National Park Service
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Natural Resource Stewardship and Science

Vegetation Classification and Map

Petroglyph National Monument

Natural Resource Technical Report NPS/SCPN/NRTR—2012/627

ON THE COVER
Petroglyph National Monument
Photograph courtesy of the Southern Colorado Plateau Network

Errata for

Vegetation Classification and Map: Petroglyph National Monument Natural Resource Technical Report NPS/SCPN/NRTR—2012/627

March 12, 2013

The following corrections apply to the report referenced above.

Pages	Error	Correction
D1 and D9	*Atriplex canescens/Pleuraphis Jamesii* Shrubland	Artemisia filifolia / Pleuraphis jamesii Shrubland
D25–D36	Warm Semi-Desert Scrub & Grassland (3.B)	Cool Semi-Desert Scrub & Grassland (3.B)
D25–D36	Warm Semi-Desert Scrub & Grassland (3.B.1)	Cool Semi-Desert Scrub & Grassland (3.B.1)
D25–D36	North American Warm Desert Scrub & Grassland (3.B.1.a)	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)

Vegetation Classification and Map

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Natural Resource Technical Report NPS/SCPN/NRTR—2012/627

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

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Executive Summary

We developed a vegetation classification and high-resolution vegetation map for Petroglyph National Monument (PETR), New Mexico, as part of the USGS Vegetation Characterization Program, a cooperative effort by the U.S. Geological Survey (USGS) and the National Park Service Inventory & Monitoring - Vegetation Mapping Program to classify, describe, and map vegetation communities in more than 280 national park units across the United States. The classification and map of PETR follow the guidelines and requirements of the national program, and are based on data collected from 499 field plots between 2007 and 2011, and from 469 independent survey points that were used to assess the accuracy of the map and completeness of the classification.

The vegetation pattern of Petroglyph National Monument (PETR) is intricately interwoven with its geology, especially the Albuquerque volcanic field (known locally as Albuquerque Volcanoes with five volcanoes and lava flows that dominate the landscape. The lava flows of the volcanic field form a broad mesa along the western flank of the Rio Grande Valley and support some of the most diverse and intact semi-desert grasslands in the state. These grasslands are dominated by black grama, New Mexico feathergrass, and galleta, along with patches of desert shrublands of sand sagebrush and fourwing saltbush and scattered oneseed junipers. The volcanoes themselves are cloaked with grasslands, except near their summits where shrublands and rocklands are the norm. Along the eastern edge of the mesa is a steep, boulder-strewn escarpment that is the location of the majority of petroglyphs for which the park is known. The escarpment supports unique shrub and grass vegetation communities that separate the mesa grasslands from a low-lying sandy area below. In this area of sandsheets and low dunes, sand scrub, dominated by sand sagebrush and broom dalea, prevails. To the south, the non-volcanic hills of the Ceja formation are composed of ancient gravels and sands that also support semi-desert grasslands. Desert wash (arroyo) shrublands are found in the intervening valleys along ephemeral stream channels.

Overall, we identified 33 plant associations. With the National Vegetation Classification Standard (NVCS) as a foundation, we constructed a vegetation map using a combination of image analysis and photo interpretation of high-resolution (0.6 m) color and color-infrared aerial ortho-photography, and satellite imagery (DigitalGlobe QuickBird). The map legend is hierarchically structured, with an upper Level 1 of nine map units corresponding more or less to the Group Level of the NVCS; and a Level 2 composed of 21 nested map units defined by the plant associations from the vegetation classification.

The PETR vegetation map is at a 1:12,000 scale with 0.25 ha minimum map unit size, and was designed to facilitate ecologically-based natural resources management. Based on an independently sampled accuracy assessment, overall accuracy was 86.8% for Level 1 and 86.1% for Level 2. Level 1 units will likely be sufficient and most appropriate for many natural resource plans and evaluations, while Level 2 units provide additional fine-scale information within major ecological groups. To support the map as a management tool, we provide an annotated map legend, local descriptions of each plant association, a corresponding diagnostic key, field forms, and a plant species list. The map was delivered to SCPN in both printed form and as digital Geographic Information System (GIS) map files. The GIS format allows flexibility to update the map as new information becomes available or when major vegetation changes occur in the park, such as those caused by fire, disease, or other impacts.

