Sideoats Grama grassland on a sandstone bench below Guadalupe Ridge at 5,650 ft.

Arroyo Riparian Woodlands and Shrublands

Arroyo Riparian Woodland	14
Trees >25% or dominant	
Ha: 67	**Acres:** 164
Primary Components: Netleaf Hackberry-Little Walnut Little Walnut-Desert Willow/Sideoats Grama	
Secondary Components:	
Inclusions: Texas Mountain Laurel-Roemer Catclaw Green Sotol/Catclaw Mimosa Bigtooth Maple-Chinkapin Oak	
Distribution: minor Southwest Arroyo Riparian Shrubland map unit found at lower elevations (<5,000 ft) along ephemeral washes.	

Figure 39. Netleaf Hackberry-Little Walnut Arroyo Woodland on channel side terrace in lower Walnut Canyon (elevation 3,928 ft). Although limited in distribution, these are critical wildlife habitats in the park.
(Photo: Y. Chauvin)

Canyon - Bajada Arroyo Shrubland	24
Tall shrubs >25% or dominant	
Ha: 203	**Acres:** 503
Primary Components: Texas Mountain Laurel-Roemer Catclaw Mexican Buckeye-Texas Mountain Laurel	
Secondary Components: Littleleaf Sumac-Texas Mountain Laurel	
Inclusions: Littleleaf Sumac/Blue Grama	
Distribution: limited Southwest Arroyo Riparian Shrubland map unit found in foothill canyons and inset arroyos of the Guadalupe Escarpment bajada. Elevations usually < 5,000 ft.	

Figure 40. Mexican Buckeye-Texas Mountain Laurel Shrubland in Yucca Canyon at an elevation of 4,728 ft.
(Photo: Y. Chauvin)

Green Sotol - Apache Plume Arroyo Riparian Shrubland	**23**
Tall shrubs >25% or dominant	
Ha: 98	**Acres:** 243
Primary Components: Green Sotol/Catclaw Mimosa Apacheplume/Green Sotol	
Secondary Components:	
Inclusions: Catclaw Mimosa/Sideoats Grama Cactus Apple-Lechuguilla	
Distribution: minor Southwest Arroyo Riparian Shrubland map unit found at lower elevations (<5,000 ft) along ephemeral washes. Green sotol dominated communities are found primarily in the eastern portion of the park, while apache plume communities are mostly in the west,	

Figure 41. Green Sotol/Catclaw Mimosa Arroyo Shrubland on an alluvial terrace in lower Walnut Canyon (elevation 3,916 ft). (Photo: Y. Chauvin)

Desert Willow Arroyo Riparian Shrubland	**20**
Tall shrubs >25% or dominant	
Ha: 121	**Acres:** 300
Primary Components: Desert Willow-Texas Mountain Laurel	
Secondary Components: Barren arroyo channel	
Inclusions: Green Sotol/Catclaw Mimosa Apache Plume/Green Sotol	
Distribution: minor Southwest Arroyo Riparian Shrubland map unit found at lower elevations (<4,500 ft) in gravelly arroyo channels.	

Figure 42. Desert Willow-Texas Mountain Laurel Arroyo Shrubland in the gravelly arroyo channel of lower Walnut Canyon. (Photo: E. Muldavin)

Mixed Arroyo Riparian Shrubland	**21**
Tall shrubs >25% or dominant	
Ha: 113	**Acres:** 278
Primary Components: Littleleaf Sumac/Blue Grama Catclaw Mimosa/Sideoats Grama	
Secondary Components: Black Grama-Blue Grama, Cactus Apple Phase Green Sotol/Catclaw Mimosa	
Inclusions: Desert Willow-Texas Mountain Laurel Apache Plume/Green Sotol Barren arroyo channel	
Distribution: minor Southwest Arroyo Riparian Shrubland map unit found at lower elevations (<4,500 ft) on alluvial terraces adjacent to arroyo channels. A complex of various arroyo shrubland communities.	

Figure 43. Littleleaf Sumac/Blue Grama Shrubland on an alluvial terrace in lower Walnut Canyon at 4,080 ft.
(Photo: E. Muldavin)

Mimosa-Acacia Arroyo Riparian Shrubland	**22**
Tall shrubs >25% or dominant	
Ha: 92	**Acres:** 228
Primary Components: Catclaw Acacia/Bullgrass Catclaw Mimosa/Sideoats Grama	
Secondary Components:	
Inclusions: Green Sotol/Catclaw Mimosa Black Grama-Blue Grama, Cactus Apple Phase Littleleaf Sumac/Blue Grama Apache Plume/Green Sotol	
Distribution: minor Southwest Arroyo Riparian Shrubland map unit found at lower elevations (<5,000 ft) on alluvial terraces adjacent to arroyo channels and extending to adjacent footslopes.	

Figure 44. Mimosa/Sideoats Grama Arroyo Shrubland on a alluvial terrace in Slaughter Canyon at 4,668 ft.
(Photo: Y. Chauvin)

Other Miscellaneous Map Units

Herbaceous Wetland	**9**
Shrub cover < 10%	
Ha:	**Acres:**
Primary Components: Western Umbrella-sedge-Sand Spikerush	
Secondary Components: Western Umbrella-sedge-Sand Spikerush	
Inclusions: Rio Grande Cottonwood-Goodding Willow	
Distribution: limited map unit restricted to the wetlands downstream of Rattlesnake Springs, and isolated springs within the interior of the park.	

Figure 45. Western Umbrella-sedge-Sand Spikerush persistent emergent wetland at Longview Spring, elevation 5,771 ft. (Photo: Y. Chauvin)

Forested Wetland	**9**
Trees > 25% or dominant over other strata.	
Ha:	**Acres:**
Primary Components: Rio Grande Cottonwood-Goodding Willow Rio Grande Cottonwood-Netleaf Hackberry-Goodding Willow	
Secondary Components: Rio Grande Cottonwood-Russian Olive	
Inclusions: Netleaf Hackberry-Little Walnut Arroyo Woodland	
Distribution: limited map unit restricted to the wetlands downstream of Rattlesnake Springs.	

Figure 46. The Rio Grande Cottonwood-Goodding Willow Forested Wetland is found only at Rattlesnake Springs. (Photo: E. Muldavin)

Cliff/Rock/Barren/Arroyo Wash	**9**
Perennial vegetation < 10%	
Ha: 628	**Acres:** 1,553
Primary Components: Rock outcrop Arroyo channel wash	
Secondary Components: Barren basin alluvial flat	
Inclusions: Ocotillo-Lechuguilla Cactus Apple-Ocotillo Mariola-Skeletonleaf Goldeneye	
Distribution: limited map unit, but one found throughout the park, particularly along horizontal beds of sedimentary rock.	

Figure 47. Cliff face in lower Walnut Canyon. "Hanging gardens" dominated by small succulents and perennial forbs are prevalent among the rock outcrops of the park.
(Photo: E. Muldavin)

Developed Ground/Disturbed	**9**
Perennial vegetation < 1%	
Ha: 90	**Acres:** 222
Primary Components: Roads and paved areas Buildings	
Secondary Components: Barrow pits and other disturbed areas	
Inclusions:	
Distribution: minor map unit associated primarily with park facilities and roads.	

Figure 48. The buildings and structures associated with the main cave entrance occupy the majority of this map unit.
(Photo: Y. Chauvin)

Agriculture/Old Field	**7**
Natural vegetation < 1%	
Ha: <25	**Acres:** <75
Primary Components: Old fields with weedy vegetation Planted/cultivated trees, shrubs and herbs	
Secondary Components:	
Inclusions: roads and buildings	
Distribution: minor map unit associated with old fields at Rattlesnake Springs.	

[no photo available]

REFERENCES

Ahlstrand GM. 1981. Fire History of a mixed conifer forest in Guadalupe Mountains National Park. Pp. 4-7 in: *Proceedings of the Fire History Workshop October 20-24, 1980, Tucson AZ.* Gen. Tech. Report RM-81. USDA Department of Agriculture, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Ahlstrand G.M. 1982. Response of Chihuahuan Desert mountain shrub vegetation to burning. Journal of Range Management 35(1):62-5.

Ahlstrand G.M. 1979. Preliminary report on the ecology of fire study, Guadalupe Mountains and Carlsbad Caverns National Parks. Pp 31-44 in: H. H. Genoways and R.J. Baker, eds. *Biological investigations in the Guadalupe Mountains National Park: Proceedings of a symposium.* April 4-5, 1975, Lubbock, TX. Proceedings and Transactions Series No. 4. U.S. Department of the Interior, National Park Service, Washington, DC.

Belsky A. J. 1996. Western juniper expansion: is it a threat to arid northwestern ecosystems. Journal of Range Management 49(1):53-9.

Brand, J. P., and A. D. Jacka. 1979. p 45-49 Geology of the Guadalupe Mountains National Park. Pp. 1-12 in: H. H. Genoways and R.J. Baker, eds. *Biological investigations in the Guadalupe Mountains National Park: Proceedings of a symposium.* April 4-5, 1975, Lubbock, TX. Proceedings and Transactions Series No. 4. U.S. Department of the Interior, National Park Service, Washington, DC.

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.

Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. *A classification of North American biotic communities*. University of Utah Press, Salt Lake City.

Bryant, F. C., Launchbaugh, G. K., and Koerth, B. H. 1983. Controlling mature ashe juniper in Texas with crown fires. Journal of Range Management. 36(2): 165-168.

Bunting, S.C. 1978. The vegetation of the Guadalupe Mountains. Ph.D. Dissertation. Texas Tech University, Lubbock, TX. 183 p.

Correll, D. S.; and M. C. Johnston. 1970. Manual of the vascular plants of Texas. Texas Research Foundation, Renner, TX: 1881 p.

Dick-Peddie, W. A., W. H. Moir, and R. Spellenberg. 1993. *New Mexico Vegetation, Past, Present, and Future*. University of New Mexico Press, Albuquerque, NM.

ERDAS 1997. *ERDAS Field Guide*, 4th Edition, ERDAS, Inc. Atlanta, Georgia. 656 p.

Elachi, C. 1987. *Introduction to the Physics and Techniques of Remote Sensing*, New York: John Wiley & Sons, 413 pp.

Ellis, D., and J. L. Schuster. 1968. Juniper age distribution on an isolated butte in Garza County, Texas. The Southwestern Naturalist. 13(3):343-348

Gehlbach, F. R. 1967. Vegetation of the Guadalupe Escarpment, New Mexico-Texas. Ecology. 48(3): 404-419.

Gehlbach, F. R. 1979. Biomes of the Guadalupe Escarpment: vegetation, lizards, and human impact. Pp 427-439 in: H. H. Genoways and R.J. Baker, eds. *Biological investigations in the Guadalupe Mountains National Park: Proceedings of a symposium.* April 4-5, 1975, Lubbock, TX. Proceedings and Transactions Series No. 4. U.S. Department of the Interior, National Park Service, Washington, DC.

Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, M. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. Vol. I. *International Classification of Ecological Communities: terrestrial vegetation of the United States*. The Nature Conservancy, Arlington, VA.

Grissino-Mayer, H.D., C. H. Baisan, and T. W. Swetnam. 1995. Fire history in the Pinaleno Mountains of southeastern Arizona: Effects of human-related disturbances. Pp 399-407 in: Debano, L.F. G.J. Gottfried, R.H. Hamre, C.B. Edminster, P.F. Ffolliott, and A. Ortega-Rubio (eds.). Biodiversity and Management of the Madrean Archipelago. General Technical Report RM-GTR-264, USDA Forest Service, Rocky Mountain Forest Experiment Station, Fort Collins, CO.

Hayes, P. T. 1957. Geology of the Carlsbad Caverns East quadrangle, New Mexico, with a chapter on geologic development of Carlsbad Caverns by B.T. Gale. U.S. Geological Survey Geol. Quad. Map GQ-98

Hayes, P. T., and R. L. Koogle. 1958. Geology of the Carlsbad Caverns West quadrangle, New Mexico-Texas. U.S. Geological Survey Geol. Quad. Map GQ-112

Hayes, P. T. 1964. Geology of the Guadalupe Mountains New Mexico. Geological Survey Professional Paper 446: 69p.

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

Hill, M.O. 1979. TWINSPAN-A fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Ecology and Systematics, Cornell University, Ithaca, NY

Johnson E. A., K. Miyanish, and S. R. J. Bridge. 2001. Wildfire regime in the boreal forest and the idea of suppression and fuel buildup. Conservation Biology 15(6):1554-7.

Johnston, M. C. 1979. The Guadalupe Mountains--a chink in the mosaic of the Chihuahuan Desert? Pp. 45-49 in: H. H. Genoways and R.J. Baker, eds. *Biological investigations in the Guadalupe Mountains National Park: Proceedings of a symposium.* April 4-5, 1975, Lubbock, TX. Proceedings and Transactions Series No. 4. U.S. Department of the Interior, National Park Service, Washington, DC.

Keeley J. E, C. J. Fotheringham. 2001a. Historic fire regime in southern California shrublands. Conservation Biology 15(6):1536-48.

Keeley J. E, C. J. Fotheringham. 2001b. History and management of crown-fire ecosystems: a summary and response. Conservation Biology 15(6):1561-7.

Lillesand, T.M. and R.W. Kiefer, 1987. *Remote sensing and image interpretation*, 2nd Edition, John Wiley & Sons, New York. 721 pp.

Ludwig, J. A. and J. F. Reynolds. 1988. Statistical Ecology: A Primer on Methods and Computing. J. Wiley and Sons, NY. 337 p.

McPherson, G. R., H. A. Wright, and D. B. Wester. 1988. Patterns of Juniper invasion in semiarid Texas grasslands. Am. Midl. Nat. 123: 144-151.

McPherson, Guy R. 1992. Ecology of oak woodlands in Arizona. p 24-33 in: Ffolliott, P. F.; G. J. Gottfried, D. A. Bennett,[and others], technical coordinators. Ecology and management of oak and associated woodlands: perspectives in the southwest United States & northern Mexico: Proceedings; 1992 April 27-30; Sierra Vista, AZ. Gen. Tech. Rep. RM-218. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

McCune, B. and M. J. Mefford. 1997. *Multivariate Analysis of Ecological Data, Version 3.15.* MjM Software, Gleneden Beach, Oregon, USA

Minnich R. A. 1983. Fire mosaics in southern California and northern Baja California. Science 219:1287-94.

Minnich R. A. 2001. An integrated model of two fire regimes. Conservation Biology 15(6):1549-53.

Moritz, M.A. 2003: Spatiotemporal analysis of controls on shrubland fire regimes: age dependency and fire hazard. Ecology: Vol. 84, No. 2, pp. 351–361.

Muldavin, E., P. Durkin, M. Bradley, M. Stuever, and P. Mehlhop. 2000. Handbook of Wetland Vegetation Communities. Vol. 1. New Mexico Natural Heritage Program, University of New Mexico.

Mueller-Dombois, D., and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. John Wiley and Sons, New York. 547p.

NatureServe. 2003. A Working Classification of Terrestrial Ecological Systems in the Coterminous United States. NatureServe. Arlington, Virginia, USA

Northington, David K.; Burgess, Tony L. 1979. Summary of the vegetative zones of the Guadalupe Mountains National Park, Texas. In: H. H.Genoways and R.J. Baker, eds. *Biological investigations in the Guadalupe Mountains National Park: Proceedings of a symposium.* April 4-5, 1975, Lubbock, TX. Proceedings and Transactions Series No. 4. U.S. Department of the Interior, National Park Service, Washington, DC.

USDA-NRCS. 2002. The PLANTS Database, Version 3.5 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA

Pase, C. P., and D. E. Brown. 1979. Interior chaparral. Pp. 95-99 in: Brown, D. E. ed. Biotic Communities of the American Southwest-United States and Mexico. Desert Plants 4 (1-4).

Powell, A. M. 1988. *Trees & shrubs of Trans-Pecos Texas including Big Bend and Guadalupe Mountains National Parks*. Big Bend National Park, TX. Big Bend Natural History Association. 536 p.

Smith M. A, H. A. Wright, and J. L. Schuster. 1975. Reproductive characteristics of redberry juniper. Journal of Range Management 26(2):126-8.

Steuter, A. A., and C. M. Britton 1983. Fire-induced mortality of Redberry Juniper [*Juniperus pinchotii* Sudw.]. Journal of Range Management 36: 343-345.

Swetnam, T. W., and C. H. Baisan 1996. Historical fire regime patterns in the southwestern United States since AD 1700. Pp. 11-32 in: *Managing Piñon-Juniper Ecosystems for Sustainability and Social Needs: Proceedings of the Second La Mesa Fire Symposium March 29-31, 1994, Los Alamos, NM.* General Technical Report. RM-GTR-286. USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 169 p.

Thompson, B. C., P. J. Christ, E. Muldavin, J. S. Prioe-Magee, R. A. Deitner, and D. L. Garber. 1996. Examining natural floral heritage and management for biological diversity in New Mexico using gap analysis. New Mexico Journal of Science 36:327-354.

Wright, H. A., and A. W. Bailey. 1982. *Fire ecology: United States and southern Canada. New York.* John Wiley and Sons. 501 p.

APPENDIX A.

Vegetation Plots and Mapping Points

List of all plots and mapping point collected for the development of the Carlsbad Caverns National Park Vegetation Map. Plot Id refers to plot number in the CAVE vegetation map database. Type refers to plot type where OMP = Observation Mapping point (dominant species only), STP = standard NMNHP vegetation plot (all species in 400m^2 square quadrat), and RP = Releve plot (expanded standard plot to include complete stand species list). Plant Association according to the NMNHP state vegetation classification. Phase is a variant of the association. PA No. refers to the unique database plant association number. Easting and northing coordinates are given in the NAD 27 datum (the spatial distribution of the plots is shown in Figure 1 of the text). In addition, an ArcGIS shapefile was produced that matches the tables, which can be found on the accompanying CD data disk.

Table B1. Standard and Releve plots for the Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
00AK001	STP	Fouquieria splendens-Parthenium incanum Shrubland		928	552560	3561764
00AK002	STP	Parthenium incanum-Agave lechuguilla Shrubland		1212	555577	3560150
00AK003	STP	Fouquieria splendens-Agave lechuguilla Shrubland		1209	556127	3561531
00AK004	STP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	556166	3561403
00AK005	STP	Bouteloua eriopoda-Bouteloua gracilis Grassland	Opuntia engelmannii	483	554554	3561338
00AK006	STP	Fouquieria splendens-Parthenium incanum Shrubland		928	552759	3559110
00AK007	STP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	552604	3559080
00AK008	STP	Acacia neovernicosa/Bouteloua eriopoda Shrubland		1619	552723	3558805
00AK009	STP	Acacia neovernicosa-Agave lechuguilla Shrubland		781	552601	3558462
00AK010	STP	Larrea tridentata-Acacia neovernicosa/Bouteloua eriopoda Shrubland		2085	556380	3559313
00AK011	STP	Larrea tridentata/Sparse Shrubland		71	556314	3559188
00AK012	STP	Acacia neovernicosa-Thymophylla acerosa Shrubland	Krameria erecta	1390	556322	3558905
00AK013	STP	Larrea tridentata-Parthenium incanum Shrubland		65	556180	3559108
00AK014	STP	Flourensia cernua/Hilaria mutica Shrubland		8	557447	3559387
00AK015	STP	Bouteloua curtipendula/Agave lechuguilla-Dasylirion leiophyllum Grassland	Eragrostis intermedia	2075	552597	3560637
00AK016	STP	Juniperus deppeana/Quercus pungens/Muhlenbergia dubia Woodland		2081	533577	3554567
00AK017	STP	Quercus pungens/Bouteloua curtipendula Shrubland		837	536608	3554281
00AK018	STP	Juniperus pinchotii/Bouteloua curtipendula Shrubland	Nolina texana	831	536582	3554395
00AK019	STP	Parthenium incanum-Viguiera stenoloba Shrubland	Muhlenbergia setifolia	1873	536236	3554817
00AK020	STP	Pinus ponderosa/Muhlenbergia pauciflora Forest		784	535296	3555600
00AK021	STP	Juniperus deppeana/Quercus pungens/Muhlenbergia emersleyi Woodland		772	534990	3555580
00AK022	STP	Cercocarpus montanus/Achnatherum lobatum Shrubland		1837	535062	3555769
00AK023	STP	Cercocarpus montanus/Muhlenbergia pauciflora Shrubland		594	534838	3556079
00AK024	STP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland	Viguiera stenoloba	2065	535970	3558375
00AK025	STP	Quercus pungens/Muhlenbergia setifolia Shrubland	Quercus undulata	845	536097	3557775
00AK026	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	536278	3557560
00AK027	STP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	536404	3558507
00AK028	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	536348	3558395
00AK029	STP	Acer grandidentatum/Muhlenbergia pauciflora Woodland		830	536066	3557944
00AK030	STP	Quercus pungens/Muhlenbergia setifolia Shrubland	Nolina texana	845	536388	3557751
00AK031	STP	Cercocarpus montanus/Achnatherum lobatum Shrubland	Nolina texana	1837	538392	3556656
00AK032	STP	Quercus pungens/Achnatherum lobatum Shrubland	Cercocarpus montanus	846	538746	3556552
00AK033	STP	Muhlenbergia emersleyi/Nolina texana Grassland	Quercus undulata	2073	538553	3556625
00AK034	STP	Quercus pungens/Muhlenbergia setifolia Shrubland	Quercus undulata	845	537971	3556793
00EM002	STP	Opuntia engelmannii-Aloysia wrightii Shrubland		782	555991	3560468

Table B1. Standard and Releve plots for the Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
00EM003	STP	Juniperus pinchotii/Bouteloua curtipendula Shrubland		831	555838	3560262
00EM004	STP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland	Hilaria mutica	2065	555023	3560007
00EM005	STP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	556148	3560999
00EM006	STP	Juniperus pinchotii/Bouteloua eriopoda Shrubland		832	556258	3561009
00EM007	STP	Muhlenbergia setifolia/Agave lechuguilla Grassland	Viguiera stenoloba	776	556098	3561099
00EM008	STP	Rhus microphylla/Bouteloua gracilis Shrubland	Opuntia engelmannii	1835	557998	3561099
00EM009	STP	Opuntia engelmannii-Aloysia wrightii Shrubland		782	554778	3559804
00EM010	STP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	554568	3559728
00EM011	STP	Acacia neovernicosa/Bouteloua eriopoda Shrubland	Viguiera stenoloba	1619	554784	3559339
00EM012	STP	Opuntia engelmannii-Aloysia wrightii Shrubland		782	555772	3559590
00EM013	STP	Sophora secundiflora-Acacia roemeriana Shrubland		2087	555776	3559502
00EM014	STP	Prosopis glandulosa/Hilaria mutica Shrubland		197	555770	3559008
00EM015	STP	Hilaria mutica-Scleropogon brevifolius Grassland		24	556069	3558897
00EM016	STP	Juniperus deppeana/Quercus pungens/Muhlenbergia dubia Woodland		2081	533798	3550097
00EM017	STP	Pinus ponderosa/Quercus pungens/Muhlenbergia pauciflora Forest		2074	533822	3550164
00PA001	STP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	555972	3560319
00PA002	STP	Juniperus pinchotii/Bouteloua eriopoda Shrubland		832	555053	3560132
00PA003	STP	Muhlenbergia setifolia/Viguiera stenoloba Grassland		1867	556161	3561295
00PA004	STP	Quercus grisea/Sophora secundiflora Woodland		788	556132	3561395
00PA005	STP	Acacia neovernicosa/Bouteloua eriopoda Shrubland	Viguiera stenoloba	1619	557575	3561288
00PA006	STP	Juniperus pinchotii/Bouteloua curtipendula Shrubland		831	554771	3559762
00PA007	STP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	554590	3559764
00PA008	STP	Opuntia engelmannii-Agave lechuguilla Shrubland		780	554765	3559442
00PA009	STP	Opuntia engelmannii-Aloysia wrightii Shrubland		782	555723	3559572
00PA010	STP	Acacia neovernicosa/Bouteloua eriopoda Shrubland	Viguiera stenoloba	1619	555765	3559373
00PA011	STP	Larrea tridentata-Acacia neovernicosa/Sparse Shrubland		775	555792	3559221
00PA012	STP	Rhus microphylla-Sophora secundiflora Shrubland		1838	555692	3559259
00PA013	STP	Quercus pungens/Cercocarpus montanus Shrubland		842	533509	3554496
00PA014	STP	Juniperus deppeana/Quercus pungens/Muhlenbergia emersleyi Woodland		772	536341	3555005
00PA015	STP	Quercus pungens/Cercocarpus montanus Shrubland		842	536714	3554625
00PA016	STP	Cercocarpus montanus/Muhlenbergia emersleyi Shrubland		593	536573	3554802
00PA017	STP	Quercus pungens/Achnatherum lobatum Shrubland	Cercocarpus montanus	846	535057	3555704
00PA018	STP	Quercus pungens/Cercocarpus montanus Shrubland		842	535169	3555704
00PA019	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	535314	3555686
00PA020	STP	Quercus pungens/Achnatherum lobatum Shrubland	Cercocarpus montanus	846	535624	3555797

Table B1. Standard and Releve plots for the Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
00PA021	STP	Quercus pungens/Cercocarpus montanus Shrubland	Quercus undulata	842	536161	3557459
00PA022	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	535870	3556846
00PA023	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	535871	3556865
00PA024	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	536146	3556696
00PA025	STP	Quercus pungens/Bouteloua curtipendula Shrubland		837	536120	3556613
00PA026	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	536221	3556502
00PA027	STP	Juniperus deppeana/Quercus pungens/Muhlenbergia emersleyi Woodland		772	536106	3556384
00PA028	STP	Juniperus pinchotii/Quercus pungens/Bouteloua hirsuta Shrubland		2084	538447	3555380
00PA029	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Juniperus pinchotii	843	538416	3555291
00PA030	STP	Quercus pungens/Muhlenbergia setifolia Shrubland	Quercus undulata	845	538110	3555474
00PA031	STP	Quercus pungens/Cercocarpus montanus Shrubland	Quercus undulata	842	537751	3555811
00PA032	STP	Quercus pungens/Bouteloua curtipendula Shrubland		837	535768	3551401
00PA033	STP	Bouteloua curtipendula/Agave lechuguilla-Dasylirion leiophyllum Grassland		2075	538722	3550608
00PA034	STP	Panicum hallii-Erioneuron pilosum Grassland		847	538670	3550234
00PA035	STP	Fouquieria splendens-Agave lechuguilla Shrubland		1209	537985	3550561
00PA036	STP	Panicum hallii-Erioneuron pilosum Grassland		847	537293	3550131
00PA037	STP	Fouquieria splendens-Agave lechuguilla Shrubland		1209	536917	3550320
00PA038	STP	Quercus pungens/Cercocarpus montanus Shrubland	Quercus undulata	842	536857	3550427
00PA039	STP	Quercus pungens/Bouteloua curtipendula Shrubland	Quercus undulata	837	536790	3550313
00SY001	STP	Juniperus deppeana/Quercus pungens/Muhlenbergia emersleyi Woodland		772	533326	3554519
00SY002	STP	Quercus pungens/Bouteloua curtipendula Shrubland	Quercus undulata	837	536460	3554908
00SY003	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland		843	536789	3554694
00SY004	STP	Quercus pungens/Bouteloua curtipendula Shrubland		837	536555	3554776
00SY005	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	535349	3555648
00SY006	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	535099	3555882
00SY007	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	535210	3555942
00SY008	STP	Muhlenbergia setifolia-Bouteloua curtipendula/Nolina texana Grassland		2071	534932	3556127
00SY009	STP	Muhlenbergia setifolia-Bouteloua curtipendula Grassland		1863	535863	3558243
00SY010	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	536025	3557803
00SY011	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	536368	3557665
00SY012	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	536567	3558571
00SY013	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland		843	536413	3558795
00SY014	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	536267	3558062
00SY015	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	536834	3557886
00SY016	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Cercocarpus montanus	843	538501	3556824

Table B1. Standard and Releve plots for the Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
00SY017	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	538947	3556884
00SY018	STP	Cercocarpus montanus/Muhlenbergia setifolia Shrubland		1800	538507	3556500
00SY019	STP	Quercus pungens/Achnatherum lobatum Shrubland	Cercocarpus montanus	846	538129	3556838
00SY020	STP	Juniperus deppeana/Bouteloua curtipendula Woodland		1846	536520	3551361
00SY021	STP	Juniperus deppeana/Quercus pungens/Muhlenbergia emersleyi Woodland		772	537067	3551589
00SY022	STP	Pinus edulis-Quercus pungens Woodland		1881	537420	3551593
00SY023	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	537993	3551946
00SY025	STP	Acacia neovernicosa-Parthenium incanum Shrubland	Tridens muticus	2025	538557	3550372
00SY026	STP	Quercus pungens/Bouteloua curtipendula Shrubland		837	538717	3550275
00SY027	STP	Panicum hallii-Erioneuron pilosum Grassland		847	538289	3549950
00SY030	STP	Acacia neovernicosa/Bouteloua gracilis Shrubland	Viguiera stenoloba	770	538221	3550295
00SY031	STP	Tridens muticus/Agave lechuguilla Grassland	Opuntia phaeacantha	2088	537691	3550245
00SY032	STP	Bouteloua gracilis/Viguieria stenoloba Grassland		1183	537577	3550041
00SY033	STP	Muhlenbergia setifolia-Erioneuron pilosum Grassland		778	537429	3549910
00SY034	STP	Bouteloua eriopoda-Bouteloua gracilis Grassland	Viguiera stenoloba	483	537450	3549937
00SY035	STP	Acacia neovernicosa/Bouteloua gracilis Shrubland	Parthenium incanum	770	537864	3549779
00SY036	STP	Unclassified/Unclassified		647	537997	3549808
00YC020	RP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	554167	3560844
00YC021	RP	Fouquieria splendens-Parthenium incanum Shrubland		928	554043	3560919
00YC022	RP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	552059	3561942
00YC023	RP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland	Juniperus pinchotii	2065	552617	3561996
00YC024	RP	Muhlenbergia setifolia-Bouteloua curtipendula Grassland		1863	552646	3561260
00YC025	RP	Juniperus pinchotii/Viguiera stenoloba Shrubland		835	556059	3560390
00YC026	STP	Quercus grisea/Sophora secundiflora Woodland		788	556069	3560471
00YC027	STP	Bouteloua eriopoda/Agave lechuguilla-Dasylirion leiophyllum Grassland	Juniperus pinchotii	2077	555630	3560088
00YC028	STP	Flourensia cernua/Bouteloua eriopoda Shrubland		1630	554513	3560127
00YC029	STP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	556380	3561363
00YC030	STP	Juniperus pinchotii/Bouteloua curtipendula Shrubland	Mimosa aculeaticarpa var. biuncifera	831	556328	3561400
00YC031	STP	Bouteloua eriopoda-Bouteloua gracilis Grassland	Opuntia engelmannii	483	556317	3561434
00YC032	RP	Dasylirion leiophyllum/Mimosa aculeaticarpa Shrubland		2079	554633	3561439
00YC033	STP	Juglans microcarpa/Bouteloua curtipendula Forested Wetland		771	554601	3561217
00YC034	STP	Fouquieria splendens-Parthenium incanum Shrubland		928	552332	3559088
00YC035	STP	Fouquieria splendens-Agave lechuguilla Shrubland		1209	552469	3559000
00YC036	STP	Acacia neovernicosa/Bouteloua eriopoda Shrubland	Viguiera stenoloba	1619	552582	3558912
00YC037	STP	Rhus microphylla/Bouteloua curtipendula Shrubland		255	552842	3558423

Table B1. Standard and Releve plots for the Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
00YC038	STP	Acacia neovernicosa-Agave lechuguilla Shrubland		781	556381	3559396
00YC039	STP	Flourensia cernua/Hilaria mutica Shrubland		8	556292	3559072
00YC040	STP	Larrea tridentata-Acacia neovernicosa/Sparse Shrubland		775	556251	3558904
00YC041	STP	Hilaria mutica-Scleropogon brevifolius Grassland		24	556223	3558966
00YC042	STP	Flourensia cernua/Hilaria mutica Shrubland		8	557474	3559110
00YC043	STP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	552698	3560634
00YC044	RP	Quercus grisea-Arbutus xalapensis Woodland		787	553670	3560729
00YC045	STP	Acer grandidentatum-Quercus muehlenbergii Woodland		727	533588	3554680
00YC046	STP	Cercocarpus montanus/Muhlenbergia pauciflora Shrubland		594	536685	3554340
00YC047	STP	Bouteloua curtipendula/Nolina texana Grassland Grassland	Aristida purpurea	1826	536529	3554594
00YC048	STP	Cercocarpus montanus/Muhlenbergia pauciflora Shrubland		594	536325	3554788
00YC049	RP	Acer grandidentatum-Quercus muehlenbergii Woodland		727	535040	3555639
00YC050	STP	Pinus ponderosa-Quercus muehlenbergii/Piptochaetium fimbriatum Forest		785	535535	3556335
00YC051	STP	Juniperus deppeana/Vitis arizonica Woodland		2082	535513	3556072
00YC052	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland		843	536158	3557351
00YC053	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	536106	3557286
00YC054	STP	Muhlenbergia setifolia-Bouteloua curtipendula/Nolina texana Grassland	Cercocarpus montanus	2071	536123	3557111
00YC055	STP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Quercus undulata	843	536161	3556809
00YC056	STP	Muhlenbergia setifolia/Agave lechuguilla Grassland		776	536315	3557266
00YC057	STP	Acer grandidentatum-Quercus muehlenbergii Woodland		727	536364	3557097
00YC058	STP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	536379	3557045
00YC059	RP	Bouteloua curtipendula/Nolina texana Grassland Grassland	Quercus undulata	1826	537274	3555582
00YC060	RP	Juniperus deppeana/Quercus pungens/Muhlenbergia emersleyi Woodland		772	537641	3554860
00YC061	RP	Juniperus pinchotii/Quercus pungens/Bouteloua curtipendula Shrubland		2083	537850	3554425
00YC062	RP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	539293	3558501
00YC063	STP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	536039	3551512
00YC064	STP	Fuirena simplex/Eleocharis montevidensis Herbaceous Wetland	Paspalum setaceum	2090	535764	3551471
00YC065	RP	Quercus pungens/Muhlenbergia pauciflora Shrubland		843	538399	3551424
00YC066	STP	Muhlenbergia setifolia-Bouteloua curtipendula Grassland	Dalea bicolor var. argyraea	1863	538515	3551381
00YC067	STP	Fallugia paradoxa/Ungnadia speciosa Shrubland		1840	538592	3551527
00YC068	STP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	538694	3551375
00YC069	STP	Quercus pungens/Bouteloua curtipendula Shrubland		837	539660	3551185
00YC070	STP	Acacia neovernicosa-Parthenium incanum Shrubland	Bouteloua eriopoda	2025	539843	3551329
00YC071	STP	Bouteloua eriopoda-Bouteloua curtipendula Grassland	Juniperus pinchotii	459	539972	3551287
00YC072	STP	Acacia neovernicosa/Bouteloua eriopoda Shrubland		1619	540053	3551024

Table B1. Standard and Releve plots for the Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
00YC073	STP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	539955	3550878
99EM001	STP	Quercus pungens/Bouteloua curtipendula Shrubland		837	546733	3558713
99EM002	STP	Muhlenbergia setifolia-Bouteloua curtipendula Grassland		1863	549234	3560777
99YC040	RP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	547017	3559075
99YC041	RP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	547845	3558874
99YC042	RP	Quercus pungens/Bouteloua curtipendula Shrubland	Quercus undulata	837	539820	3555910
99YC043	RP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	540013	3555796
99YC044	RP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	540333	3555543
99YC045	RP	Fouquieria splendens-Parthenium incanum Shrubland		928	553930	3562082
99YC046	RP	Muhlenbergia setifolia/Agave lechuguilla Grassland	Fouquieria splendens	776	553933	3561953
99YC047	RP	Parthenium incanum-Viguiera stenoloba Shrubland	Muhlenbergia setifolia	1873	553883	3561929
99YC048	RP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	546771	3558622
99YC049	RP	Bouteloua curtipendula/Dasylirion leiophyllum Grassland	Heteropogon contortus	1173	549223	3560635
99YC050	RP	Quercus grisea-Acer grandidentatum Woodland		786	551832	3560691
99YC051	RP	Opuntia engelmannii-Fouquieria splendens Shrubland		783	557332	3561160
99YC052	RP	Celtis laevigata var. reticulata-Juglans microcarpa Forested Wetland		735	553348	3560935
99YC053	RP	Quercus pungens/Achnatherum lobatum Shrubland		846	535954	3555918

Table B2. Observation mapping points for Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
00SY024	OMP	Quercus pungens/Bouteloua curtipendula Shrubland	Parthenium incanum	837	537640	3551704
00SY028	OMP	Panicum hallii-Erioneuron pilosum Grassland		847	538189	3550072
00SY029	OMP	Acacia neovernicosa/Bouteloua gracilis Shrubland		770	538187	3550343
01AK010	OMP	Juniperus pinchotii/Bouteloua eriopoda Shrubland		832	547707	3557206
01AK011	OMP	Bouteloua eriopoda-Bouteloua curtipendula Grassland	Juniperus pinchotii	459	551954	3560700
01AK012	OMP	Acacia neovernicosa/Sparse Shrubland		1237	551927	3558690
01AK013	OMP	Bouteloua curtipendula/Agave lechuguilla-Dasylirion leiophyllum Grassland		2075	548068	3557152
01AK014	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	550639	3560562
01AK015	OMP	Prosopis glandulosa/Muhlenbergia porteri Shrubland		198	557456	3559371
01AK016	OMP	Flourensia cernua/Hilaria mutica Shrubland	Setaria leucopila	8	553557	3558598
01AK017	OMP	Larrea tridentata-Acacia neovernicosa/Sparse Shrubland		775	556811	3559522
01AK018	OMP	Larrea tridentata-Acacia neovernicosa/Sparse Shrubland		775	556934	3559171
01AK019	OMP	Juniperus pinchotii/Bouteloua curtipendula Shrubland		831	546467	3557466
01AK020	OMP	Acacia neovernicosa-Agave lechuguilla Shrubland	Opuntia phaeacantha	781	547317	3557214
01AK021	OMP	Acacia neovernicosa-Agave lechuguilla Shrubland		781	552040	3558529
01AK022	OMP	Acacia neovernicosa-Agave lechuguilla Shrubland		781	554552	3559267
01AK023	OMP	Acacia neovernicosa/Bouteloua eriopoda Shrubland		1619	556909	3559638
01AK024	OMP	Acacia neovernicosa/Sparse Shrubland		1237	557672	3559586
01AK025	OMP	Acacia neovernicosa/Sparse Shrubland		1237	555325	3558713
01AK026	OMP	Acacia neovernicosa/Sparse Shrubland		1237	547411	3556997
01AK027	OMP	Flourensia cernua/Hilaria mutica Shrubland		8	553807	3558464
01AK028	OMP	Flourensia cernua/Muhlenbergia porteri Shrubland		1633	557139	3559320
01AK029	OMP	Acacia neovernicosa/Sparse Shrubland		1237	547088	3557338
01AK030	OMP	Larrea tridentata-Acacia neovernicosa/Sparse Shrubland		775	552454	3558322
01AK031	OMP	Acacia neovernicosa-Agave lechuguilla Shrubland		781	548007	3556963
01DO001	OMP	Fouquieria splendens-Agave lechuguilla Shrubland		1209	549080	3559591
01DO002	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	550310	3559460
01DO003	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland	Mimosa aculeaticarpa var. biuncifera	1157	552773	3559922
01DO004	OMP	Fouquieria splendens-Agave lechuguilla Shrubland		1209	552133	3560537
01DO005	OMP	Acacia neovernicosa/Sparse Shrubland	Opuntia phaeacantha	1237	547169	3556882
01DO006	OMP	Muhlenbergia setifolia/Agave lechuguilla Grassland	Hilaria mutica	776	558221	3561978
01DO007	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	550714	3561022