Acknowledgments

This project was funded by the USGS-NPS National Vegetation Mapping Program, Southern Colorado Plateau Network (SCPN) and the Natural Heritage New Mexico (NHNM) Division of the Museum of Southwestern Biology, University of New Mexico. The NHNM technicians Hannah Varani, Sandy Sacher, Eric Lindahl, Amanda Kennedy, Hugh Hulse, Matthew Wilder, and Katie Carillo conducted the majority of the fieldwork and data entry. Rayo McCollough and Elizabeth Milford provided database design and support. Rebecca Keeshen provided management support and editorial review. In addition, we thank Mike Medrano at Petroglyph National Monument for logistical support and review for the project. Lisa Thomas, SCPN Program Manager, provided support for the project through agreements with the SCPN and CPCESU; and Allison Snyder and Kristin Straka provided review on behalf of the SCPN. Tom Forsyth and Lynelle Wright at the NPS Intermountain Region assisted with contract development. From the USGS-NPS Vegetation Mapping Program national office, important guidance and review was provided by Karl Brown, Tammy Hamer, and Chris Lea.

Acronyms and Abbreviations

CE	Common Era
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System
GPS	Global Positioning System
I&M	Inventory and Monitoring Program
ITIS	Integrated Taxonomic Information System
KA	kilo-annum, a thousand years ago
MMU	minimum mapping unit
NDSVI	Normalized Senescent Difference Vegetation Index
NDVI	Normalized Difference Vegetation Index
NHNM	Natural Heritage New Mexico
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NVC	National Vegetation Classification
NVCS	National Vegetation Classification Standard
PA	plant association
PETR	Petroglyph National Monument
SCPN	Southern Colorado Plateau Network
TM	Landsat Thematic Mapper
USGS	United States Geological Survey
UNM	University of New Mexico
UTM	Universal Transverse Mercator

1 Introduction

1.1 Background, scope, and products

Petroglyph National Monument (PETR) harbors some 25,000 prehistoric images carved into volcanic rocks by ancestors of the Puebloan people that occupied the lands between 1300 and 1680 BCE. These petroglyphs and other archeological sites are distributed across a picturesque volcanic landscape dominated by desert grasslands and shrublands that now provide habitat and forage for wildlife as well as exceptional open space and recreational opportunities for park visitors. The National Park Service (NPS) has sought to manage these biological resources with the same care and attention as that given to the archeological values of the park. In addition to comprehensive biological inventories and monitoring, a key tool for effective natural resource management is a high-resolution vegetation map that can support such activities as flora and fauna habitat modeling, recreation planning, fire management, ecological research, and broad-scale facilities planning.

In 2006, the Southern Colorado Plateau Inventory and Monitoring Network (SCPN), in cooperation with Natural Heritage New Mexico (NHNM)[1], NatureServe[2] , and the staff at Petroglyph National Monument (PETR), set out to develop a vegetation map that meets or exceeds the standards of the U.S. Geological Survey (USGS)-National Park Service Vegetation Mapping Program (http://biology.usgs.gov/npsveg/standards.html) (1:24,000 scale and 0.5 ha minimum map unit size). The map was to be based on high-resolution aerial photography and satellite imagery and extensive ground sampling. Field surveys of the vegetation communities began in the summer of 2007. The vegetation survey data was entered into a database and used to develop a park-wide vegetation classification following the National Vegetation Classification System (FGDC 2008) guidelines. A vegetation map was generated from the vegetation classification and associated ground control points at the 1:12,000 scale, using a combination of automated image analysis (image segmentation and supervised classifications) and direct image interpretation. Map units were designed to support ecologically-based natural resources management with an emphasis on its uses for fire, wildlife, and recreation management.

In this report, we provide (1) the details on how the map was developed; (2) an overview of the classification and ecology of the vegetation communities of the park; (3) the vegetation map with associated map unit descriptions; (4) plant community descriptions and a diagnostic key; and (5) a vouchered species list. The map is provided in both printed form and as digital Geographic Information System (GIS) map files. In addition, all field data were compiled into a relational database, and all data and reports elements have been made ready for web-based applications. Finally, we provide an accuracy assessment that reflects both user and producer confidence in the map.