Table B2. Observation mapping points for Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
01DO008	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	549267	3559553
01DO009	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	549276	3559514
01DO010	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	548324	3558627
01DO011	OMP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	553116	3560016
01DO012	OMP	Muhlenbergia setifolia/Viguira stenoloba Grassland		1867	551774	3559863
01DO013	OMP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	548761	3559308
01DO014	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	549414	3559504
01DO015	OMP	Muhlenbergia setifolia/Viguira stenoloba Grassland	Juniperus pinchotii	1867	552928	3560376
01DO016	OMP	Acacia neovernicosa/Bouteloua eriopoda Shrubland		1619	551626	3558350
01DO017	OMP	Muhlenbergia setifolia-Bouteloua curtipendula Grassland	Tridens muticus	1863	550054	3559556
01DO018	OMP	Opuntia engelmannii-Fouquieria splendens Shrubland		783	558403	3560593
01DO019	OMP	Bouteloua eriopoda-Bouteloua gracilis Grassland		483	557732	3561867
01EM004	OMP	Sophora secundiflora-Acacia roemeriana Shrubland		2087	554562	3561191
01EM005	OMP	Celtis laevigata var. reticulata-Juglans microcarpa Forested Wetland	Bouteloua curtipendula	735	554579	3561193
01EM006	OMP	Opuntia engelmannii-Aloysia wrightii Shrubland		782	554409	3561373
01EM007	OMP	Fouquieria splendens-Agave lechuguilla Shrubland		1209	554448	3561330
01EM008	OMP	Bouteloua eriopoda-Bouteloua gracilis Grassland		483	554572	3561346
01EM009	OMP	Dasylirion leiophyllum/Mimosa aculeaticarpa Shrubland		2079	554572	3561346
01EM010	OMP	Bouteloua eriopoda-Bouteloua gracilis Grassland		483	554677	3561421
01EM011	OMP	Fouquieria splendens-Agave lechuguilla Shrubland		1209	554244	3561312
01EM012	OMP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	555036	3561271
01EM013	OMP	Dasylirion leiophyllum/Mimosa aculeaticarpa Shrubland		2079	554968	3561378
01EM014	OMP	Fouquieria splendens-Agave lechuguilla Shrubland		1209	554914	3561502
01EM015	OMP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	555601	3561862
01EM016	OMP	Juglans microcarpa/Bouteloua curtipendula Forested Wetland		771	555477	3561802
01EM017	OMP	Fouquieria splendens-Parthenium incanum Shrubland		928	556704	3561508
01EM018	OMP	Juglans microcarpa/Bouteloua curtipendula Forested Wetland	Chilopsis linearis	771	556537	3561529
01EM019	OMP	Acacia neovernicosa-Agave lechuguilla Shrubland	Parthenium incanum	781	558093	3560522
01EM020	OMP	Dasylirion leiophyllum/Mimosa aculeaticarpa Shrubland		2079	558075	3560780
01EM021	OMP	Dasylirion leiophyllum/Mimosa aculeaticarpa Shrubland		2079	548245	3560100
01EM022	OMP	Juglans microcarpa/Bouteloua curtipendula Forested Wetland	Sapindus saponaria	771	556296	3561730
01EM023	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	556759	3561109
01EM024	OMP	Bouteloua eriopoda-Bouteloua gracilis Grassland		483	555015	3561430
01EM050	OMP	Unclassified/Unclassified		647	530502	3549684

Table B2. Observation mapping points for Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
01EM051	OMP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	530442	3549718
01EM053	OMP	Acer grandidentatum-Quercus muehlenbergii Woodland		727	530559	3549548
01EM054	OMP	Fallugia paradoxa/Wash Shrubland	Dasylirion leiophyllum	1625	530810	3549547
01EM055	OMP	Fallugia paradoxa/Wash Shrubland	Cercocarpus montanus	1625	530988	3549522
01EM056	OMP	Quercus pungens/Bouteloua curtipendula Shrubland	Acacia greggii	837	531047	3549446
01EM057	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	550389	3560383
01EM058	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland	Juniperus pinchotii	2065	550374	3560305
01EM059	OMP	Bouteloua gracilis/Yucca elata Grassland		1781	550301	3560237
01EM060	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland	Juniperus pinchotii	2065	550097	3560185
01EM061	OMP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	549873	3560150
01EM062	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland	Juniperus pinchotii	2065	549808	3559814
01EM063	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	549820	3559649
01EM064	OMP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	548435	3559157
01EM065	OMP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	549559	3560439
01ER008	OMP	Quercus grisea/Sophora secundiflora Woodland		788	547105	3557227
01ER009	OMP	Opuntia engelmannii-Fouquieria splendens Shrubland		783	547631	3557417
01ER010	OMP	Acacia neovernicosa-Agave lechuguilla Shrubland	Opuntia engelmannii	781	547879	3557451
01ER011	OMP	Acacia neovernicosa/Sparse Shrubland		1237	548203	3557103
01ER012	OMP	Acacia neovernicosa-Agave lechuguilla Shrubland	Juniperus pinchotii	781	548029	3556983
01ER013	OMP	Juniperus pinchotii/Unclassified Shrubland		2157	546377	3557345
01ER014	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	533596	3548514
01ER015	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	533476	3548513
01ER016	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	533177	3548309
01ER017	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	532994	3548444
01ER018	OMP	Acacia neovernicosa/Bouteloua eriopoda Shrubland		1619	553537	3558958
01ER019	OMP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	552108	3558568
01ER020	OMP	Opuntia engelmannii-Fouquieria splendens Shrubland		783	553466	3559195
01ER021	OMP	Sophora secundiflora-Acacia roemeriana Shrubland		2087	554380	3559080
01ER022	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	533881	3548794
01JS001	OMP	Quercus pungens/Cercocarpus montanus Shrubland		842	546637	3560030
01JS002	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	546851	3560571
01JS003	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	547709	3560151
01JS004	OMP	Muhlenbergia setifolia Grassland Alliance		987	548656	3560224
01JS005	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	547539	3559562

Table B2. Observation mapping points for Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
01JS006	OMP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	530813	3548274
01JS007	OMP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	544743	3560525
01JS008	OMP	Bouteloua curtipendula/Dasylirion leiophyllum Grassland		1173	530673	3548494
01JS009	OMP	Quercus pungens/Bouteloua curtipendula Shrubland		837	530804	3548055
01JS010	OMP	Juniperus pinchotii/Bouteloua curtipendula Shrubland		831	545986	3560467
01JS011	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	546806	3560372
01JS012	OMP	Quercus pungens/Cercocarpus montanus Shrubland		842	546424	3560654
01JS013	OMP	Quercus grisea-Arbutus xalapensis Woodland		787	548616	3559948
01JS014	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	546481	3560629
01JS015	OMP	Unclassified/Unclassified		647	546043	3560402
01JS016	OMP	Muhlenbergia setifolia Grassland Alliance		987	548861	3560260
01JS017	OMP	Muhlenbergia setifolia/Agave lechuguilla Grassland		776	548437	3560083
01PA001	OMP	Quercus pungens/Unclassified Shrubland		2156	531565	3547583
01PA002	OMP	Mimosa aculeaticarpa var. biuncifera/Unclassified Shrubland		2158	531415	3547563
01PA003	OMP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	531124	3547672
01PA004	OMP	Mimosa aculeaticarpa var. biuncifera/Unclassified Shrubland		2158	531148	3547802
01PA005	OMP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	531612	3548108
01PA006	OMP	Quercus pungens/Muhlenbergia pauciflora Shrubland	Juniperus pinchotii	843	549970	3559764
01PA007	OMP	Quercus grisea-Arbutus xalapensis Woodland		787	549957	3559842
01PA008	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	550479	3559757
01PA009	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland	Quercus grisea	834	550533	3559811
01PA010	OMP	Quercus grisea-Arbutus xalapensis Woodland	Acer grandidentatum	787	550608	3559922
01PA011	OMP	Dasylirion leiophyllum/Mimosa aculeaticarpa Shrubland		2079	540779	3553626
01PA012	OMP	Acacia neovernicosa/Bouteloua curtipendula Shrubland		1228	540078	3553779
01PA013	OMP	Quercus pungens/Bouteloua curtipendula Shrubland		837	539993	3553729
01PA014	OMP	Quercus pungens/Unclassified Shrubland		2156	539921	3553802
01PA015	OMP	Acacia neovernicosa/Unclassified Shrubland	Arroyo	2159	539820	3553966
01PA016	OMP	Acacia neovernicosa-Agave lechuguilla Shrubland		781	539851	3554090
01PA017	OMP	Acacia neovernicosa/Bouteloua curtipendula Shrubland	Arroyo	1228	540651	3553575
01PA018	OMP	Fallugia paradoxa/Wash Shrubland	Dasylirion leiophyllum	1625	539615	3553854
01PA019	OMP	Acacia neovernicosa/Unclassified Shrubland	Arroyo	2159	539447	3553801
01PA020	OMP	Acacia neovernicosa/Bouteloua curtipendula Shrubland		1228	539603	3553979
01PA021	OMP	Bouteloua gracilis/Unclassified Grassland		1499	540599	3553826
01PA022	OMP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland	Arroyo	1680	540076	3555356

Table B2. Observation mapping points for Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
01PA023	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	539955	3555347
01PA024	OMP	Acacia neovernicosa/Unclassified Shrubland	grass	2159	540956	3552119
01PA025	OMP	Acacia neovernicosa/Unclassified Shrubland	grass	2159	541325	3552436
01PA026	OMP	Sophora secundiflora-Acacia roemeriana Shrubland		2087	555325	3559436
01PA097	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland	Nolina texana	2065	545771	3559779
01PA098	OMP	Muhlenbergia setifolia-Bouteloua gracilis Grassland		1685	544682	3560575
01PA099	OMP	Muhlenbergia setifolia/Agave lechuguilla Grassland		776	546005	3559839
01PA100	OMP	Bouteloua eriopoda-Bouteloua gracilis Grassland		483	545073	3560562
01PA101	OMP	Muhlenbergia setifolia/Agave lechuguilla Grassland		776	546312	3559935
01PA102	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	546514	3559774
01PA103	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	546409	3560041
01PA104	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	553108	3560183
01PA105	OMP	Acacia neovernicosa/Bouteloua eriopoda Shrubland		1619	551403	3559248
01PA106	OMP	Acacia neovernicosa/Sparse Shrubland	Prosopis glandulosa	1237	546956	3556575
01PA107	OMP	Acacia neovernicosa-Agave lechuguilla Shrubland		781	532947	3548645
01PA109	OMP	Muhlenbergia setifolia-Bouteloua gracilis Grassland		1685	547313	3559474
01PA110	OMP	Muhlenbergia setifolia/Agave lechuguilla Grassland		776	547491	3560044
01PA111	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	547976	3559717
01PA112	OMP	Parthenium incanum-Agave lechuguilla Shrubland		1212	548214	3560236
01PA113	OMP	Muhlenbergia setifolia/Agave lechuguilla Grassland		776	548417	3560329
01PA114	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	548535	3560324
01PA115	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland	Juniperus pinchotii	1157	548626	3559996
01PA116	OMP	Quercus pungens/Bouteloua curtipendula Shrubland	Tridens muticus	837	530909	3548395
01PA117	OMP	Quercus pungens/Bouteloua curtipendula Shrubland	Muhlenbergia emersleyi	837	530671	3548582
01PA118	OMP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	531044	3548311
01TN001	OMP	Quercus pungens/Bouteloua curtipendula Shrubland		837	531979	3548853
01TN002	OMP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	531715	3549512
01TN003	OMP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	531529	3547767
01TN004	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	531132	3547992
01TN005	OMP	Fallugia paradoxa Shrubland Alliance		507	532858	3548154
01TN006	OMP	Bouteloua eriopoda Grassland Alliance		362	533870	3548602
01TN007	OMP	Mimosa aculeaticarpa Shrubland Alliance		972	530965	3547922
01TN009	OMP	Dasylirion leiophyllum/Mimosa aculeaticarpa Shrubland		2079	532622	3548548
01TN010	OMP	Quercus pungens/Bouteloua curtipendula Shrubland		837	531967	3549168

Table B2. Observation mapping points for Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
01TN011	OMP	Quercus pungens/Bouteloua curtipendula Shrubland		837	531276	3549597
01TN012	OMP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	531312	3549591
01TN014	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	532378	3548677
01TN015	OMP	Unclassified/Unclassified		647	532981	3548189
01TN016	OMP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	533741	3548146
01TN017	OMP	Quercus grisea Woodland Alliance		249	554758	3561863
01TN018	OMP	Fallugia paradoxa/Ungnadia speciosa Shrubland		1840	532797	3548263
01TN019	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	531447	3547824
01TN020	OMP	Quercus pungens Shrubland Alliance		790	531771	3547642
01TN021	OMP	Quercus pungens Shrubland Alliance		790	531785	3548825
01TN022	OMP	Muhlenbergia setifolia/Dasylirion leiophyllum Grassland		1157	531153	3548125
01TN023	OMP	Quercus pungens/Muhlenbergia setifolia Shrubland		845	531153	3548197
01TN025	OMP	Dasylirion leiophyllum/Mimosa aculeaticarpa Shrubland		2079	531790	3547833
01TN026	OMP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	531517	3547721
01TN028	OMP	Quercus pungens/Cercocarpus montanus Shrubland		842	531983	3548798
01TN030	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	532314	3548703
01TN031	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	533933	3548145
01YC012	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	551637	3561390
01YC013	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	551586	3560114
01YC014	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	549177	3559170
01YC015	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland	Juniperus pinchotii	2065	553505	3559917
01YC016	OMP	Opuntia engelmannii-Aloysia wrightii Shrubland		782	558538	3560621
01YC017	OMP	Muhlenbergia setifolia/Agave lechuguilla Grassland		776	550507	3559451
01YC018	OMP	Quercus pungens/Bouteloua curtipendula Shrubland	Juniperus pinchotii	837	549054	3559055
01YC019	OMP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	557721	3561687
01YC020	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	549784	3559328
01YC021	OMP	Opuntia engelmannii-Agave lechuguilla Shrubland		780	554099	3560018
01YC022	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	552714	3560257
01YC023	OMP	Bouteloua eriopoda-Bouteloua gracilis Grassland		483	550832	3560789
01YC024	OMP	Parthenium incanum-Viguiera stenoloba Shrubland	Juniperus pinchotii	1873	557309	3561875
01YC025	OMP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	553107	3560183
01YC026	OMP	Muhlenbergia setifolia/Agave lechuguilla-Dasylirion leiophyllum Grassland		2065	549404	3559174
01YC027	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	548922	3559067
01YC028	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	548477	3558626

Table B2. Observation mapping points for Carlsbad Caverns National Park vegetation map.

Plot ID	Type	Plant Association	Phase	PA No	Easting	Northing
01YC029	OMP	Mimosa aculeaticarpa/Bouteloua curtipendula Shrubland		1680	552704	3559925
01YC030	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	552344	3560294
01YC031	OMP	Juniperus pinchotii/Muhlenbergia setifolia Shrubland		834	548554	3558624
01YC032	OMP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	549829	3559244
01YC033	OMP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	553026	3559820
01YC034	OMP	Muhlenbergia setifolia/Agave lechuguilla Grassland		776	552484	3560176
01YC035	OMP	Parthenium incanum-Viguiera stenoloba Shrubland		1873	551876	3559626

APPENDIX B

Plant Species List

Lists of plant species recorded as part of the Carlsbad Caverns National Park Vegetation Map field survey from 1999 through 2002. LF refers to lifeform strata: 1 = trees, 2 = tall shrubs, (>0.5 m), 2.5 = dwarf shrubs (<0.5 m), 3 = grasses and grass-like plants (graminoids), and 4 = forbs. Some species may occur in two or more strata. Plants symbol refers to the code form the PLANTS database (USDA-NRCS, 2002). The NMNHP code is the respective code in the in the database provided in the Data Addendum. N refers to the number of occurrences in the database.

Table A-1. CCNP vegetation map plant species list ordered by lifeform strata and scientific name.

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
1	Acer grandidentatum	bigtooth maple	Aceraceae	ACGR3	ACEGRA	9
1	Arbutus xalapensis	Texas madrone	Ericaceae	ARAL	ARBXAL	16
1	Celtis laevigata var. reticulata	netleaf hackberry	Ulmaceae	CELAR	CELLAER	12
1	Chilopsis linearis	desert willow	Bignoniaceae	CHLI2	CHILIN	5
1	Chilopsis linearis - mature	desert willow	Bignoniaceae	CHLI2	CHILIN3	1
1	Fraxinus velutina	velvet ash	Oleaceae	FRVE2	FRAVEL	3
1	Garrya ovata ssp. goldmanii	Goldman's silktassel	Garryaceae	GAOVG	GAROVAG	1
1	Juniperus deppeana	alligator juniper	Cupressaceae	JUDE2	JUNDEP	17
1	Juniperus deppeana - mature	alligator juniper	Cupressaceae	JUDE2	JUNDEP3	7
1	Juniperus pinchotii - mature	Pinchot juniper	Cupressaceae	JUPI	JUNPIN3	1
1	Juniperus scopulorum	Rocky Mountain juniper	Cupressaceae	JUSC2	JUNSCO	2
1	Pinus edulis	pinyon pine	Pinaceae	PIED	PINEDU	3
1	Pinus ponderosa	ponderosa pine	Pinaceae	PIPO	PINPON	9
1	Pinus ponderosa - mature	ponderosa pine	Pinaceae	PIPO	PINPON3	1
1	Quercus gambelii	Gambel's oak	Fagaceae	QUGA	QUEGAM	1
1	Quercus grisea	gray oak	Fagaceae	QUGR3	QUEGRI	24
1	Quercus muehlenbergii	Chinkapin oak	Fagaceae	QUMU	QUEMUE	7
1	Quercus pungens - mature	sandpaper oak	Fagaceae	QUPU	QUEPUN3	5
1	Robinia neomexicana	New Mexico locust	Fabaceae	RONE	ROBNEO	1
1	Ungnadia speciosa	Mexican buckeye	Sapindaceae	UNSP	UNGSPE	6
1	Ungnadia speciosa - mature	Mexican buckeye	Sapindaceae	UNSP	UNGSPE3	1
2	Acacia constricta	mescat acacia	Fabaceae	ACCO2	ACACON	2
2	Acacia greggii	catclaw acacia	Fabaceae	ACGR	ACAGRE	14
2	Acacia neovernicosa	viscid acacia	Fabaceae	ACNE4	ACANEO	83
2	Acacia roemeriana	Catclaw	Fabaceae	ACRO	ACAROE	122
2	Aloysia wrightii	Wright's beebrush	Verbenaceae	ALWR	ALOWRI	94
2	Amelanchier pumila	dwarf serviceberry	Rosaceae	AMPU5	AMEPUM	6
2	Atriplex canescens	fourwing saltbush	Chenopodiaceae	ATCA2	ATRCAN	7
2	Baccharis emoryi	Emory's falsewillow	Asteraceae	BAEM	BACEMO	1
2	Baccharis pteronioides	yerba de pasmo	Asteraceae	BAPT	BACPTE	7
2	Bernardia myricifolia	Oreja de raton	Euphorbiaceae	BEMY	BERMYR	3
2	Bernardia obovata	Johnston bernardia	Euphorbiaceae	BEOB	BEROBO	48
2	Brickellia californica	California brickellbush	Asteraceae	BRCA3	BRICAL	7
2	Brickellia eupatorioides var. chlorolepis	false boneset	Asteraceae	BREUC2	BRIEUPC	1
2	Brickellia laciniata	splitleaf brickellbush	Asteraceae	BRLA	BRILAC	23
2	Brickellia spp.	brickellbush	Asteraceae	BRICK	bricke	2
2	Ceanothus greggii	desert ceanothus	Rhamnaceae	CEGR	CEAGRE	53
2	Celtis laevigata var. reticulata - adv regen	netleaf hackberry	Ulmaceae	CELAR	CELLAR2	1
2	Cercocarpus montanus	mountain mahogany	Rosaceae	CEMO2	CERMON	7
2	Cercocarpus montanus var. paucidentatus	Shaggy mountain mahogany	Rosaceae	CEMOP	CERMONP	83
2	Chilopsis linearis - adv regen	desert willow	Bignoniaceae	CHLI2	CHILIN2	1
2	Choisya dumosa	Mexican orange	Rutaceae	CHDU	CHODUM	8
2	Condalia ericoides	javelin bush	Rhamnaceae	COER5	CONERI	37
2	Condalia warnockii	Warnock's snakewood	Rhamnaceae	COWA	CONWAR	1
2	Croton fruticulosus	bush croton	Euphorbiaceae	CRFR	CROFRU	39
2	Dasylirion leiophyllum	green sotol	Agavaceae	DALE2	DASLEI	318
2	Ephedra aspera	jointfir	Ephedraceae	EPAS	EPHASP	30
2	Ephedra nevadensis	Nevada jointfir	Ephedraceae	EPNE	EPHNEV	1

Table A-1. CCNP vegetation map plant species list ordered by lifeform strata and scientific name (continued).

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
2	Ephedra spp.	mormontea	Ephedraceae	EPHED	EPHEDR	11
2	Ephedra torreyana	Torrey's jointfir	Ephedraceae	EPTO	EPHTOR	5
2	Fallugia paradoxa	Apacheplume	Rosaceae	FAPA	FALPAR	32
2	Fendlera rupicola	cliff fendlerbrush	Hydrangeaceae	FERU	FENRUP	41
2	Flourensia cernua	tarbush	Asteraceae	FLCE	FLOCER	20
2	Forestiera pubescens var. glabrifolia	stretchberry	Oleaceae	FOPUG2	FORPUBG	2
2	Fouquieria splendens	ocotillo	Fouquieriaceae	FOSP2	FOUSPL	77
2	Garrya flavescens	ashy silktassel	Garryaceae	GAFL2	GARFLA	14
2	Garrya spp.	silktassel	Garryaceae	GARRY	GARRYA	1
2	Juglans microcarpa	little walnut	Juglandaceae	JUMI	JUGMIC	14
2	Juglans microcarpa - adv regen	little walnut	Juglandaceae	JUMI	JUGMIC2	1
2	Juniperus deppeana - adv regen	alligator juniper	Cupressaceae	JUDE2	JUNDEP2	10
2	Juniperus pinchotii	Pinchot juniper	Cupressaceae	JUPI	JUNPIN	150
2	Juniperus pinchotii - adv regen	Pinchot juniper	Cupressaceae	JUPI	JUNPIN2	106
2	Koeberlinia spinosa	crown of thorns	Koeberliniaceae	KOSP	KOESPI	10
2	Larrea tridentata	creosotebush	Zygophyllaceae	LATR2	LARTRI	30
2	Leucophyllum minus	Big Bend silver-leaf	Scrophulariaceae	LEMI4	LEUMIN	1
2	Lonicera albiflora	western white honeysuckle	Caprifoliaceae	LOAL	LONALB	4
2	Lonicera spp.	honeysuckle	Caprifoliaceae	LONIC	LONICE	1
2	Mahonia spp.	berberis sp.	Berberidaceae	MAHON	MAHONI	3
2	Mahonia trifoliata	algerita	Berberidaceae	MATR3	MAHTRI	90
2	Mimosa aculeaticarpa var. biuncifera	catclaw mimosa	Fabaceae	MIACB	MIMACUB	158
2	Mimosa borealis	fragrant mimosa	Fabaceae	MIBO2	MIMBOR	16
2	Morus microphylla	Texas mulberry	Moraceae	MOMI	MORMIC	6
2	Nolina microcarpa	sacahuista	Agavaceae	NOMI	NOLMIC	6
2	Nolina spp.	beargrass	Agavaceae	NOLIN	NOLINA	26
2	Nolina texana	Texas sacahuista	Agavaceae		NOLTEX	94
2	Opuntia engelmannii	cactus apple	Cactaceae	OPEN3	OPUENG	98
2	Opuntia imbricata	tree cholla	Cactaceae	OPIM	OPUIMB	124
2	Opuntia leptocaulis	Christmas cactus	Cactaceae	OPLE	OPULEP	17
2	Opuntia spp.	pricklypear	Cactaceae	OPUNT	OPUNTI	7
2	Philadelphus argenteus	silver mockorange	Hydrangeaceae	PHAR12	PHIARG	2
2	Philadelphus hitchcockianus	Hitchock's mockorange	Hydrangeaceae	PHHI3	PHIHIT	5
2	Prosopis glandulosa	honey mesquite	Fabaceae	PRGL2	PROGLA	39
2	Prosopis spp.	mesquite	Fabaceae	PROSO	PROSOP	1
2	Prunus serotina var. virens	Southwestern chokecherry	Rosaceae	PRSEV	PRUSERV	2
2	Ptelea trifoliata	common hoptree	Rutaceae	PTTR	PTETRI	8
2	Quercus gambelii - adv regen	Gambel's oak	Fagaceae	QUGA	QUEGAM2	1
2	Quercus grisea - adv regen	gray oak	Fagaceae	QUGR3	QUEGRI2	2
2	Quercus mohriana	Mohr shin oak	Fagaceae	QUMO	QUEMOH	2
2	Quercus pungens	sandpaper oak	Fagaceae	QUPU	QUEPUN	86
2	Quercus pungens - adv regen	sandpaper oak	Fagaceae	QUPU	QUEPUN2	6
2	Quercus spp.	oak	Fagaceae	QUERC	QUERCU	5
2	Quercus undulata	wavyleaf oak	Fagaceae	QUUN	QUEUND	53
2	Quercus undulata x pungens	wavyleaf/pungent oak	Fagaceae		QUEUNDP	29
2	Rhus lanceolata	prairie sumac	Anacardiaceae	RHLA3	RHULAN	1
2	Rhus microphylla	littleleaf sumac	Anacardiaceae	RHMI3	RHUMIC	31
2	Rhus trilobata	skunkbush sumac	Anacardiaceae	RHTR	RHUTRI	70
2	Rhus virens	Evergreen sumac	Anacardiaceae	RHVI3	RHUVIR	5
2	Rhus virens var. choriophylla	evergreen sumac	Anacardiaceae	RHVIC	RHUVIRC	19
2	Salvia pinguifolia	rock sage	Lamiaceae	SAPI2	SALPIN	1
2	Sapindus saponaria	wingleaf soapberry	Sapindaceae	SASA4	SAPSAP	5
2	Sapindus saponaria var. drummondii	western soapberry	Sapindaceae	SASAD	SAPSAPD	3
2	Sophora secundiflora	Texas Mountain Laurel	Fabaceae	SOSE3	SOPSEC	56
2	Symphoricarpos longiflorus	desert snowberry	Caprifoliaceae	SYLO	SYMLON	1
2	Ungnadia speciosa - adv regen	Mexican buckeye	Sapindaceae	UNSP	UNGSPE2	1
2	Viguiera stenoloba	skeletonleaf goldeneye	Asteraceae	VIST	VIGSTE	238
2	Vitis arizonica	canyon grape	Vitaceae	VIAR2	VITARI	4
2	Yucca baccata	banana yucca	Agavaceae	YUBA	YUCBAC	55
2	Yucca elata	soaptree yucca	Agavaceae	YUEL	YUCELA	7
2	Yucca spp.	yucca	Agavaceae	YUCCA	YUCCA	8
2	Yucca torreyi	Torrey's yucca	Agavaceae	YUTO	YUCTOR	84
2	Ziziphus obtusifolia	lotebush	Rhamnaceae	ZIOB	ZIZOBT	15
2.5	Acacia angustissima var. texensis	prairie wattle	Fabaceae	ACANT4	ACAANGT	18

Table A-1. CCNP vegetation map plant species list ordered by lifeform strata and scientific name (continued).

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
2.5	Agave lechuguilla	lechuguilla	Agavaceae	AGLE	AGALEC	227
2.5	Agave parryi ssp. neomexicana	Parry's agave	Agavaceae	AGPAN6	AGAPARN	29
2.5	Ageratina herbacea	fragrant snakeroot	Asteraceae	AGHE5	AGEHER	1
2.5	Artemisia dracunculus	wormwood	Asteraceae	ARDR4	ARTDRA	1
2.5	Brickellia brachyphylla	plumed brickellbush	Asteraceae	BRBR2	BRIBRA	5
2.5	Chrysactinia mexicana	damiantia	Asteraceae	CHME3	CHRMEX	53
2.5	Coryphantha spp.	beehive cactus	Cactaceae	CORYP	CORYPH	1
2.5	Croton dioicus	grassland croton	Euphorbiaceae	CRDI6	CRODIO	3
2.5	Croton pottsii	leatherweed	Euphorbiaceae	CRPO5	CROPOT	59
2.5	Dalea bicolor	silver prairieclover	Fabaceae	DABI	DALBIC	3
2.5	Dalea bicolor var. argyraea	silver prairieclover	Fabaceae	DABIA	DALBICA	87
2.5	Dalea formosa	featherplume	Fabaceae	DAFO	DALFOR	109
2.5	Dalea frutescens	black prairieclover	Fabaceae	DAFR2	DALFRU	37
2.5	Dalea greggii	Gregg dalea	Fabaceae	DAGR2	DALGRE	2
2.5	Desmanthus glandulosus	glandular bundleflower	Fabaceae	DEGL8	DESGLA	3
2.5	Echinocactus horizonthalonius	devilshead	Cactaceae	ECHO	ECHHOR	8
2.5	Echinocereus chloranthus var. cylindricus	brownspine hedgehog cactus	Cactaceae	ECCHC2	ECHCHLC	6
2.5	Echinocereus pectinatus	rainbow cactus	Cactaceae	ECPE	ECHPEC	6
2.5	Echinocereus pectinatus var. dasyacanthus	rainbow cactus	Cactaceae	ECPED	ECHPECD	47
2.5	Echinocereus spp.	hedgehog cactus	Cactaceae	ECHIN3	ECHINO2	6
2.5	Echinocereus stramineus	strawberry hedgehog cactus	Cactaceae	ECST2	ECHSTR	38
2.5	Echinocereus triglochidiatus	kingcup cactus	Cactaceae	ECTR	ECHTRI	16
2.5	Epithelantha micromeris	pingpong ball cactus	Cactaceae	EPMI2	EPIMIC	3
2.5	Epithelantha spp.	Epithelantha	Cactaceae	EPITH	EPITHE	1
2.5	Escobaria sneedii var. leei	Lee's pincushion cactus	Cactaceae	ESSNL	ESCSNEL	9
2.5	Escobaria spp.	beehive cactus	Cactaceae	ESCOB	ESCOBA	1
2.5	Escobaria tuberculosa	whitecolumn foxtail cactus	Cactaceae	ESTU	ESCTUB	21
2.5	Escobaria vivipara	spinystar	Cactaceae	ESVI2	ESCVIV	1
2.5	Gutierrezia sarothrae	broom snakeweed	Asteraceae	GUSA2	GUTSAR	135
2.5	Gymnosperma glutinosum	gumhead	Asteraceae	GYGL	GYMGLU	74
2.5	Heterotheca villosa	hairy goldenaster	Asteraceae	HEVI4	HETVIL	2
2.5	Krameria grayi	white ratany	Krameriaceae	KRGR	KRAGRA	18
2.5	Mahonia repens	Oregongrape	Berberidaceae	MARE11	MAHREP	2
2.5	Mammillaria heyderi var. macdougalii	Macdougal's nipple cactus	Cactaceae	MAHEM	MAMHEYM	2
2.5	Mammillaria heyderi var. meiacantha	little nipple cactus	Cactaceae	MAHEM2	MAMHEY2	8
2.5	Menodora longiflora	showy menodora	Oleaceae	MELO2	MENLON	23
2.5	Menodora scabra	rough menodora	Oleaceae	MESC	MENSCA	1
2.5	Opuntia phaeacantha	tulip pricklypear	Cactaceae	OPPH	OPUPHA	257
2.5	Paronychia jamesii	James' nailwort	Caryophyllaceae	PAJA	PARJAM	48
2.5	Parthenium incanum	mariola	Asteraceae	PAIN2	PARINC	162
2.5	Petrophytum caespitosum	mat rockspirea	Rosaceae	PECA12	PETCAE	4
2.5	Ruellia parryi	Parry's wild petunia	Acanthaceae	RUPA3	RUEPAR	43
2.5	Salvia lycioides	canyon sage	Lamiaceae	SALY	SALLYC	3
2.5	Sclerocactus uncinatus var. wrightii	Wright's fishhook cactus	Cactaceae	SCUNW	SCLUNCW	5
2.5	Thymophylla acerosa	pricklyleaf dogweed	Asteraceae	THAC	THYACE	9
2.5	Thymophylla setifolia var. radiata	Texas pricklyleaf	Asteraceae	THSER	THYSETR	23
2.5	Tiquilia canescens	woody crinklemat	Boraginaceae	TICA3	TIQCAN	4
2.5	Zinnia acerosa	desert zinnia	Asteraceae	ZIAC	ZINACE	4
2.5	Zinnia grandiflora	Rocky Mountain zinnia	Asteraceae	ZIGR	ZINGRA	12
3	Agrostis spp.	bentgrass	Poaceae	AGROS2	AGROST	2
3	Andropogon glomeratus var. scabriglumis	roughglume bushy bluestem	Poaceae	ANGLS	ANDGLOS	1
3	Aristida adscensionis	sixweeks threeawn	Poaceae	ARAD	ARIADS	13
3	Aristida divaricata	poverty threeawn	Poaceae	ARDI5	ARIDIV	2
3	Aristida purpurea	purple threeawn	Poaceae	ARPU9	ARIPUR	170
3	Aristida purpurea var. nealleyi	Nealley's threeawn	Poaceae	ARPUN	ARIPURN	4
3	Aristida purpurea var. perplexa	purple threeawn	Poaceae	ARPUP9	ARIPER	2
3	Aristida purpurea var. purpurea	purple threeawn	Poaceae	ARPUP6	ARIPURP	3
3	Aristida purpurea var. wrightii	Wright's threeawn	Poaceae	ARPUW	ARIPURW	13
3	Aristida spp.	threeawn	Poaceae	ARIST	ARISTI	15
3	Aristida ternipes var. gentilis	spidergrass	Poaceae	ARTEG	ARITERG	1
3	Bothriochloa barbinodis	cane bluestem	Poaceae	BOBA3	BOTBAR	22
3	Bothriochloa laguroides ssp. torreyana	silver beardgrass	Poaceae	BOLAT	BOTLAGT	7
3	Bouteloua barbata	sixweeks grama	Poaceae	BOBA2	BOUBAR	1
3	Bouteloua curtipendula	sideoats grama	Poaceae	BOCU	BOUCUR	262

Table A-1. CCNP vegetation map plant species list ordered by lifeform strata and scientific name (continued).

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
3	Bouteloua eriopoda	black grama	Poaceae	BOER4	BOUERI	117
3	Bouteloua gracilis	blue grama	Poaceae	BOGR2	BOUGRA	62
3	Bouteloua hirsuta	hairy grama	Poaceae	BOHI2	BOUHIR	89
3	Bouteloua spp.	grama	Poaceae	BOUTE	BOUTEL	3
3	Bromus porteri	Porter brome	Poaceae	BRPO2	BROPOR	1
3	Carex muricata	pointed sedge	Cyperaceae		CARMUR	12
3	Carex spp.	sedge	Cyperaceae	CAREX	CAREX	10
3	Cyperaceae		Cyperaceae		CYPERA	1
3	Dichanthelium acuminatum var. acuminatum	tapered rosette grass	Poaceae	DIACA	DICACUA	2
3	Digitaria californica	Arizona cottontop	Poaceae	DICA8	DIGCAL	7
3	Digitaria cognata ssp pubiflora	Carolina crabgrass	Poaceae	DICOP2	DIGCOGP	1
3	Echinochloa crus-galli	barnyardgrass	Poaceae	ECCR	ECHCRU	1
3	Eleocharis montevidensis	sand spikerush	Cyperaceae	ELMO2	ELEMON	1
3	Eleocharis palustris	common spikerush	Cyperaceae	ELPA3	ELEPAL	1
3	Elymus canadensis	Canada wildrye	Poaceae	ELCA4	ELYCAN	1
3	Elymus canadensis x trachycaulus	hybrid wildrye	Poaceae		ELYCANT	2
3	Elymus elymoides	bottlebrush squirreltail	Poaceae	ELEL5	ELYELY	7
3	Elymus spp.	wildrye	Poaceae	ELYMU	ELYMUS	2
3	Elymus x pseudorepens	false quackgrass	Poaceae	ELPS	ELYPSE	3
3	Enneapogon desvauxii	nineawn pappusgrass	Poaceae	ENDE	ENNDES	20
3	Eragrostis intermedia	plains lovegrass	Poaceae	ERIN	ERAINT	98
3	Eragrostis lehmanniana	Lehmann's lovegrass	Poaceae	ERLE	ERALEH	1
3	Erioneuron pilosum	hairy woollygrass	Poaceae	ERPI5	ERIPIL	71
3	Erioneuron pulchellum	fluffgrass	Poaceae	ERPU8	ERIPUL	5
3	Erioneuron spp.	Fluffgrass	Poaceae	ERION	ERIONE	1
3	Fuirena simplex var. simplex	western umbrella-sedge	Cyperaceae	FUSIS	FURSIMS	1
3	Heteropogon contortus	tanglehead	Poaceae	HECO10	HETCON	8
3	Hilaria mutica	tobosa	Poaceae	HIMU2	HILMUT	24
3	Juncus dudleyi	slender rush	Juncaceae	JUDU2	JUNDUD	1
3	Juncus interior	inland rush	Juncaceae	JUIN2	JUNINT	1
3	Juncus torreyi	Torrey's rush	Juncaceae	JUTO	JUNTOR	2
3	Koeleria macrantha	prairie junegrass	Poaceae	KOMA	KOEMAC	3
3	Leptochloa dubia	green sprangletop	Poaceae	LEDU	LEPDUB	45
3	Leptochloa spp.	sprangletop	Poaceae	LEPTO	LEPTOC	1
3	Lycurus phleoides	common wolfstail	Poaceae	LYPH	LYCPHL	2
3	Lycurus setosus	bristly wolfstail	Poaceae	LYSE3	LYCSET	58
3	Lycurus spp.	wolfstail	Poaceae	LYCUR	lycuru	2
3	Melica nitans	threeflower melicgrass	Poaceae	MENI	MELNIT	3
3	Muhlenbergia arenacea	ear muhly	Poaceae	MUAR	MUHARE	1
3	Muhlenbergia arenicola	sand muhly	Poaceae	MUAR2	MUHARE2	2
3	Muhlenbergia dubia	pine muhly	Poaceae	MUDU	MUHDUB	44
3	Muhlenbergia emersleyi	bullgrass	Poaceae	MUEM	MUHEME	69
3	Muhlenbergia pauciflora	New Mexico muhly	Poaceae	MUPA2	MUHPAU	54
3	Muhlenbergia porteri	bush muhly	Poaceae	MUPO2	MUHPOR	18
3	Muhlenbergia setifolia	curlyleaf muhly	Poaceae	MUSE	MUHSET	201
3	Muhlenbergia spp.	muhly	Poaceae	MUHLE	MUHLEN	5
3	Muhlenbergia tenuifolia	slimflower muhly	Poaceae	MUTE4	MUHTEN	8
3	Muhlenbergia torreyi	ring muhly	Poaceae	MUTO2	MUHTOR	1
3	Munroa squarrosa	false buffalograss	Poaceae	MUSQ	MUNSQU	2
3	Panicum bulbosum	bulb panicgrass	Poaceae	PABU	PANBUL	3
3	Panicum hallii	Hall's panicgrass	Poaceae	PAHA	PANHAL	68
3	Panicum hirticaule	Mexican panicgrass	Poaceae	PAHI5	PANHIR	1
3	Panicum obtusum	vine mesquite	Poaceae	PAOB	PANOBT	11
3	Panicum spp.	panicgrass	Poaceae	PANIC	PANICU	5
3	Paspalum distichum	knotgrass	Poaceae	PADI6	PASDIS	1
3	Piptochaetium fimbriatum	pinyon ricegrass	Poaceae	PIFI	PIPFIM	14
3	Poa fendleriana	muttongrass	Poaceae	POFE	POAFEN	1
3	Poa fendleriana ssp. longiligula	longtongue muttongrass	Poaceae		POAFENL	1
3	Schizachyrium scoparium	little bluestem	Poaceae	SCSC	SCHSCO	20
3	Scleropogon brevifolius	burrograss	Poaceae	SCBR2	SCLBRE	9
3	Setaria leucopila	streambed bristlegrass	Poaceae	SELE6	SETLEU	31
3	Sorghastrum nutans	Indiangrass	Poaceae	SONU2	SORNUT	2
3	Sporobolus airoides	alkali sacaton	Poaceae	SPAI	SPOAIR	2

Table A-1. CCNP vegetation map plant species list ordered by lifeform strata and scientific name (continued).