1.2 The USGS-NPS Vegetation Characterization/Mapping Program

The USGS-NPS Vegetation Characterization Program is a cooperative effort by the USGS and the NPS to classify, describe, and map vegetation communities in more than 280 national park units across the Fifth order headings do not show up in the table of Contents provided in this template.

[1]A division of the Museum of Southwestern Biology at the University of New Mexico.

[2]The national network organization of natural heritage programs and conservation data centers. See: http://www.natureserve.org/

The NPS I&M Program established guidance and standards for all vegetation mapping projects in a series of documents:

- Vegetation classification guidelines: National Park Service Vegetation Inventory, version 2.0 (Lea 2011)
- Thematic accuracy assessment procedures: National Park Service Vegetation Inventory, version 2.0. (Lea and Curtis 2010)
- National Vegetation Classification Standard (FGDC 2008)
- Spatial Data Transfer Standard (FGDC 1998b)
- Content Standard for Digital Geospatial Metadata (FGDC 1998a)
- United States National Map Accuracy Standards (USGS 1999)
- Integrated Taxonomic Information System
- 12-Step Guidance for NPS Vegetation Inventories

1.3 Park environment

1.3.1 Location and cultural setting

Petroglyph National Monument lies in the middle Rio Grande Valley of north-central New Mexico, adjacent to the city of Albuquerque within Bernalillo County (fig. 1). Established in 1990, the legislated area of the park is 2,927 ha (7,235 ac) and comprises three units. The Atrisco unit, at 2,177 ha (5,380 ac), is the core unit and encompasses a significant portion the original Atrisco Land Grant. The Boca Negro and Piedras Marcadas units comprise 87 ha (215 ac) and 477 ha (1,179 ac), respectively, and together form a long and narrow corridor extending from the northeast corner of the Atrisco unit along the lava flow escarpment (fig. 2). These units were added in 1992 and are flanked on the east by residential areas. The Piedras Marcadas unit also includes two small and isolated Northern Geologic and Southern Geologic subunits acquired at the same time. These lie to the north of the Atrisco unit and, while they are administratively isolated, they are linked to the park by a large open space area co-managed by the City of Albuquerque and the NPS. After a long and controversial court battle that ended in 2007, the eastern Piedras Marcadas unit was split in two by the extension of the Paseo del Norte roadway and the highway corridor removed from the park. A small, separate unit in the valley encompassing the actual Piedras Marcadas pueblo ruin, while a part of the park, was excluded from the mapping project.

Physiographically, PETR lies along the western side of Rio Grande Rift valley and at the eastern edge of the Colorado Plateau (fig. 3). To the east, across the valley, lie the Sandia Mountains that locally form the western boundary of the rift and rise to a height of 3,255 m (10,678 ft). The mountains set the valley apart from the expanse of the Southern Great Plains further to the east. The Rio Grande, whose ancient river terraces fall within the eastern boundary of the park, runs through the valley and forms a wide floodplain. But the dominant feature of the park is the Albuquerque volcanic field with its line of north-to-south trending cinder cones and extensive basalt lava flows which form a marked escarpment of jumbled boulders about 50 m high along the east side, above the valley (fig.2) . It is along this escarpment that the majority of the petroglyphs were carved into the rocks. The lava flows make up a broad, elevated grassland plain that is part of what is locally referred to as the “West Mesa.” Elevations range from 1,838 m (6,033 ft) at the top of Volcan cone to 1,563 m (5,127 ft) along the eastern base of the escarpment in the Piedras Marcadas unit.

This striking volcanic landscape forms the western horizon backdrop to Albuquerque and provides a major open space for the largest urban center of the state, as well as preserving a portion of the cultural heritage of the Puebloan people (fig. 4). While the area is known to have been inhabited over the past 11,000 years, the majority of the approximately 25,000 petroglyphs in the park were created between 1,300

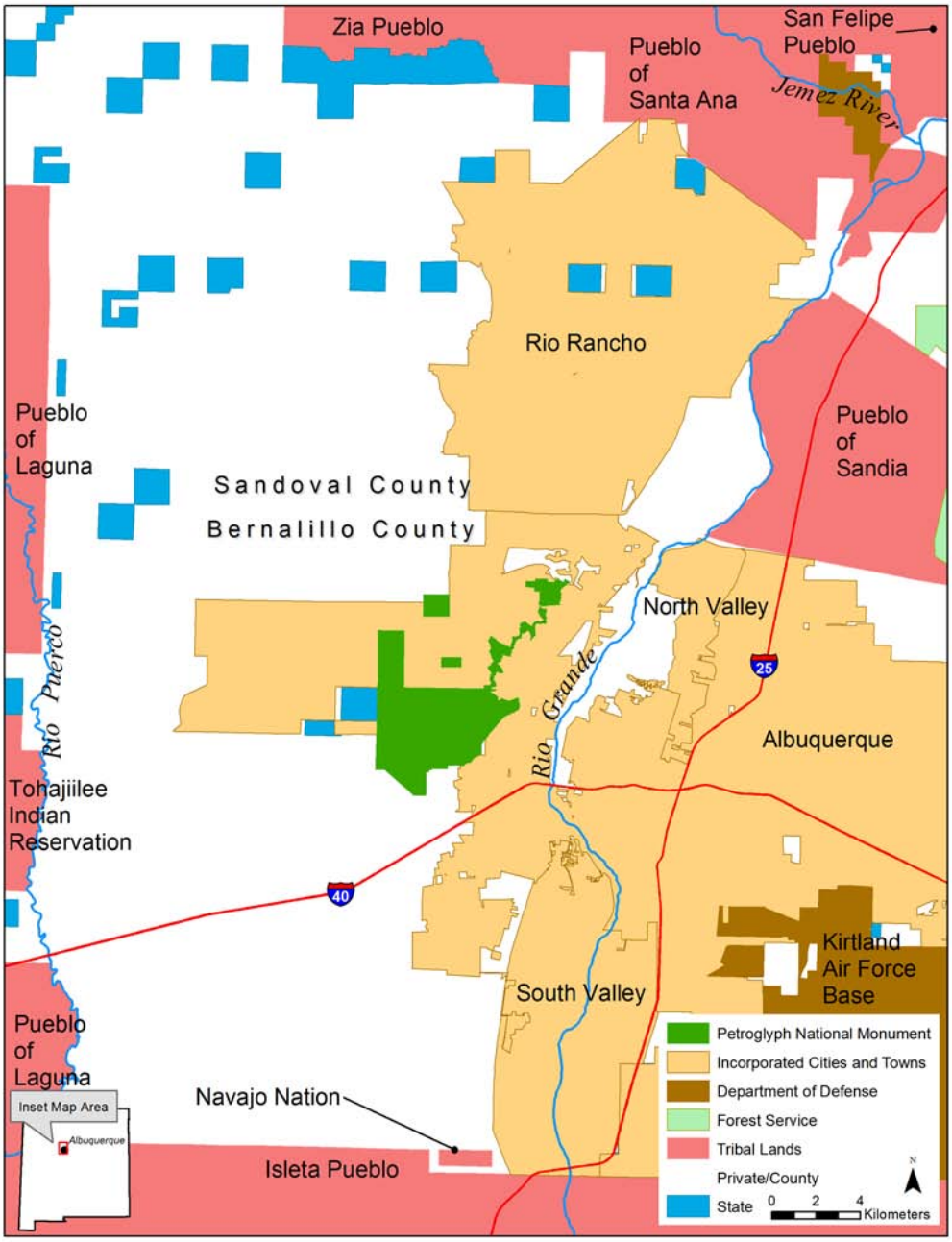


Figure 1. Petroglyph National Monument is located in the Middle Rio Grande valley to the west of, and adjacent to, the city of Albuquerque. The inset on the lower left depicts the monument in the broader New Mexico context.

and 1,600 CE (Pueblo IV/Classic Period), with some possibly dating back to 500–900 CE (Basketmaker III to Pueblo I/Developmental Pueblo Period) (NPS 1995, 2005; Kelly 2010) Land use at that time likely focused on agriculture in the river valley, with hunting forays onto the mesa (Scurlock 1998).