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
3	Sporobolus cryptandrus	sand dropseed	Poaceae	SPCR	SPOCRY	6
3	Sporobolus flexuosus	mesa dropseed	Poaceae	SPFL2	SPOFLE	1
3	Sporobolus spp.	dropseed	Poaceae	SPORO	SPOROB	7
3	Sporobolus wrightii	giant sacaton	Poaceae	SPWR2	SPOWRI	2
3	Stipa eminens	southwestern needlegrass	Poaceae	STEM2	STIEMI	6
3	Stipa lobata	little awn needlegrass	Poaceae	STLO3	STILOB	49
3	Stipa neomexicana	New Mexico needlegrass	Poaceae	STNE2	STINEO	1
3	Stipa spp.	needlegrass	Poaceae	STIPA	STIPA	5
3	Tridens muticus	slim tridens	Poaceae	TRMU	TRIMUT	117
3	Tridens spp.	tridens	Poaceae	TRIDE	TRIDEN	1
4	Abutilon malacum	yellow Indian mallow	Malvaceae	ABMA3	ABUMAL	10
4	Abutilon parvulum	dwarf Indian mallow	Malvaceae	ABPA3	ABUPAR	6
4	Abutilon spp.	Indian mallow	Malvaceae	ABUTI	ABUTIL	5
4	Abutilon wrightii	Wright's Indian mallow	Malvaceae	ABWR	ABUWRI	3
4	Acalypha neomexicana	New Mexico copperleaf	Euphorbiaceae	ACNE	ACANEO2	10
4	Acleisanthes longiflora	angel's trumpets	Nyctaginaceae	ACLO2	ACLLON	5
4	Acourtia nana	desert holly	Asteraceae	ACNA2	ACONAN	8
4	Acourtia wrightii	brownfoot	Asteraceae	ACWR5	ACOWRI	5
4	Allionia incarnata	trailing windmills	Nyctaginaceae	ALIN	ALLINC	3
4	Allium cernuum	nodding onion	Liliaceae	ALCE2	ALLCER	5
4	Allium spp.	onion	Liliaceae	ALLIU	ALLIUM	1
4	Allowissadula holosericea	Chisos Mountain false Indian mallow	Malvaceae	ALHO4	ALLHOL	3
4	Ambrosia artemisiifolia	annual ragweed	Asteraceae	AMAR2	AMBART	1
4	Ambrosia spp.	ragweed	Asteraceae	AMBRO	AMBROS	1
4	Aphanostephus ramosissimus	plains dozedaisy	Asteraceae	APRA	APHRAM	4
4	Argyrochosma microphylla	smallleaf falsecloak fern	Pteridaceae	ARMI6	ARGMIC	23
4	Argythamnia neomexicana	New Mexico silverbush	Euphorbiaceae	ARNE2	ARGNEO	10
4	Artemisia franserioides	ragweed sagebrush	Asteraceae	ARFR3	ARTFRA	1
4	Artemisia ludoviciana	Louisiana sagewort	Asteraceae	ARLU	ARTLUD	71
4	Asclepias asperula ssp. capricornu	antelopehorns	Asclepiadaceae	ASASC	ASCASPC	10
4	Asclepias macrotis	longhood milkweed	Asclepiadaceae	ASMA	ASCMAC	1
4	Asclepias spp.	milkweed	Asclepiadaceae	ASCLE	ASCLEP	2
4	Asclepias tuberosa ssp. interior	butterfly milkweed	Asclepiadaceae	ASTUI	ASCTUBI	2
4	Astrolepis cochisensis	Cochise scaly cloakfern	Pteridaceae	ASCO42	ASTCOC	58
4	Astrolepis integerrima	hybrid cloakfern	Pteridaceae	ASIN19	ASTINT	3
4	Astrolepis spp.	Cloakfern	Pteridaceae	ASTRO	ASTROL	1
4	Bahia absinthifolia	hairyseed bahia	Asteraceae	BAAB	BAHABS	3
4	Bahia pedata	bluntscale bahia	Asteraceae	BAPE	BAHPED	4
4	Bidens spp.	beggartick	Asteraceae	BIDEN	BIDENS	1
4	Boerhaavia spp.	spiderling	Nyctaginaceae	BOERH2	BOERHA	1
4	Boerhavia linearifolia	Narrowleaf spiderling	Nyctaginaceae	BOLI2	BOELIN	1
4	Celtis laevigata var. reticulata - yng regen	netleaf hackberry	Ulmaceae	CELAR	CELLAR1	2
4	Cevallia sinuata	stinging serpent	Loasaceae	CESI	CEVSIN	1
4	Chaetopappa ericoides	rose heath	Asteraceae	CHER2	CHAERI	8
4	Chamaesaracha pallida	pale five eyes	Solanaceae	CHPA16	CHAPAL	3
4	Chamaesaracha sordida	hairy five eyes	Solanaceae	CHSO	CHASOR	17
4	Chamaesyce acuta	pointed sandmat	Euphorbiaceae	CHAC2	CHAACU	4
4	Chamaesyce fendleri	Fendler's sandmat	Euphorbiaceae	CHFE3	CHAFEN	42
4	Chamaesyce lata	hoary sandmat	Euphorbiaceae	CHLA10	CHALAT	1
4	Chamaesyce revoluta	threadstem sandmat	Euphorbiaceae	CHRE4	CHAREV	1
4	Chamaesyce serrula	sawtooth sandmat	Euphorbiaceae	CHSE7	CHASER3	1
4	Chamaesyce spp.	sandmat	Euphorbiaceae	CHAMA1	CHAMAE2	1
4	Chamaesyce stictospora	slimseed sandmat	Euphorbiaceae	CHST8	CHASTI	3
4	Cheilanthes alabamensis	Alabama lipfern	Pteridaceae	CHAL5	CHEALA	1
4	Cheilanthes eatonii	Eaton's lipfern	Pteridaceae	CHEA	CHEEAT	5
4	Cheilanthes feei	slender lipfern	Pteridaceae	CHFE	CHEFEE	2
4	Cheilanthes spp.	lipfern	Pteridaceae	CHEIL	CHEILA	2
4	Chenopodium neomexicanum	New Mexico goosefoot	Chenopodiaceae	CHNE3	CHENEO	1
4	Chenopodium spp.	goosefoot	Chenopodiaceae	CHENO	CHENOP	1
4	Cirsium spp.	thistle	Asteraceae	CISI	CIRSIU	3
4	Cirsium undulatum	wavyleaf thistle	Asteraceae	CIUN	CIRUND	5
4	Clematis pitcheri var. pitcheri	bluebill	Ranunculaceae	CLPIP	CLEPITP	10
4	Commelina dianthifolia	birdbill dayflower	Commelinaceae	CODI4	COMDIA	2

Table A-1. CCNP vegetation map plant species list ordered by lifeform strata and scientific name (continued).

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
4	Commelina erecta	whitemouth dayflower	Commelinaceae	COER	COMERE	2
4	Convolvulus equitans	Texas bindweed	Convolvulaceae	COEQ	CONEQU	10
4	Conyza canadensis	Canadian horseweed	Asteraceae	COCA5	CONCAN	2
4	Croton lindheimerianus	threeseed croton	Euphorbiaceae	CRLI	CROLIN	6
4	Croton spp.	Croton	Euphorbiaceae	CROTO	CROTON	8
4	Cucurbitaceae	Gourd Family	Cucurbitaceae		CUCURB	1
4	Cyphomeris gypsophiloides	red cyphomeris	Nyctaginaceae	CYGY	CYPGYP	2
4	Dalea aurea	Golden prairieclover	Fabaceae	DAAU	DALAUR	4
4	Dalea spp.	prairieclover	Fabaceae	DALEA	DALEA	15
4	Desmanthus obtusus	bluntpod bundleflower	Fabaceae	DEOB2	DESOBT	23
4	Dichondra brachypoda	New Mexico ponysfoot	Convolvulaceae	DIBR	DICBRA	2
4	Dyschoriste decumbens	spreading snakeherb	Acanthaceae	DYDE	DYSDEC	4
4	Erigeron divergens	spreading fleabane	Asteraceae	ERDI4	ERIDIV	11
4	Erigeron flagellaris	trailing fleabane	Asteraceae	ERFL	ERIFLA	2
4	Eriogonum hieraciifolium	hawkweed buckwheat	Polygonaceae	ERHI3	ERIHIE	71
4	Euphorbia davidii	David'sspurge	Euphorbiaceae	EUDA5	EUPDAV	8
4	Euphorbia eriantha	beetle spurge	Euphorbiaceae	EUER2	EUPERI	1
4	Euphorbia exstipulata	squareseed spurge	Euphorbiaceae	EUEX4	EUPEXS	2
4	Euphorbia spp.	spurge	Euphorbiaceae	EUPHO	EUPHOR	3
4	Evolvulus nuttallianus	shaggy dwarf morningglory	Convolvulaceae	EVNU	EVONUT	13
4	Evolvulus spp.	morningglory sp.	Convolvulaceae	EVOLV	EVOLVU	1
4	Galium microphyllum	Bracted bedstraw	Rubiaceae	GAMI	GALMIC	14
4	Galium spp.	bedstraw	Rubiaceae	GALIU	GALIUM	1
4	Gaura coccinea	scarlet beeblossom	Onagraceae	GACO5	GAUCOC	13
4	Gaura spp.	beeblossom	Onagraceae	GAURA	GAURA	1
4	Glandularia bipinnatifida	Dakota mock vervain	Verbenaceae	GLBI2	GLABIP	10
4	Glandularia bipinnatifida var. bipinnatifida	Dakota mock vervain	Verbenaceae	GLBIB	GLABIPB	1
4	Grindelia havardii	Havard's gumweed	Asteraceae	GRHA2	GRIHAV	2
4	Grindelia squarrosa	curlycup gumweed	Asteraceae	GRSQ	GRISQU	1
4	Hedeoma costata var. pulchella	ribbed false pennyroyal	Lamiaceae	HECOP	HEDCOSP	25
4	Hedeoma drummondii	Drummond's false pennyroyal	Lamiaceae	HEDR	HEDDRU	4
4	Hedeoma nana	dwarf false pennyroyal	Lamiaceae	HENA	HEDNAN	2
4	Hedeoma spp.	false pennyroyal	Lamiaceae	HEDEO	HEDEOM	2
4	Hedyotis nigricans	Diamond flowers	Rubiaceae	HENI4	HEDNIG	12
4	Heliomeris longifolia	longleaf falsegoldeneye	Asteraceae	HELO6	HELLON	4
4	Heliomeris multiflora	showy goldeneye	Asteraceae	HEMU3	HELMUL	1
4	Heliomeris spp.	goldeneye	Asteraceae	HELIO4	HELIOM	1
4	Heterosperma pinnatum	wingpetal	Asteraceae	HEPI2	HETPIN	1
4	Houstonia acerosa	needleleaf bluet	Rubiaceae	HOAC	HOUACE	1
4	Houstonia acerosa ssp. polypremoides	needleleaf bluet	Rubiaceae	HOACP	HOUACEP	6
4	Ibervillea tenuisecta	slimlobe globeberry	Cucurbitaceae	IBTE2	IBETEN	1
4	Ipomoea costellata	crestrib morningglory	Convolvulaceae	IPCO2	IPOCOS	3
4	Ipomoea lindheimeri	Lindheimer's morningglory	Convolvulaceae	IPLI	IPOLIN	7
4	Ipomoea spp.	morning glory	Convolvulaceae		IPOMOE	2
4	Ipomopsis aggregata	skyrocket gilia	Polemoniaceae	IPAG	IPOAGG	2
4	Juniperus deppeana - yng regen	alligator juniper	Cupressaceae	JUDE2	JUNDEP1	2
4	Kallstroemia parviflora	warty caltrop	Zygophyllaceae	KAPA	KALPAR	13
4	Kallstroemia spp.	caltrop	Zygophyllaceae	KALLS	KALLST	1
4	Lesquerella fendleri	Fendler's bladderpod	Brassicaceae	LEFE	LESFEN	7
4	Liatris punctata	dotted gayfeather	Asteraceae	LIPU	LIAPUN	9
4	Linum lewisii	prairie flax	Linaceae	LILE3	LINLEW	25
4	Linum puberulum	plains flax	Linaceae	LIPU4	LINPUB	2
4	Linum rupestre	rock flax	Linaceae	LIRU2	LINRUP	4
4	Linum schiedeanum	Schied's flax	Linaceae	LISC5	LINSCH	2
4	Linum spp.	flax	Linaceae	LINUM	LINUM	4
4	Lithospermum incisum	narrowleaf gromwell	Boraginaceae	LIIN2	LITINC	7
4	Lithospermum spp.	gromwell	Boraginaceae	LITHO3	LITHOS	1
4	Lithospermum viride	green gromwell	Boraginaceae	LIVI2	LITVIR	5
4	Lobelia cardinalis	cardinalflower	Campanulaceae	LOCA2	LOBCAR	2
4	Lotus spp.	trefoil	Fabaceae	LOTUS	LOTUS	2
4	Lygodesmia texana	Texas skeletonplant	Asteraceae	LYTE	LYGTEX	2
4	Machaeranthera blephariphylla	Texas tansyaster	Asteraceae	MABL2	MACBLE	10
4	Machaeranthera pinnatifida	lacy tansyaster	Asteraceae	MAPIP	MACPIN	2
4	Margaranthus solanaceus	netted globecherry	Solanaceae	MASO4	MARSOL	1

Table A-1. CCNP vegetation map plant species list ordered by lifeform strata and scientific name (continued).

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
4	Marrubium vulgare	horehound	Lamiaceae	MAVU	MARVUL	3
4	Maurandella antirrhiniflora	roving sailor	Scrophulariaceae	MAAN9	MAUANT	2
4	Melampodium leucanthum	plains blackfoot	Asteraceae	MELE2	MELLEU	35
4	Mentzelia oligosperma	chickenthief	Loasaceae	MEOL	MENOLI	3
4	Mirabilis spp.	four o'clock	Nyctaginaceae	MIRAB	MIRABI	1
4	Nama spp.	fiddleleaf	Hydrophyllaceae	NAMA4	NAMA	1
4	Nama xylopodum	yellowseed fiddleleaf	Hydrophyllaceae	NAXY	NAMXYL	5
4	Notholaena spp.	cloak fern	Pteridaceae	NOTHO	NOTHOL	1
4	Oenothera brachycarpa	shortfruit eveningprimrose	Onagraceae	OEBR	OENBRA	2
4	Oenothera spp.	eveningprimrose	Onagraceae	OENOT	OENOTH	1
4	Oxalis drummondii	Drummond's woodsorrel	Oxalidaceae	OXDR	OXADRU	1
4	Parthenium confertum var. lyratum	Gray's feverfew	Asteraceae	PACOL	PARCONL	5
4	Pellaea atropurpurea	purple cliffbrake	Pteridaceae	PEAT2	PELATR	5
4	Pellaea spp.	cliffbrake	Pteridaceae	PELLA	PELLAE	1
4	Penstemon spp.	beardtongue	Scrophulariaceae	PENST	PENSTE	5
4	Perityle quinqueflora	five-flowered rockdaisy	Asteraceae	PEQU	PERQUI	2
4	Phlox triovulata	threeseed phlox	Polemoniaceae	PHTR	PHLTRI	7
4	Phyllanthus polygonoides	smartweed leafflower	Euphorbiaceae	PHPO3	PHYPOL	17
4	Pinaropappus roseus	white rocklettuce	Asteraceae	PIRO	PINROS	2
4	Polygala alba	white milkwort	Polygalaceae	POAL4	POLALB	7
4	Polygala barbeyana	blue milkwort	Polygalaceae	POBA	POLBAR	4
4	Polygala macradenia	glandleaf milkwort	Polygalaceae	POMA7	POLMAC	6
4	Polygala spp.	milkwort	Polygalaceae	POLYG	POLYGA	1
4	Portulaca oleracea	common purslane	Portulacaceae	POOL	POROLE	1
4	Portulaca pilosa	kiss me quick	Portulacaceae	POPI3	PORPIL	7
4	Portulaca spp.	hogweed	Portulacaceae	PORTU	PORTUL	1
4	Psilostrophe spp.	paperflower	Asteraceae	PSILO3	PSILO	1
4	Ratibida columnifera	upright prairie coneflower	Asteraceae	RACO3	RATCOL	2
4	Rhynchosia senna var. texana	Texas snoutbean	Fabaceae	RHSET	RHYSENT	8
4	Rivinia humilis	Rougeplant	Phytolaccaceae	RIHU2	RIVHUM	2
4	Sanvitalia abertii	Albert's creeping zinnia	Asteraceae	SAAB	SANABE	1
4	Sarcostemma crispum	wavyleaf twinevine	Asclepiadaceae	SACR3	SARCRI	4
4	Sarcostemma cynanchoides ssp. cynanchoides	fringed twinevine	Asclepiadaceae	SACYC	SARCYNC	1
4	Sarcostemma spp.	twinevine	Asclepiadaceae		SARCOS	2
4	Sartwellia flaveriae	threadleaf glowwort	Asteraceae	SAFL5	SARFLA	1
4	Schoenocrambe linearifolia	slimleaf plainsmustard	Brassicaceae	SCLI12	SCHLIN	6
4	Scutellaria drummondii	Drummond's skullcap	Lamiaceae	SCDR2	SCUDRU	1
4	Selaginella pilifera	resurrection plant	Selaginellaceae	SEPI	SELPIL	1
4	Selaginella wrightii	Wright's spikemoss	Selaginellaceae	SEWR2	SELWRI	30
4	Senecio flaccidus	threadleaf ragwort	Asteraceae	SEFL3	SENFLA	2
4	Senecio flaccidus var. flaccidus	threadleaf ragwort	Asteraceae	SEFLF	SENFLAF	4
4	Senna bauhinioides	twinleaf senna	Fabaceae	SEBA3	SENBAU	4
4	Senna lindheimeriana	velvet leaf wild sensitive plant	Fabaceae	SELI4	SENLIN	17
4	Senna roemeriana	twoleaf wild sensitive plant	Fabaceae	SERO8	SENROE	21
4	Sida abutifolia	spreading fanpetals	Malvaceae	SIAB	SIDABU	16
4	Sida longipes	stockflower fanpetals	Malvaceae	SILO	SIDLON	7
4	Sida spp.	sida	Malvaceae	SIDA	SIDA	8
4	Solanum elaeagnifolium	silverleaf nightshade	Solanaceae	SOEL	SOLELA	14
4	Solidago wrightii var. adenophora	Wright's goldenrod	Asteraceae	SOWRA	SOLWRIA	4
4	Solidago wrightii var. wrightii	Wright's goldenrod	Asteraceae	SOWRW	SOLWRIW	4
4	Sphaeralcea angustifolia	copper globemallow	Malvaceae	SPAN3	SPHANG	5
4	Sphaeralcea incana	gray globemallow	Malvaceae	SPIN2	SPHINC	5
4	Sphaeralcea spp.	globemallow	Malvaceae	SPHAE	SPHAER	2
4	Stenandrium barbatum	early shaggytuft	Acanthaceae	STBA	STEBAR	21
4	Symphyotrichum falcatum var. commutatum	Cluster aster	Asteraceae	SYFAC	SYMFALC	1
4	Talinum aurantiacum	orange flameflower	Portulacaceae	TAAU	TALAUR	4
4	Talinum pulchellum	showy flameflower	Portulacaceae	TAPU	TALPUL	3
4	Talinum spp.	flameflower	Portulacaceae	TALIN2	TALINU	2
4	Tetraclea coulteri	Coulter's wrinklefruit	Verbenaceae	TECO	TETCOU	2
4	Tetraneuris argentea	perkysue	Asteraceae	TEAR4	TETARG	2
4	Tetraneuris scaposa	stemmy hymenoxys	Asteraceae	TESC2	TETSCA	18
4	Tetraneuris spp.	hymenoxys	Asteraceae	TETRA17	TETRAN	1
4	Thamnosma texana	rue of the mountains	Rutaceae	THTE2	THATEX	8

Table A-1. CCNP vegetation map plant species list ordered by lifeform strata and scientific name (continued).