Spanish settlement in the area began in the 1600s and led to the demise or conquering of the pueblos and a dramatic decline in native populations (today only three Indian pueblos remain in the immediate vicinity: Sandia, Isleta, and Santa Ana). The Spanish brought livestock with them and likely used the grasslands that dominate the mesa within the current park as pasture. The Spanish human population in the middle Rio Grande grew slowly to about 50,000 by about 1850, but their livestock numbers grew faster. It has been estimated that there were about 240,000 sheep and goats, 5,000 cattle, and 3,000 horses and mules in the Santa Fe-Albuquerque area alone by 1820 (Scurlock 1998). The land grants were established during the

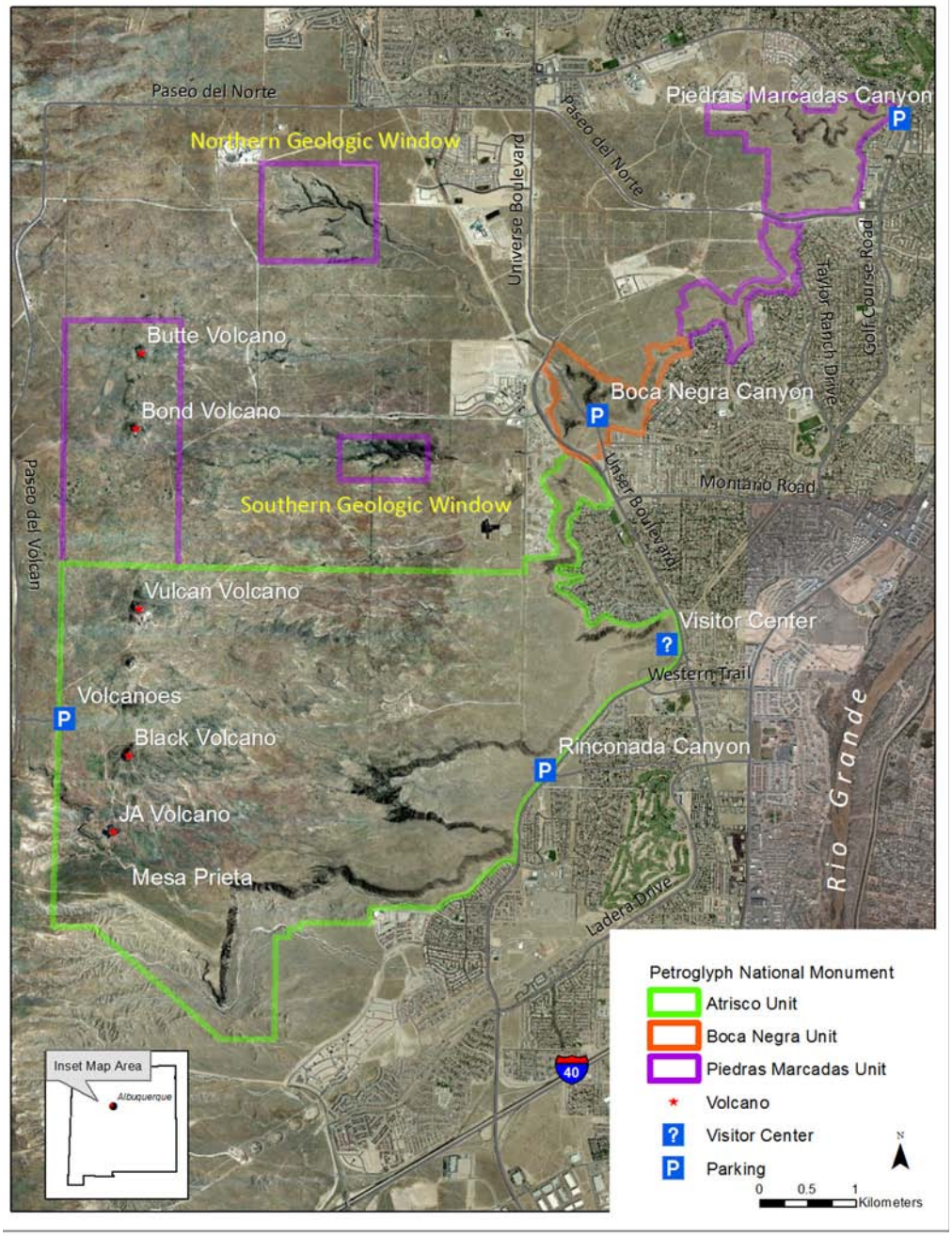


Figure 2. Petroglyph NM vegetation map study area. The project area consists of three administrative units: Atrisco, Boca Negro, and Piedras Marcadas. The Piedras Marcadas unit also includes two isolated subunits—the northern and southern geologic windows—which are surrounded by City of Albuquerque Open Space (the latter is not fenced off from the monument.

Spanish settlement period, and included the Atrisco Land Grant in 1692 in the valley adjacent to the modern day park. By 1760, over 200 people occupied the valley areas of the land grant and the grant was expanded in 1768 to include the surrounding mesa that now makes up the core of the park (http://www.nps.gov/petr/historyculture/atrisco.htm, NPS n.d.).

With the Treaty of Guadalupe Hildago in 1848, which ceded New Mexico to the U.S., and with the introduction of the railroad, Anglo-European settlement began in earnest and human populations and livestock numbers in New Mexico increased dramatically. It is estimated that human population reached 150,000 by 1880 and perhaps five million sheep were grazing across New Mexico. In Bernalillo County alone, an estimated 475,000 sheep and 41,700 cattle grazed on rangelands in 1883 (Scurlock 1998). It is likely that the mesa area within the park was heavily utilized during this period. Although human popu-