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
4	Thelesperma longipes	longstalk greenthread	Asteraceae	THLO	THELON	32
4	Thymophylla pentachaeta	fiveneedle pricklyleaf	Asteraceae	THPE4	THYPEN	44
4	Tradescantia wrightii	Wright's spiderwort	Commelinaceae	TRWR	TRAWRI	1
4	Tragia ramosa	branched noseburn	Euphorbiaceae	TRRA5	TRARAM	78
4	Tragia spp.	noseburn	Euphorbiaceae	TRAGI	TRAGIA	1
4	Verbascum thapsus	common mullein	Scrophulariaceae	VETH	VERTHA	1
4	Verbena perennis	pinleaf vervain	Verbenaceae	VEPE	VERPER	8
4	Viguiera dentata	toothleaf goldeneye	Asteraceae	VIDE3	VIGDEN	80

Table A-2.CCNP vegetation map plant species list ordered by lifeform strata and common name.

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
1	alligator juniper	Juniperus deppeana	Cupressaceae	JUDE2	JUNDEP	17
1	alligator juniper	Juniperus deppeana - mature	Cupressaceae	JUDE2	JUNDEP3	7
1	bigtooth maple	Acer grandidentatum	Aceraceae	ACGR3	ACEGRA	9
1	Chinkapin oak	Quercus muehlenbergii	Fagaceae	QUMU	QUEMUE	7
1	desert willow	Chilopsis linearis	Bignoniaceae	CHLI2	CHILIN	5
1	desert willow	Chilopsis linearis - mature	Bignoniaceae	CHLI2	CHILIN3	1
1	Gambel's oak	Quercus gambelii	Fagaceae	QUGA	QUEGAM	1
1	Goldman's silktassel	Garrya ovata ssp. goldmanii	Garryaceae	GAOVG	GAROVAG	1
1	gray oak	Quercus grisea	Fagaceae	QUGR3	QUEGRI	24
1	Mexican buckeye	Ungnadia speciosa	Sapindaceae	UNSP	UNGSPE	6
1	Mexican buckeye	Ungnadia speciosa - mature	Sapindaceae	UNSP	UNGSPE3	1
1	netleaf hackberry	Celtis laevigata var. reticulata	Ulmaceae	CELAR	CELLAER	12
1	New Mexico locust	Robinia neomexicana	Fabaceae	RONE	ROBNEO	1
1	Pinchot juniper	Juniperus pinchotii - mature	Cupressaceae	JUPI	JUNPIN3	1
1	pinyon pine	Pinus edulis	Pinaceae	PIED	PINEDU	3
1	ponderosa pine	Pinus ponderosa	Pinaceae	PIPO	PINPON	9
1	ponderosa pine	Pinus ponderosa - mature	Pinaceae	PIPO	PINPON3	1
1	Rocky Mountain juniper	Juniperus scopulorum	Cupressaceae	JUSC2	JUNSCO	2
1	sandpaper oak	Quercus pungens - mature	Fagaceae	QUPU	QUEPUN3	5
1	Texas madrone	Arbutus xalapensis	Ericaceae	ARAL	ARBXAL	16
1	velvet ash	Fraxinus velutina	Oleaceae	FRVE2	FRAVEL	3
2	algerita	Mahonia trifoliata	Berberidaceae	MATR3	MAHTRI	90
2	alligator juniper	Juniperus deppeana - adv regen	Cupressaceae	JUDE2	JUNDEP2	10
2	Apacheplume	Fallugia paradoxa	Rosaceae	FAPA	FALPAR	32
2	ashy silktassel	Garrya flavescens	Garryaceae	GAFL2	GARFLA	14
2	banana yucca	Yucca baccata	Agavaceae	YUBA	YUCBAC	55
2	beargrass	Nolina spp.	Agavaceae	NOLIN	NOLINA	26
2	berberis sp.	Mahonia spp.	Berberidaceae	MAHON	MAHONI	3
2	Big Bend silver-leaf	Leucophyllum minus	Scrophulariaceae	LEMI4	LEUMIN	1
2	brickellbush	Brickellia spp.	Asteraceae	BRICK	bricke	2
2	bush croton	Croton fruticulosus	Euphorbiaceae	CRFR	CROFRU	39
2	cactus apple	Opuntia engelmannii	Cactaceae	OPEN3	OPUENG	98
2	California brickellbush	Brickellia californica	Asteraceae	BRCA3	BRICAL	7
2	canyon grape	Vitis arizonica	Vitaceae	VIAR2	VITARI	4
2	Catclaw	Acacia roemeriana	Fabaceae	ACRO	ACAROE	122
2	catclaw acacia	Acacia greggii	Fabaceae	ACGR	ACAGRE	14
2	catclaw mimosa	Mimosa aculeaticarpa var. biuncifera	Fabaceae	MIACB	MIMACUB	158
2	Christmas cactus	Opuntia leptocaulis	Cactaceae	OPLE	OPULEP	17
2	cliff fendlerbrush	Fendlera rupicola	Hydrangeaceae	FERU	FENRUP	41
2	common hoptree	Ptelea trifoliata	Rutaceae	PTTR	PTETRI	8
2	creosotebush	Larrea tridentata	Zygophyllaceae	LATR2	LARTRI	30
2	crown of thorns	Koeberlinia spinosa	Koeberliniaceae	KOSP	KOESPI	10
2	desert ceanothus	Ceanothus greggii	Rhamnaceae	CEGR	CEAGRE	53
2	desert snowberry	Symphoricarpos longiflorus	Caprifoliaceae	SYLO	SYMLON	1
2	desert willow	Chilopsis linearis - adv regen	Bignoniaceae	CHLI2	CHILIN2	1
2	dwarf serviceberry	Amelanchier pumila	Rosaceae	AMPU5	AMEPUM	6
2	Emory's falsewillow	Baccharis emoryi	Asteraceae	BAEM	BACEMO	1
2	Evergreen sumac	Rhus virens	Anacardiaceae	RHVI3	RHUVIR	5
2	evergreen sumac	Rhus virens var. choriophylla	Anacardiaceae	RHVIC	RHUVIRC	19
2	false boneset	Brickellia eupatorioides var. chlorolepis	Asteraceae	BREUC2	BRIEUPC	1
2	fourwing saltbush	Atriplex canescens	Chenopodiaceae	ATCA2	ATRCAN	7
2	fragrant mimosa	Mimosa borealis	Fabaceae	MIBO2	MIMBOR	16
2	Gambel's oak	Quercus gambelii - adv regen	Fagaceae	QUGA	QUEGAM2	1
2	gray oak	Quercus grisea - adv regen	Fagaceae	QUGR3	QUEGRI2	2
2	green sotol	Dasylirion leiophyllum	Agavaceae	DALE2	DASLEI	318
2	Hitchock's mockorange	Philadelphus hitchcockianus	Hydrangeaceae	PHHI3	PHIHIT	5
2	honey mesquite	Prosopis glandulosa	Fabaceae	PRGL2	PROGLA	39
2	honeysuckle	Lonicera spp.	Caprifoliaceae	LONIC	LONICE	1
2	javelina bush	Condalia ericoides	Rhamnaceae	COER5	CONERI	37
2	Johnston bernardia	Bernardia obovata	Euphorbiaceae	BEOB	BEROBO	48
2	jointfir	Ephedra aspera	Ephedraceae	EPAS	EPHASP	30
2	little walnut	Juglans microcarpa	Juglandaceae	JUMI	JUGMIC	14
2	little walnut	Juglans microcarpa - adv regen	Juglandaceae	JUMI	JUGMIC2	1
2	littleleaf sumac	Rhus microphylla	Anacardiaceae	RHMI3	RHUMIC	31

Table A-1.CCNP vegetation map plant species list ordered by lifeform strata and common name

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
2	lotebush	Ziziphus obtusifolia	Rhamnaceae	ZIOB	ZIZOBT	15
2	mescat acacia	Acacia constricta	Fabaceae	ACCO2	ACACON	2
2	mesquite	Prosopis spp.	Fabaceae	PROSO	PROSOP	1
2	Mexican buckeye	Ungnadia speciosa - adv regen	Sapindaceae	UNSP	UNGSPE2	1
2	Mexican orange	Choisya dumosa	Rutaceae	CHDU	CHODUM	8
2	Mohr shin oak	Quercus mohriana	Fagaceae	QUMO	QUEMOH	2
2	mormontea	Ephedra spp.	Ephedraceae	EPHED	EPHEDR	11
2	mountain mahogany	Cercocarpus montanus	Rosaceae	CEMO2	CERMON	7
2	netleaf hackberry	Celtis laevigata var. reticulata - adv regen	Ulmaceae	CELAR	CELLAR2	1
2	Nevada jointfir	Ephedra nevadensis	Ephedraceae	EPNE	EPHNEV	1
2	oak	Quercus spp.	Fagaceae	QUERC	QUERCU	5
2	ocotillo	Fouquieria splendens	Fouquieriaceae	FOSP2	FOUSPL	77
2	Oreja de raton	Bernardia myricifolia	Euphorbiaceae	BEMY	BERMYR	3
2	Pinchot juniper	Juniperus pinchotii	Cupressaceae	JUPI	JUNPIN	150
2	Pinchot juniper	Juniperus pinchotii - adv regen	Cupressaceae	JUPI	JUNPIN2	106
2	prairie sumac	Rhus lanceolata	Anacardiaceae	RHLA3	RHULAN	1
2	pricklypear	Opuntia spp.	Cactaceae	OPUNT	OPUNTI	7
2	rock sage	Salvia pinguifolia	Lamiaceae	SAPI2	SALPIN	1
2	sacahuista	Nolina microcarpa	Agavaceae	NOMI	NOLMIC	6
2	sandpaper oak	Quercus pungens	Fagaceae	QUPU	QUEPUN	86
2	sandpaper oak	Quercus pungens - adv regen	Fagaceae	QUPU	QUEPUN2	6
2	Shaggy mountain mahogany	Cercocarpus montanus var. paucidentatus	Rosaceae	CEMOP	CERMONP	83
2	silktassel	Garrya spp.	Garryaceae	GARRY	GARRYA	1
2	silver mockorange	Philadelphus argenteus	Hydrangeaceae	PHAR12	PHIARG	2
2	skeletonleaf goldeneye	Viguiera stenoloba	Asteraceae	VIST	VIGSTE	238
2	skunkbush sumac	Rhus trilobata	Anacardiaceae	RHTR	RHUTRI	70
2	soaptree yucca	Yucca elata	Agavaceae	YUEL	YUCELA	7
2	Southwestern chokecherry	Prunus serotina var. virens	Rosaceae	PRSEV	PRUSERV	2
2	splitleaf brickellbush	Brickellia laciniata	Asteraceae	BRLA	BRILAC	23
2	stretchberry	Forestiera pubescens var. glabrifolia	Oleaceae	FOPUG2	FORPUBG	2
2	tarbush	Flourensia cernua	Asteraceae	FLCE	FLOCER	20
2	Texas Mountain Laurel	Sophora secundiflora	Fabaceae	SOSE3	SOPSEC	56
2	Texas mulberry	Morus microphylla	Moraceae	MOMI	MORMIC	6
2	Texas sacahuista	Nolina texana	Agavaceae		NOLTEX	94
2	Torrey's jointfir	Ephedra torreyana	Ephedraceae	EPTO	EPHTOR	5
2	Torrey's yucca	Yucca torreyi	Agavaceae	YUTO	YUCTOR	84
2	tree cholla	Opuntia imbricata	Cactaceae	OPIM	OPUIMB	124
2	viscid acacia	Acacia neovernicosa	Fabaceae	ACNE4	ACANEO	83
2	Warnock's snakewood	Condalia warnockii	Rhamnaceae	COWA	CONWAR	1
2	wavyleaf oak	Quercus undulata	Fagaceae	QUUN	QUEUND	53
2	wavyleaf/pungent oak	Quercus undulata x pungens	Fagaceae		QUEUNDP	29
2	western soapberry	Sapindus saponaria var. drummondii	Sapindaceae	SASAD	SAPSAPD	3
2	western white honeysuckle	Lonicera albiflora	Caprifoliaceae	LOAL	LONALB	4
2	wingleaf soapberry	Sapindus saponaria	Sapindaceae	SASA4	SAPSAP	5
2	Wright's beebrush	Aloysia wrightii	Verbenaceae	ALWR	ALOWRI	94
2	yerba de pasmo	Baccharis pteronioides	Asteraceae	BAPT	BACPTE	7
2	yucca	Yucca spp.	Agavaceae	YUCCA	YUCCA	8
2.5	beehive cactus	Coryphantha spp.	Cactaceae	CORYP	CORYPH	1
2.5	beehive cactus	Escobaria spp.	Cactaceae	ESCOB	ESCOBA	1
2.5	black prairieclover	Dalea frutescens	Fabaceae	DAFR2	DALFRU	37
2.5	broom snakeweed	Gutierrezia sarothrae	Asteraceae	GUSA2	GUTSAR	135
2.5	brownspine hedgehog cactus	Echinocereus chloranthus var. cylindricus	Cactaceae	ECCHC2	ECHCHLC	6
2.5	canyon sage	Salvia lycioides	Lamiaceae	SALY	SALLYC	3
2.5	damiantia	Chrysactinia mexicana	Asteraceae	CHME3	CHRMEX	53
2.5	desert zinnia	Zinnia acerosa	Asteraceae	ZIAC	ZINACE	4
2.5	devilshead	Echinocactus horizonthalonius	Cactaceae	ECHO	ECHHOR	8
2.5	Epithelantha	Epithelantha spp.	Cactaceae	EPITH	EPITHE	1
2.5	featherplume	Dalea formosa	Fabaceae	DAFO	DALFOR	109
2.5	fragrant snakeroot	Ageratina herbacea	Asteraceae	AGHE5	AGEHER	1
2.5	glandular bundleflower	Desmanthus glandulosus	Fabaceae	DEGL8	DESGLA	3
2.5	grassland croton	Croton dioicus	Euphorbiaceae	CRDI6	CRODIO	3
2.5	Gregg dalea	Dalea greggii	Fabaceae	DAGR2	DALGRE	2
2.5	gumhead	Gymnosperma glutinosum	Asteraceae	GYGL	GYMGLU	74
2.5	hairy goldenaster	Heterotheca villosa	Asteraceae	HEVI4	HETVIL	2

Table A-2. CCNP vegetation map plant species list ordered by lifeform strata and common name (continued)

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
2.5	hedgehog cactus	Echinocereus spp.	Cactaceae	ECHIN3	ECHINO2	6
2.5	James' nailwort	Paronychia jamesii	Caryophyllaceae	PAJA	PARJAM	48
2.5	kingcup cactus	Echinocereus triglochidiatus	Cactaceae	ECTR	ECHTRI	16
2.5	leatherweed	Croton pottsii	Euphorbiaceae	CRPO5	CROPOT	59
2.5	lechuguilla	Agave lechuguilla	Agavaceae	AGLE	AGALEC	227
2.5	Lee's pincushion cactus	Escobaria sneedii var. leei	Cactaceae	ESSNL	ESCSNEL	9
2.5	little nipple cactus	Mammillaria heyderi var. meiacantha	Cactaceae	MAHEM2	MAMHEY2	8
2.5	Macdougal's nipple cactus	Mammillaria heyderi var. macdougalii	Cactaceae	MAHEM	MAMHEYM	2
2.5	mariola	Parthenium incanum	Asteraceae	PAIN2	PARINC	162
2.5	mat rockspirea	Petrophytum caespitosum	Rosaceae	PECA12	PETCAE	4
2.5	Oregongrape	Mahonia repens	Berberidaceae	MARE11	MAHREP	2
2.5	Parry's agave	Agave parryi ssp. neomexicana	Agavaceae	AGPAN6	AGAPARN	29
2.5	Parry's wild petunia	Ruellia parryi	Acanthaceae	RUPA3	RUEPAR	43
2.5	pingpong ball cactus	Epithelantha micromeris	Cactaceae	EPMI2	EPIMIC	3
2.5	plumed brickellbush	Brickellia brachyphylla	Asteraceae	BRBR2	BRIBRA	5
2.5	prairie wattle	Acacia angustissima var. texensis	Fabaceae	ACANT4	ACAANGT	18
2.5	pricklyleaf dogweed	Thymophylla acerosa	Asteraceae	THAC	THYACE	9
2.5	rainbow cactus	Echinocereus pectinatus	Cactaceae	ECPE	ECHPEC	6
2.5	rainbow cactus	Echinocereus pectinatus var. dasyacanthus	Cactaceae	ECPED	ECHPECD	47
2.5	Rocky Mountain zinnia	Zinnia grandiflora	Asteraceae	ZIGR	ZINGRA	12
2.5	rough menodora	Menodora scabra	Oleaceae	MESC	MENSCA	1
2.5	showy menodora	Menodora longiflora	Oleaceae	MELO2	MENLON	23
2.5	silver prairieclover	Dalea bicolor	Fabaceae	DABI	DALBIC	3
2.5	silver prairieclover	Dalea bicolor var. argyraea	Fabaceae	DABIA	DALBICA	87
2.5	spinystar	Escobaria vivipara	Cactaceae	ESVI2	ESCVIV	1
2.5	strawberry hedgehog cactus	Echinocereus stramineus	Cactaceae	ECST2	ECHSTR	38
2.5	Texas pricklyleaf	Thymophylla setifolia var. radiata	Asteraceae	THSER	THYSETR	23
2.5	tulip pricklypear	Opuntia phaeacantha	Cactaceae	OPPH	OPUPHA	257
2.5	white ratany	Krameria grayi	Krameriaceae	KRGR	KRAGRA	18
2.5	whitecolumn foxtail cactus	Escobaria tuberculosa	Cactaceae	ESTU	ESCTUB	21
2.5	woody crinklemat	Tiquilia canescens	Boraginaceae	TICA3	TIQCAN	4
2.5	wormwood	Artemisia dracunculus	Asteraceae	ARDR4	ARTDRA	1
2.5	Wright's fishhook cactus	Sclerocactus uncinatus var. wrightii	Cactaceae	SCUNW	SCLUNCW	5
3		Cyperaceae	Cyperaceae		CYPERA	1
3	alkali sacaton	Sporobolus airoides	Poaceae	SPAI	SPOAIR	2
3	Arizona cottontop	Digitaria californica	Poaceae	DICA8	DIGCAL	7
3	barnyardgrass	Echinochloa crus-galli	Poaceae	ECCR	ECHCRU	1
3	bentgrass	Agrostis spp.	Poaceae	AGROS2	AGROST	2
3	black grama	Bouteloua eriopoda	Poaceae	BOER4	BOUERI	117
3	blue grama	Bouteloua gracilis	Poaceae	BOGR2	BOUGRA	62
3	bottlebrush squirreltail	Elymus elymoides	Poaceae	ELEL5	ELYELY	7
3	bristly wolfstail	Lycurus setosus	Poaceae	LYSE3	LYCSET	58
3	bulb panicgrass	Panicum bulbosum	Poaceae	PABU	PANBUL	3
3	bullgrass	Muhlenbergia emersleyi	Poaceae	MUEM	MUHEME	69
3	burrograss	Scleropogon brevifolius	Poaceae	SCBR2	SCLBRE	9
3	bush muhly	Muhlenbergia porteri	Poaceae	MUPO2	MUHPOR	18
3	Canada wildrye	Elymus canadensis	Poaceae	ELCA4	ELYCAN	1
3	cane bluestem	Bothriochloa barbinodis	Poaceae	BOBA3	BOTBAR	22
3	Carolina crabgrass	Digitaria cognata ssp pubiflora	Poaceae	DICOP2	DIGCOGP	1
3	common spikerush	Eleocharis palustris	Cyperaceae	ELPA3	ELEPAL	1
3	common wolfstail	Lycurus phleoides	Poaceae	LYPH	LYCPHL	2
3	curlyleaf muhly	Muhlenbergia setifolia	Poaceae	MUSE	MUHSET	201
3	dropseed	Sporobolus spp.	Poaceae	SPORO	SPOROB	7
3	ear muhly	Muhlenbergia arenacea	Poaceae	MUAR	MUHARE	1
3	false buffalograss	Munroa squarrosa	Poaceae	MUSQ	MUNSQU	2
3	false quackgrass	Elymus x pseudorepens	Poaceae	ELPS	ELYPSE	3
3	fluffgrass	Erioneuron pulchellum	Poaceae	ERPU8	ERIPUL	5
3	Fluffgrass	Erioneuron spp.	Poaceae	ERION	ERIONE	1
3	giant sacaton	Sporobolus wrightii	Poaceae	SPWR2	SPOWRI	2
3	grama	Bouteloua spp.	Poaceae	BOUTE	BOUTEL	3
3	green sprangletop	Leptochloa dubia	Poaceae	LEDU	LEPDUB	45
3	hairy grama	Bouteloua hirsuta	Poaceae	BOHI2	BOUHIR	89
3	hairy woollygrass	Erioneuron pilosum	Poaceae	ERPI5	ERIPIL	71
3	Hall's panicgrass	Panicum hallii	Poaceae	PAHA	PANHAL	68