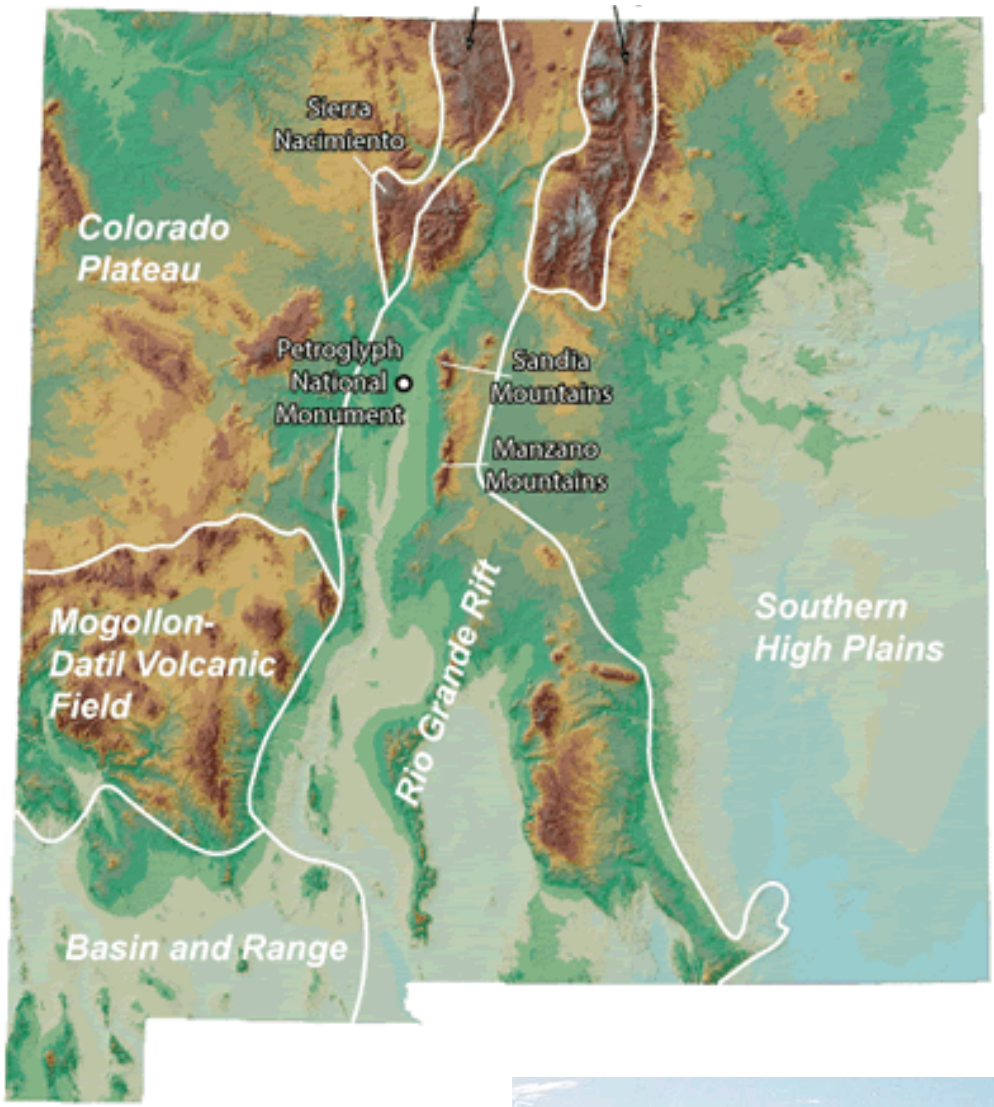


Figure 3. The regional physiographic setting for Petroglyph NM (from: S. A. Kelley http://geoinfo.nmt.edu/tour/federal/monuments/petroglyphs/home.html)

lations continued to increase into the 20th century (there were over 327,000 people in New Mexico when statehood occurred in 1912), the livestock number actually began to decline as modern-day land management practices were implemented through regulated leasing programs. Grazing leases on the mesa were slowly eliminated as the city bought up open space in the 1980s. Following establishment of the park in 1990, trespass grazing continued until a complete barbed wire fence was put in place by 2002.

Today, the park abuts a metropolitan area approaching 900,000 people (fig. 5) and the issues are no longer about grazing itself, but rather about the

Figure 4. Petroglyph NM and the Albuquerque volcanic field lie just west of the Albuquerque metropolitan area, with a population approaching 900,000 (photo by E. Muldavin).

Figure 5. The human presence in Petroglyph NM runs deep. This an example of petroglyphs etched perhaps between 1,300 and 1,600 CE into a basalt boulder in the Rinconada area along the eastern escarpment (photo by E. Muldavin).

mesa's restoration and recovery from past land use practices; the management of visitors and recreational use; implementation of a fire-management plan that adequately addresses ecosystem-management goals at the same time as wildland-urban-interface issues; and, of course, the protection of the unique archeological heritage of the park.

1.3.2 Climate

The climate of PETR is characterized by cool-to-cold, relatively dry winters, and warm, wet (monsoonal) summers. In Albuquerque, the daily temperature extremes range between -27.2°C and 24.4°C in winter, and from 2.7°C to 41.4°C in summer, with large differentials between the average monthly minimum and maximum temperatures over the course of a year, reflecting an essentially continental climate (fig. 6). Forty percent (113 mm) of the precipitation at PETR occurs in winter (October through March) and is delivered principally by low-pressure systems that sweep from west to east across the Southwest, coalescing with moisture from the Pacific Ocean or the Gulf of Mexico (fig. 7). Winter precipitation is generally followed by a seasonal dry period during the months of April through June. This dry period is defined as much by the increased potential for evapo-transpiration that accompanies increased day length, solar radiation, and temperatures as by decreased precipitation. The spring dry period is usually relieved by the Mexican/Arizona monsoon season, which is characterized by short-duration, high-intensity thunderstorms during the months of July through September, However, thunderstorms can be localized, which