Table A-2. CCNP vegetation map plant species list ordered by lifeform strata and common name (continued)

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
3	hybrid wildrye	Elymus canadensis x trachycaulus	Poaceae		ELYCANT	2
3	Indiangrass	Sorghastrum nutans	Poaceae	SONU2	SORNUT	2
3	inland rush	Juncus interior	Juncaceae	JUIN2	JUNINT	1
3	knotgrass	Paspalum distichum	Poaceae	PADI6	PASDIS	1
3	Lehmann's lovegrass	Eragrostis lehmanniana	Poaceae	ERLE	ERALEH	1
3	little awn needlegrass	Stipa lobata	Poaceae	STLO3	STILOB	49
3	little bluestem	Schizachyrium scoparium	Poaceae	SCSC	SCHSCO	20
3	longtongue muttongrass	Poa fendleriana ssp. longiligula	Poaceae		POAFENL	1
3	mesa dropseed	Sporobolus flexuosus	Poaceae	SPFL2	SPOFLE	1
3	Mexican panicgrass	Panicum hirticaule	Poaceae	PAHI5	PANHIR	1
3	muhly	Muhlenbergia spp.	Poaceae	MUHLE	MUHLEN	5
3	muttongrass	Poa fendleriana	Poaceae	POFE	POAFEN	1
3	Nealley's threeawn	Aristida purpurea var. nealleyi	Poaceae	ARPUN	ARIPURN	4
3	needlegrass	Stipa spp.	Poaceae	STIPA	STIPA	5
3	New Mexico muhly	Muhlenbergia pauciflora	Poaceae	MUPA2	MUHPAU	54
3	New Mexico needlegrass	Stipa neomexicana	Poaceae	STNE2	STINEO	1
3	nineawn pappusgrass	Enneapogon desvauxii	Poaceae	ENDE	ENNDES	20
3	panicgrass	Panicum spp.	Poaceae	PANIC	PANICU	5
3	pine muhly	Muhlenbergia dubia	Poaceae	MUDU	MUHDUB	44
3	pinyon ricegrass	Piptochaetium fimbriatum	Poaceae	PIFI	PIPFIM	14
3	plains lovegrass	Eragrostis intermedia	Poaceae	ERIN	ERAINT	98
3	pointed sedge	Carex muricata	Cyperaceae		CARMUR	12
3	Porter brome	Bromus porteri	Poaceae	BRPO2	BROPOR	1
3	poverty threeawn	Aristida divaricata	Poaceae	ARDI5	ARIDIV	2
3	prairie junegrass	Koeleria macrantha	Poaceae	KOMA	KOEMAC	3
3	purple threeawn	Aristida purpurea	Poaceae	ARPU9	ARIPUR	170
3	purple threeawn	Aristida purpurea var. perplexa	Poaceae	ARPUP9	ARIPER	2
3	purple threeawn	Aristida purpurea var. purpurea	Poaceae	ARPUP6	ARIPURP	3
3	ring muhly	Muhlenbergia torreyi	Poaceae	MUTO2	MUHTOR	1
3	roughglume bushy bluestem	Andropogon glomeratus var. scabriglumis	Poaceae	ANGLS	ANDGLOS	1
3	sand dropseed	Sporobolus cryptandrus	Poaceae	SPCR	SPOCRY	6
3	sand muhly	Muhlenbergia arenicola	Poaceae	MUAR2	MUHARE2	2
3	sand spikerush	Eleocharis montevidensis	Cyperaceae	ELMO2	ELEMON	1
3	sedge	Carex spp.	Cyperaceae	CAREX	CAREX	10
3	sideoats grama	Bouteloua curtipendula	Poaceae	BOCU	BOUCUR	262
3	silver beardgrass	Bothriochloa laguroides ssp. torreyana	Poaceae	BOLAT	BOTLAGT	7
3	sixweeks grama	Bouteloua barbata	Poaceae	BOBA2	BOUBAR	1
3	sixweeks threeawn	Aristida adscensionis	Poaceae	ARAD	ARIADS	13
3	slender rush	Juncus dudleyi	Juncaceae	JUDU2	JUNDUD	1
3	slim tridens	Tridens muticus	Poaceae	TRMU	TRIMUT	117
3	slimflower muhly	Muhlenbergia tenuifolia	Poaceae	MUTE4	MUHTEN	8
3	southwestern needlegrass	Stipa eminens	Poaceae	STEM2	STIEMI	6
3	spidergrass	Aristida ternipes var. gentilis	Poaceae	ARTEG	ARITERG	1
3	sprangletop	Leptochloa spp.	Poaceae	LEPTO	LEPTOC	1
3	streambed bristlegrass	Setaria leucopila	Poaceae	SELE6	SETLEU	31
3	tanglehead	Heteropogon contortus	Poaceae	HECO10	HETCON	8
3	tapered rosette grass	Dichanthelium acuminatum var. acuminatum	Poaceae	DIACA	DICACUA	2
3	threeawn	Aristida spp.	Poaceae	ARIST	ARISTI	15
3	threeflower melicgrass	Melica nitans	Poaceae	MENI	MELNIT	3
3	tobosa	Hilaria mutica	Poaceae	HIMU2	HILMUT	24
3	Torrey's rush	Juncus torreyi	Juncaceae	JUTO	JUNTOR	2
3	tridens	Tridens spp.	Poaceae	TRIDE	TRIDEN	1
3	vine mesquite	Panicum obtusum	Poaceae	PAOB	PANOBT	11
3	western umbrella-sedge	Fuirena simplex var. simplex	Cyperaceae	FUSIS	FURSIMS	1
3	wildrye	Elymus spp.	Poaceae	ELYMU	ELYMUS	2
3	wolfstail	Lycurus spp.	Poaceae	LYCUR	lycuru	2
3	Wright's threeawn	Aristida purpurea var. wrightii	Poaceae	ARPUW	ARIPURW	13
4	Alabama lipfern	Cheilanthes alabamensis	Pteridaceae	CHAL5	CHEALA	1
4	Albert's creeping zinnia	Sanvitalia abertii	Asteraceae	SAAB	SANABE	1
4	alligator juniper	Juniperus deppeana - yng regen	Cupressaceae	JUDE2	JUNDEP1	2
4	angel's trumpets	Acleisanthes longiflora	Nyctaginaceae	ACLO2	ACLLON	5
4	annual ragweed	Ambrosia artemisiifolia	Asteraceae	AMAR2	AMBART	1
4	antelopehorns	Asclepias asperula ssp. capricornu	Asclepiadaceae	ASASC	ASCASPC	10

Table A-2. CCNP vegetation map plant species list ordered by lifeform strata and common name (continued)

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
4	beardtongue	Penstemon spp.	Scrophulariaceae	PENST	PENSTE	5
4	bedstraw	Galium spp.	Rubiaceae	GALIU	GALIUM	1
4	beeblossom	Gaura spp.	Onagraceae	GAURA	GAURA	1
4	beetle spurge	Euphorbia eriantha	Euphorbiaceae	EUER2	EUPERI	1
4	beggartick	Bidens spp.	Asteraceae	BIDEN	BIDENS	1
4	birdbill dayflower	Commelina dianthifolia	Commelinaceae	CODI4	COMDIA	2
4	blue milkwort	Polygala barbeyana	Polygalaceae	POBA	POLBAR	4
4	bluebill	Clematis pitcheri var. pitcheri	Ranunculaceae	CLPIP	CLEPITP	10
4	bluntpod bundleflower	Desmanthus obtusus	Fabaceae	DEOB2	DESOBT	23
4	bluntscale bahia	Bahia pedata	Asteraceae	BAPE	BAHPED	4
4	Bracted bedstraw	Galium microphyllum	Rubiaceae	GAMI	GALMIC	14
4	branched noseburn	Tragia ramosa	Euphorbiaceae	TRRA5	TRARAM	78
4	brownfoot	Acourtia wrightii	Asteraceae	ACWR5	ACOWRI	5
4	butterfly milkweed	Asclepias tuberosa ssp. interior	Asclepiadaceae	ASTUI	ASCTUBI	2
4	caltrop	Kallstroemia spp.	Zygophyllaceae	KALLS	KALLST	1
4	Canadian horseweed	Conyza canadensis	Asteraceae	COCA5	CONCAN	2
4	cardinalflower	Lobelia cardinalis	Campanulaceae	LOCA2	LOBCAR	2
4	chickenthief	Mentzelia oligosperma	Loasaceae	MEOL	MENOLI	3
4	Chisos Mountain false Indian mallow	Allowissadula holosericea	Malvaceae	ALHO4	ALLHOL	3
4	cliffbrake	Pellaea spp.	Pteridaceae	PELLA	PELLAE	1
4	cloak fern	Notholaena spp.	Pteridaceae	NOTHO	NOTHOL	1
4	Cloakfern	Astrolepis spp.	Pteridaceae	ASTRO	ASTROL	1
4	Cluster aster	Symphyotrichum falcatum var. commutatum	Asteraceae	SYFAC	SYMFALC	1
4	Cochise scaly cloakfern	Astrolepis cochisensis	Pteridaceae	ASCO42	ASTCOC	58
4	common mullein	Verbascum thapsus	Scrophulariaceae	VETH	VERTHA	1
4	common purslane	Portulaca oleracea	Portulacaceae	POOL	POROLE	1
4	copper globemallow	Sphaeralcea angustifolia	Malvaceae	SPAN3	SPHANG	5
4	Coulter's wrinklefruit	Tetraclea coulteri	Verbenaceae	TECO	TETCOU	2
4	crestrib morningglory	Ipomoea costellata	Convolvulaceae	IPCO2	IPOCOS	3
4	Croton	Croton spp.	Euphorbiaceae	CROTO	CROTON	8
4	curlycup gumweed	Grindelia squarrosa	Asteraceae	GRSQ	GRISQU	1
4	Dakota mock vervain	Glandularia bipinnatifida	Verbenaceae	GLBI2	GLABIP	10
4	Dakota mock vervain	Glandularia bipinnatifida var. bipinnatifida	Verbenaceae	GLBIB	GLABIPB	1
4	David'sspurge	Euphorbia davidii	Euphorbiaceae	EUDA5	EUPDAV	8
4	desert holly	Acourtia nana	Asteraceae	ACNA2	ACONAN	8
4	Diamond flowers	Hedyotis nigricans	Rubiaceae	HENI4	HEDNIG	12
4	dotted gayfeather	Liatris punctata	Asteraceae	LIPU	LIAPUN	9
4	Drummond's false pennyroyal	Hedeoma drummondii	Lamiaceae	HEDR	HEDDRU	4
4	Drummond's skullcap	Scutellaria drummondii	Lamiaceae	SCDR2	SCUDRU	1
4	Drummond's woodsorrel	Oxalis drummondii	Oxalidaceae	OXDR	OXADRU	1
4	dwarf false pennyroyal	Hedeoma nana	Lamiaceae	HENA	HEDNAN	2
4	dwarf Indian mallow	Abutilon parvulum	Malvaceae	ABPA3	ABUPAR	6
4	early shaggytuft	Stenandrium barbatum	Acanthaceae	STBA	STEBAR	21
4	Eaton's lipfern	Cheilanthes eatonii	Pteridaceae	CHEA	CHEEAT	5
4	eveningprimrose	Oenothera spp.	Onagraceae	OENOT	OENOTH	1
4	false pennyroyal	Hedeoma spp.	Lamiaceae	HEDEO	HEDEOM	2
4	Fendler's bladderpod	Lesquerella fendleri	Brassicaceae	LEFE	LESFEN	7
4	Fendler's sandmat	Chamaesyce fendleri	Euphorbiaceae	CHFE3	CHAFEN	42
4	fiddleleaf	Nama spp.	Hydrophyllaceae	NAMA4	NAMA	1
4	five-flowered rockdaisy	Perityle quinqueflora	Asteraceae	PEQU	PERQUI	2
4	fiveneedle pricklyleaf	Thymophylla pentachaeta	Asteraceae	THPE4	THYPEN	44
4	flameflower	Talinum spp.	Portulacaceae	TALIN2	TALINU	2
4	flax	Linum spp.	Linaceae	LINUM	LINUM	4
4	four o'clock	Mirabilis spp.	Nyctaginaceae	MIRAB	MIRABI	1
4	fringed twinevine ssp. cynanchoides	Sarcostemma cynanchoides	Asclepiadaceae	SACYC	SARCYNC	1
4	glandleaf milkwort	Polygala macradenia	Polygalaceae	POMA7	POLMAC	6
4	globemallow	Sphaeralcea spp.	Malvaceae	SPHAE	SPHAER	2
4	Golden prairieclover	Dalea aurea	Fabaceae	DAAU	DALAUR	4
4	goldeneye	Heliomeris spp.	Asteraceae	HELIO4	HELIOM	1
4	goosefoot	Chenopodium spp.	Chenopodiaceae	CHENO	CHENOP	1
4	Gourd Family	Cucurbitaceae	Cucurbitaceae		CUCURB	1

Table A-2. CCNP vegetation map plant species list ordered by lifeform strata and common name (continued)

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
4	gray globemallow	Sphaeralcea incana	Malvaceae	SPIN2	SPHINC	5
4	Gray's feverfew	Parthenium confertum var. lyratum	Asteraceae	PACOL	PARCONL	5
4	green gromwell	Lithospermum viride	Boraginaceae	LIVI2	LITVIR	5
4	gromwell	Lithospermum spp.	Boraginaceae	LITHO3	LITHOS	1
4	hairy five eyes	Chamaesaracha sordida	Solanaceae	CHSO	CHASOR	17
4	hairyseed bahia	Bahia absinthifolia	Asteraceae	BAAB	BAHABS	3
4	Havard's gumweed	Grindelia havardii	Asteraceae	GRHA2	GRIHAV	2
4	hawkweed buckwheat	Eriogonum hieraciifolium	Polygonaceae	ERHI3	ERIHIE	71
4	hoary sandmat	Chamaesyce lata	Euphorbiaceae	CHLA10	CHALAT	1
4	hogweed	Portulaca spp.	Portulacaceae	PORTU	PORTUL	1
4	horehound	Marrubium vulgare	Lamiaceae	MAVU	MARVUL	3
4	hybrid cloakfern	Astrolepis integerrima	Pteridaceae	ASIN19	ASTINT	3
4	hymenoxys	Tetraneuris spp.	Asteraceae	TETRA17	TETRAN	1
4	Indian mallow	Abutilon spp.	Malvaceae	ABUTI	ABUTIL	5
4	kiss me quick	Portulaca pilosa	Portulacaceae	POPI3	PORPIL	7
4	lacy tansyaster	Machaeranthera pinnatifida	Asteraceae	MAPIP	MACPIN	2
4	Lindheimer's morningglory	Ipomoea lindheimeri	Convolvulaceae	IPLI	IPOLIN	7
4	lipfern	Cheilanthes spp.	Pteridaceae	CHEIL	CHEILA	2
4	longhood milkweed	Asclepias macrotis	Asclepiadaceae	ASMA	ASCMAC	1
4	longleaf falsegoldeneye	Heliomeris longifolia	Asteraceae	HELO6	HELLON	4
4	longstalk greenthread	Thelesperma longipes	Asteraceae	THLO	THELON	32
4	Louisiana sagewort	Artemisia ludoviciana	Asteraceae	ARLU	ARTLUD	71
4	milkweed	Asclepias spp.	Asclepiadaceae	ASCLE	ASCLEP	2
4	milkwort	Polygala spp.	Polygalaceae	POLYG	POLYGA	1
4	morning glory	Ipomoea spp.	Convolvulaceae		IPOMOE	2
4	morningglory sp.	Evolvulus spp.	Convolvulaceae	EVOLV	EVOLVU	1
4	narrowleaf gromwell	Lithospermum incisum	Boraginaceae	LIIN2	LITINC	7
4	Narrowleaf spiderling	Boerhavia linearifolia	Nyctaginaceae	BOLI2	BOELIN	1
4	needleleaf bluet	Houstonia acerosa	Rubiaceae	HOAC	HOUACE	1
4	needleleaf bluet	Houstonia acerosa ssp. polypremoides	Rubiaceae	HOACP	HOUACEP	6
4	netleaf hackberry	Celtis laevigata var. reticulata - yng regen	Ulmaceae	CELAR	CELLAR1	2
4	netted globecherry	Margaranthus solanaceus	Solanaceae	MASO4	MARSOL	1
4	New Mexico copperleaf	Acalypha neomexicana	Euphorbiaceae	ACNE	ACANEO2	10
4	New Mexico goosefoot	Chenopodium neomexicanum	Chenopodiaceae	CHNE3	CHENEO	1
4	New Mexico ponysfoot	Dichondra brachypoda	Convolvulaceae	DIBR	DICBRA	2
4	New Mexico silverbush	Argythamnia neomexicana	Euphorbiaceae	ARNE2	ARGNEO	10
4	nodding onion	Allium cernuum	Liliaceae	ALCE2	ALLCER	5
4	noseburn	Tragia spp.	Euphorbiaceae	TRAGI	TRAGIA	1
4	onion	Allium spp.	Liliaceae	ALLIU	ALLIUM	1
4	orange flameflower	Talinum aurantiacum	Portulacaceae	TAAU	TALAUR	4
4	pale five eyes	Chamaesaracha pallida	Solanaceae	CHPA16	CHAPAL	3
4	paperflower	Psilostrophe spp.	Asteraceae	PSILO3	PSILO	1
4	perkysue	Tetraneuris argentea	Asteraceae	TEAR4	TETARG	2
4	pinleaf vervain	Verbena perennis	Verbenaceae	VEPE	VERPER	8
4	plains blackfoot	Melampodium leucanthum	Asteraceae	MELE2	MELLEU	35
4	plains dozedaisy	Aphanostephus ramosissimus	Asteraceae	APRA	APHRAM	4
4	plains flax	Linum puberulum	Linaceae	LIPU4	LINPUB	2
4	pointed sandmat	Chamaesyce acuta	Euphorbiaceae	CHAC2	CHAACU	4
4	prairie flax	Linum lewisii	Linaceae	LILE3	LINLEW	25
4	prairieclover	Dalea spp.	Fabaceae	DALEA	DALEA	15
4	purple cliffbrake	Pellaea atropurpurea	Pteridaceae	PEAT2	PELATR	5
4	ragweed	Ambrosia spp.	Asteraceae	AMBRO	AMBROS	1
4	ragweed sagebrush	Artemisia franserioides	Asteraceae	ARFR3	ARTFRA	1
4	red cyphomeris	Cyphomeris gypsophiloides	Nyctaginaceae	CYGY	CYPGYP	2
4	resurrection plant	Selaginella pilifera	Selaginellaceae	SEPI	SELPIL	1
4	ribbed false pennyroyal	Hedeoma costata var. pulchella	Lamiaceae	HECOP	HEDCOSP	25
4	rock flax	Linum rupestre	Linaceae	LIRU2	LINRUP	4
4	rose heath	Chaetopappa ericoides	Asteraceae	CHER2	CHAERI	8
4	Rougeplant	Rivinia humilis	Phytolaccaceae	RIHU2	RIVHUM	2
4	roving sailor	Maurandella antirrhiniflora	Scrophulariaceae	MAAN9	MAUANT	2
4	rue of the mountains	Thamnosma texana	Rutaceae	THTE2	THATEX	8
4	sandmat	Chamaesyce spp.	Euphorbiaceae	CHAMA1	CHAMAE2	1
4	sawtooth sandmat	Chamaesyce serrula	Euphorbiaceae	CHSE7	CHASER3	1
4	scarlet beeblossom	Gaura coccinea	Onagraceae	GACO5	GAUCOC	13

Table A-2. CCNP vegetation map plant species list ordered by lifeform strata and common name (continued)

LF	Common Name	Species Name	Family	PLANTS Symbol	NMNHP Code	N
4	Schied's flax	Linum schiedeanum	Linaceae	LISC5	LINSCH	2
4	shaggy dwarf morningglory	Evolvulus nuttallianus	Convolvulaceae	EVNU	EVONUT	13
4	shortfruit eveningprimrose	Oenothera brachycarpa	Onagraceae	OEBR	OENBRA	2
4	showy flameflower	Talinum pulchellum	Portulacaceae	TAPU	TALPUL	3
4	showy goldeneye	Heliomeris multiflora	Asteraceae	HEMU3	HELMUL	1
4	sida	Sida spp.	Malvaceae	SIDA	SIDA	8
4	silverleaf nightshade	Solanum elaeagnifolium	Solanaceae	SOEL	SOLELA	14
4	skyrocket gilia	Ipomopsis aggregata	Polemoniaceae	IPAG	IPOAGG	2
4	slender lipfern	Cheilanthes feei	Pteridaceae	CHFE	CHEFEE	2
4	slimleaf plainsmustard	Schoenocrambe linearifolia	Brassicaceae	SCLI12	SCHLIN	6
4	slimlobe globeberry	Ibervillea tenuisecta	Cucurbitaceae	IBTE2	IBETEN	1
4	slimseed sandmat	Chamaesyce stictospora	Euphorbiaceae	CHST8	CHASTI	3
4	smallleaf falsecloak fern	Argyrochosma microphylla	Pteridaceae	ARMI6	ARGMIC	23
4	smartweed leafflower	Phyllanthus polygonoides	Euphorbiaceae	PHPO3	PHYPOL	17
4	spiderling	Boerhaavia spp.	Nyctaginaceae	BOERH2	BOERHA	1
4	spreading fanpetals	Sida abutifolia	Malvaceae	SIAB	SIDABU	16
4	spreading fleabane	Erigeron divergens	Asteraceae	ERDI4	ERIDIV	11
4	spreading snakeherb	Dyschoriste decumbens	Acanthaceae	DYDE	DYSDEC	4
4	spurge	Euphorbia spp.	Euphorbiaceae	EUPHO	EUPHOR	3
4	squareseed spurge	Euphorbia exstipulata	Euphorbiaceae	EUEX4	EUPEXS	2
4	stemmy hymenoxys	Tetraneuris scaposa	Asteraceae	TESC2	TETSCA	18
4	stinging serpent	Cevallia sinuata	Loasaceae	CESI	CEVSIN	1
4	stockflower fanpetals	Sida longipes	Malvaceae	SILO	SIDLON	7
4	Texas bindweed	Convolvulus equitans	Convolvulaceae	COEQ	CONEQU	10
4	Texas skeletonplant	Lygodesmia texana	Asteraceae	LYTE	LYGTEX	2
4	Texas snoutbean	Rhynchosia senna var. texana	Fabaceae	RHSET	RHYSENT	8
4	Texas tansyaster	Machaeranthera blephariphylla	Asteraceae	MABL2	MACBLE	10
4	thistle	Cirsium spp.	Asteraceae	CISI	CIRSIU	3
4	threadleaf glowwort	Sartwellia flaveriae	Asteraceae	SAFL5	SARFLA	1
4	threadleaf ragwort	Senecio flaccidus	Asteraceae	SEFL3	SENFLA	2
4	threadleaf ragwort	Senecio flaccidus var. flaccidus	Asteraceae	SEFLF	SENFLAF	4
4	threadstem sandmat	Chamaesyce revoluta	Euphorbiaceae	CHRE4	CHAREV	1
4	threeseed croton	Croton lindheimerianus	Euphorbiaceae	CRLI	CROLIN	6
4	threeseed phlox	Phlox triovulata	Polemoniaceae	PHTR	PHLTRI	7
4	toothleaf goldeneye	Viguiera dentata	Asteraceae	VIDE3	VIGDEN	80
4	trailing fleabane	Erigeron flagellaris	Asteraceae	ERFL	ERIFLA	2
4	trailing windmills	Allionia incarnata	Nyctaginaceae	ALIN	ALLINC	3
4	trefoil	Lotus spp.	Fabaceae	LOTUS	LOTUS	2
4	twinevine	Sarcostemma spp.	Asclepiadaceae		SARCOS	2
4	twinleaf senna	Senna bauhinioides	Fabaceae	SEBA3	SENBAU	4
4	twoleaf wild sensitive plant	Senna roemeriana	Fabaceae	SERO8	SENROE	21
4	upright prairie coneflower	Ratibida columnifera	Asteraceae	RACO3	RATCOL	2
4	velvet leaf wild sensitive plant	Senna lindheimeriana	Fabaceae	SELI4	SENLIN	17
4	warty caltrop	Kallstroemia parviflora	Zygophyllaceae	KAPA	KALPAR	13
4	wavyleaf thistle	Cirsium undulatum	Asteraceae	CIUN	CIRUND	5
4	wavyleaf twinevine	Sarcostemma crispum	Asclepiadaceae	SACR3	SARCRI	4
4	white milkwort	Polygala alba	Polygalaceae	POAL4	POLALB	7
4	white rocklettuce	Pinaropappus roseus	Asteraceae	PIRO	PINROS	2
4	whitemouth dayflower	Commelina erecta	Commelinaceae	COER	COMERE	2
4	wingpetal	Heterosperma pinnatum	Asteraceae	HEPI2	HETPIN	1
4	Wright's goldenrod	Solidago wrightii var. adenophora	Asteraceae	SOWRA	SOLWRIA	4
4	Wright's goldenrod	Solidago wrightii var. wrightii	Asteraceae	SOWRW	SOLWRIW	4
4	Wright's Indian mallow	Abutilon wrightii	Malvaceae	ABWR	ABUWRI	3
4	Wright's spiderwort	Tradescantia wrightii	Commelinaceae	TRWR	TRAWRI	1
4	Wright's spikemoss	Selaginella wrightii	Selaginellaceae	SEWR2	SELWRI	30
4	yellow Indian mallow	Abutilon malacum	Malvaceae	ABMA3	ABUMAL	10
4	yellowseed fiddleleaf	Nama xylopodum	Hydrophyllaceae	NAXY	NAMXYL	5

APPENDIX C

Image Analysis Technical Information

Image Processing

Geometric Correction

Both satellite imagery were acquired on stable sensor platforms, which allow for a simple geometric correction algorithm to model the orbital path and rectify the imagery. The height of the sensors above the earth - 680 km (423 miles) for IKONOS and 705 km (438 miles) for Landsat - negates most parallax problems, but IKONOS, with its high spatial resolution and non-nadir viewing angle, is more sensitive to parallax distortion, especially in high relief areas. Because of this, the SpaceImaging® ortho-rectified product was acquired for this project. Ortho-rectification models the geometry of the sensor and the relief on the ground and results in an image free of geometric distortion in the x, y, and z plane using a DEM as the topographic reference.

The ortho-rectified IKONOS images were found to be fairly accurate, within a meter or two of the DOQ reference, but to insure that it was directly tied in to the reference, both the Pan and MS data were registered directly to the DOQ and resampled to 1 m spatial resolution. The ETM^+ scene, likewise, was rectified to the DOQ and it was resampled to the 1 m spatial resolution using a cubic convolution re-sampling technique. This technique, which interpolates an output image value from the 16 closest input image values, is generally not used because it can change the original values too much, but it was required in this case in order to break the discrete boundaries of the original 30m cell down into more of a gradient at the one-meter spatial resolution level.

Normalized Difference Vegetation Index

A Normalized Difference Vegetation Index (NDVI) was created from the IKONOS data. The NDVI enhances the spectral response of vigorous vegetation over the response from other major surface features. This was used to help emphasize vegetation response patterns in the classification. The NDVI also allows for a quick assessment of class signatures: for example, the shrubbier oak areas should have a higher NDVI response than the senescent grasslands.

The Normalized Difference Vegetation Index (NDVI) was created using Equation 1 and added to the file.

$$NDVI = (MS4 - MS3) / (MS4 + MS3) \quad \text{(Eq. 1)}$$

Where **MS4** is the near infrared IKONOS MS band and **MS3** is the visible red IKONOS MS band.

Texture Filter

As mentioned prior, the spectral detail of panchromatic image is minimal, but the overall brightness response at such a spatial detail still provides useful information. For example, an oak shrubland community will have an overall dark response in the image, whereas a desert shrubland will have a brighter response due to the barren patches in the community. This overall brightness response was modeled using an averaging filter (Eq. 2) to minimize the effects of individual cell noise in the image.

$$\mu = (\sum DN) /k \quad \text{(Eq. 2)}$$

where μ is the resulting mean, **DN** is the individual cell brightness response, and **k** is the number of cells sampled.

The amount of change of response from one cell to another cell is another important spatial component that is provided by the imagery, especially given that at this high spatial resolution a cell is close to the size of shrubs such as sotol and agave. In the above case, the oak shrubland may have a dark brightness response, but it will have a high spatial variation response due to changes in the image representing the changing shrub/grass/barren patchiness of this landscape, whereas a short-grass community which with may also have similar dark brightness response, will probably have a low spatial variation response due to a more homogenous cover type. The variance was modeled using the below equation for every 3x3, 5x5, and 7x7 cell window in the image:

$$V = \sum(DN - \mu)^2 / 9 \quad \text{(Eq. 3)}$$

where **V** is the resulting variance. The resulting three different images were then added together to create an overall variance filtered image. The average brightness image was divided by the variance image (Eq. 4) to create a combined texture image, **T**, which shows on a cell-by-cell basis the corresponding changes of brightness with variance.

$$T = \mu/V \quad \text{(Eq. 4)}$$

This image was then combined with the image data for the classification.

Image Classification

Supervised Strategy and Seeding

The image classification procedure synthesizes satellite image data with field plot data and ancillary data derived principally from Geographic Information System (GIS) coverages. A supervised classification strategy was adopted to create the vegetation map based on vegetation community types. This strategy develops spectral classes based on ground locations with known characteristics such as vegetation composition and landscape context.

In a supervised classification strategy, the field data is applied to the image data 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 (Eq. 5) searches around that point within user-defined parameters that contain a seed within: 1) a certain distance, 2) a certain area, and 3) a certain spectral distance defined as:

$$SD = \sqrt{\sum(\mu - X)^2} \text{ (Eq. 5)}$$

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 image band, and **X** is the spectral value of the new pixel for each band.

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

The seed shape and location was checked against field notes and maps, and by direct interpretation of the seed in the 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.

Supervised Classification

Statistics gathered in the seeding process were used to perform a supervised classification. Supervised classifications are based on a maximum likelihood decision rule that contains a Bayesian classifier that uses probabilities to weight the classification towards particular classes. In this study the probabilities were unknown, so the maximum likelihood equation for each of the classes is given as:

$$D = [0.5\ln(cov_c)]-[0.5(X-M_c)^T * (cov_c^{-1})*(X-M_c)] \text{ (Eq. 6)}$$

where **D** is the weighted distance, $\mathbf{cov_c}$ is the covariance matrix for a particular class, **X** is the measurement vector of the pixel, $\mathbf{M_c}$ is the mean vector of the class and $^{\mathbf{T}}$ is the matrix transpose function (ERDAS 1997). Each pixel is then assigned to the class with the lowest weighted distance. This technique assumes the statistical signatures have a normal distribution.

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

APPENDIX D

Fire Monitoring Validation Plots

Table D1 lists the fire monitoring vegetation plots used for a partial validation of the Carlsbad Caverns National Park vegetation map. The original monitoring plot data was provided by the park in a spreadsheet along with hardcopy photocopies of the field sheets (Mark Bremer, pers. com.). This data was collected between 1992 and 1998 and follows standard NPS protocols for fire monitoring plots. Using density and abundance values on the 10m by 30m shrub plots and 60m line intercepts, the plots were classified according to the vegetation classification given in Table 7 of the main report. Based on this classification, plots were compared to how they were mapped at their locations (user accuracy). In Table D1, those that matched either the primary of secondary components of the target map units within 20 m of the stated locations were considered correctly classified (Map MU = Ground MU). If not, an "x" is indicated in the error column (E) with the cross-classified map unit under Ground MU. The patch size of the mapped polygon is give as small patch (<1 ha), large patch (1-5 ha), or matrix (>5 ha), i.e., the dominant map unit across that portion of the landscape with only scattered patch inclusions of other map units. The locations were provided by NPS as UTM and/or latitude/longitude coordinates, in NAD 1927.

Table D1. Location and classification of fire monitoring plots used to validate the Carlsbad Caverns National Par\k vegetation map

FIRE PLOT ID	UTMN	UTME	LONG	LAT	E	Map MU	Ground MU	Map Patch size	Vegetation Classification				
BMUSE1D02 01	3559856	551341	104 27' 19.53"	32 10' 26.52"		100	100	matrix	BOUERI	MUHSET	BOUCUR	AGALEC	
BMUSE1D02 02	3559948	551441	104 27' 15.68"	32 10' 29.51"		100	100	matrix	MUHSET	AGALEC	DASLEI		
BMUSE1D02 03	3560032	551655	104 27' 07.49"	32 10' 32.19"		110	110	matrix	BOUERI	MUHSET	BOUCUR	AGALEC	
BMUSE1D02 04	3559937	551767	104 27' 03.24"	32 10' 29.08"		100	100	matrix	MUHSET	BOUERI	BOUGRA	AGALEC	DASLEI
BMUHL1D02 05	3558935	547328	104 29' 52.96"	32 09' 57.27"	x	100	103	matrix	MUHSET	MUHDUB	AGALEC	DASLEI	JUNPIN
BMUHL1D02 06	3559283	547744	104 29' 59.88"	32 10' 08.57"		103	103	small	MUHSET	AGALEC	DASLEI	JUNPIN	
BMUHL1D02 07	3559003	546827	104 30' 12.07"	32 09' 59.51"		103	103	small	MUHSET	AGALEC	DASLEI	JUNPIN	
BMUHL1D02 08	3559697	547095				103	103	small	MUHSET	AGALEC	DASLEI	JUNPIN	
BMUHL1D02 10	3599900	544248	104 30' 30.81"	32 10' 34.92"	x	103	33	small	QUEPUN	JUNPIN	BOUHIR	MUHDUB	DASLEI
BMUHL1D02 11	3560510	546168				103	103	large	MUHSET	AGALEC	DASLEI	JUNPIN	
BMHUL1D02 12	3560847	545240	104 31' 16.12"	32 10" 59.67"		101	101	matrix	QUEPUN	JUNPIN	MUHSET	BOUHIR	AGALEC
BMHUL1D02 13	3560939	545017				100	100	large	MUHSET	DASLEI	CEAGRE	VIGSTE	
BMUHL1D02 14	3560961	547599	104 29" 42.20"	32 11" 09.13"		100/31	100/31	large/small	MUHSET	AGALEC	DASLEI	JUNPIN	QUEPUN
BMUHL1D02 15	3560795	546704	104 30' 16.40"	32 11' 03.87"		100	100	large	BOUHIR	MUHSET	AGALEC	DASLEI	VIGSTE
BMUHL1D02 17	3561886	551958				103	103	small	MUHSET	AGALEC	DASLEI	JUNPIN	
BMUHL1D02 19	3599060	546334				100	100	large	MUHSET	AGALEC	DASLEI		
BMUHL1D02 20	3558885	545934	104 30' 46.09"	32 09' 55.80"		100	100	large	MUHSET	BOUCUR	AGALEC	DASLEI	VIGSTE
BMUHL1D02 21	3558474	546793	104 30' 13.45"	32 09' 42.51"	x	103	100	large	MUHSET	AGALEC	VIGSTE	PARINC	
BMUHL1D02 22	3558834	546568	104 30' 21.98"	32 09' 54.08"		31	31	large	MUHSET	AGALEC	DASLEI	JUNPIN	
BMUHL1D02 23	3559813	546161	104 30' 37.31"	32 10' 25.92"	x	103	32	small	JUNPIN	MUHSET	AGALEC	DASLEI	
BMUHL1D02 24	3559778	546116	104 30' 39.07"	32 10' 24.79"		100	100	large	MUHSET	BOUCUR	AGALEC	DASLEI	
BMUSE1D02 25	3560000	548731			x	103	100	large	MUHSET	AGALEC	DASLEI		
BMUHL1G02 26	3560210	554070			x	103	100	large	MUHSET	BOUHIR	AGALEC		
BMUHL1G02 27	3560685	551449				103	103	large	MUHSET	AGALEC	DASLEI	JUNPIN	
BMUSE1G02 28	3561380	555100				100	100	small	MUHSET	AGALEC	DASLEI	VIGSTE	
BMUSE1D02 29	3561378	553833	104 25' 4.07"	32 11' 25.51"	x	112	103	large	MUHSET	AGALEC	DASLEI	JUNPIN	VIGSTE
BMUSE1D02 30	3559754	553344				100	100	matrix	MUHSET	AGALEC	DASLEI	VIGSTE	
BMUSE1D02 32			104 31' 24"	32 08' 03"		40	40	matrix	ACANEO	AGALEC	TRIMUT	TRIPIL	
BMUHL1D02 33			104 31' 11"	32 08' 09"		40	40	matrix	ACANEO	AGALEC	BOUERI	PARINC	
BMUHL1D02 34			104 30' 10"	32 08' 43"		52	52	large	ACANEO	AGALEC	PANHAL		