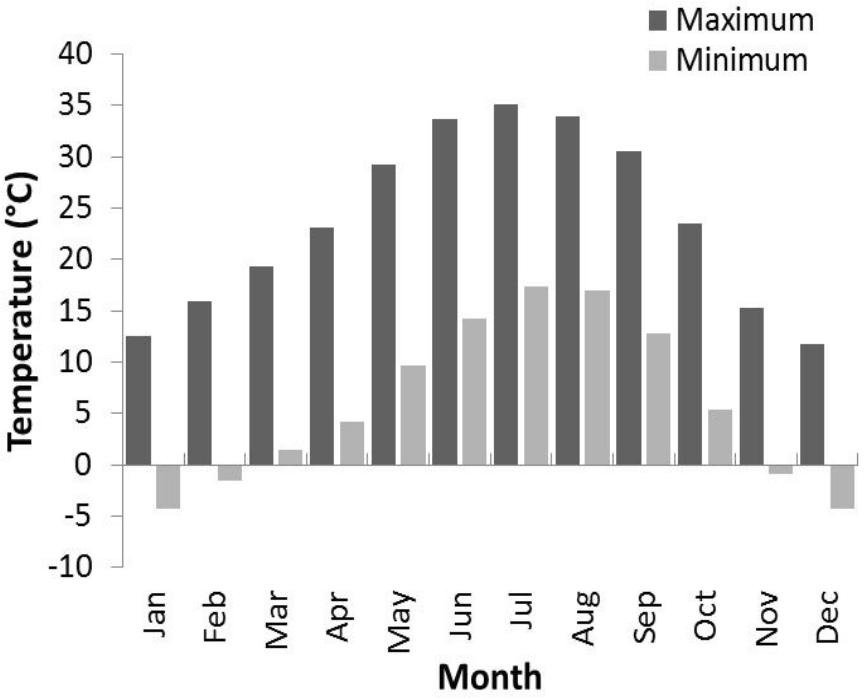


Figure 6. Average monthly temperature patterns for Petroglyph NM between 1971-2010. Average annual maximum temperature was 42.2°C; average minimum was 11.4°C.

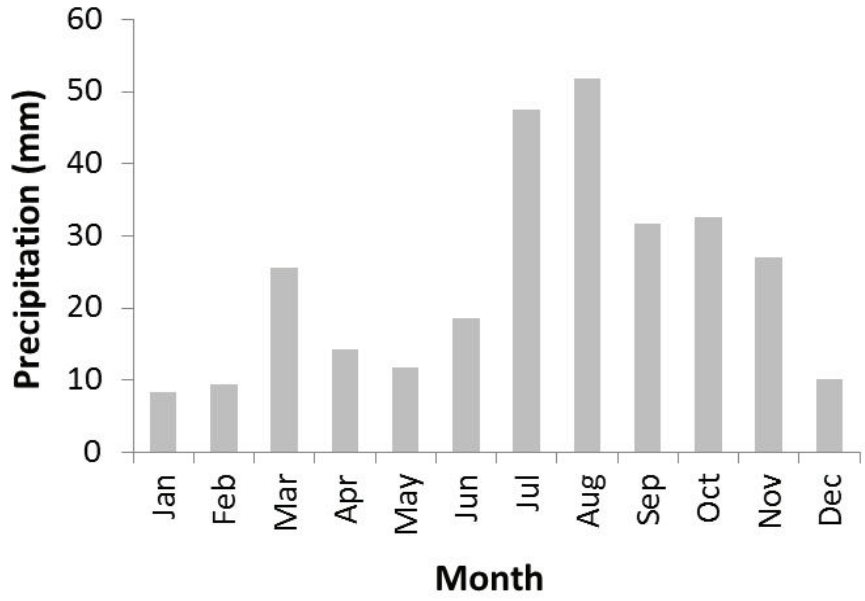


Figure 7. Average monthly precipitation patterns for Petroglyph NM between 1971-2010. Average annual precipitation was 288.3 mm.

can lead to high year-to-year variability of precipitation over small areas. Even at the scale of PETR, there can be a differential in summer rainfall across the park. During the project period, 2007 through 2010, precipitation was near normal (average 217 mm), but dipped to 169 mm in 2009, although summer precipitation in that year was only 7% below normal.

1.3.3 Geology and soils

The central geologic feature of PETR is the Albuquerque volcanic field made up of five distinct lava flows and five major cinder cones (fig. 8). The field formed from about 180 KA ± 49 KA to 149 KA ± 28 KA (KA = kilo-annum or thousand years ago) in association with the many north-to-south trending faults that are

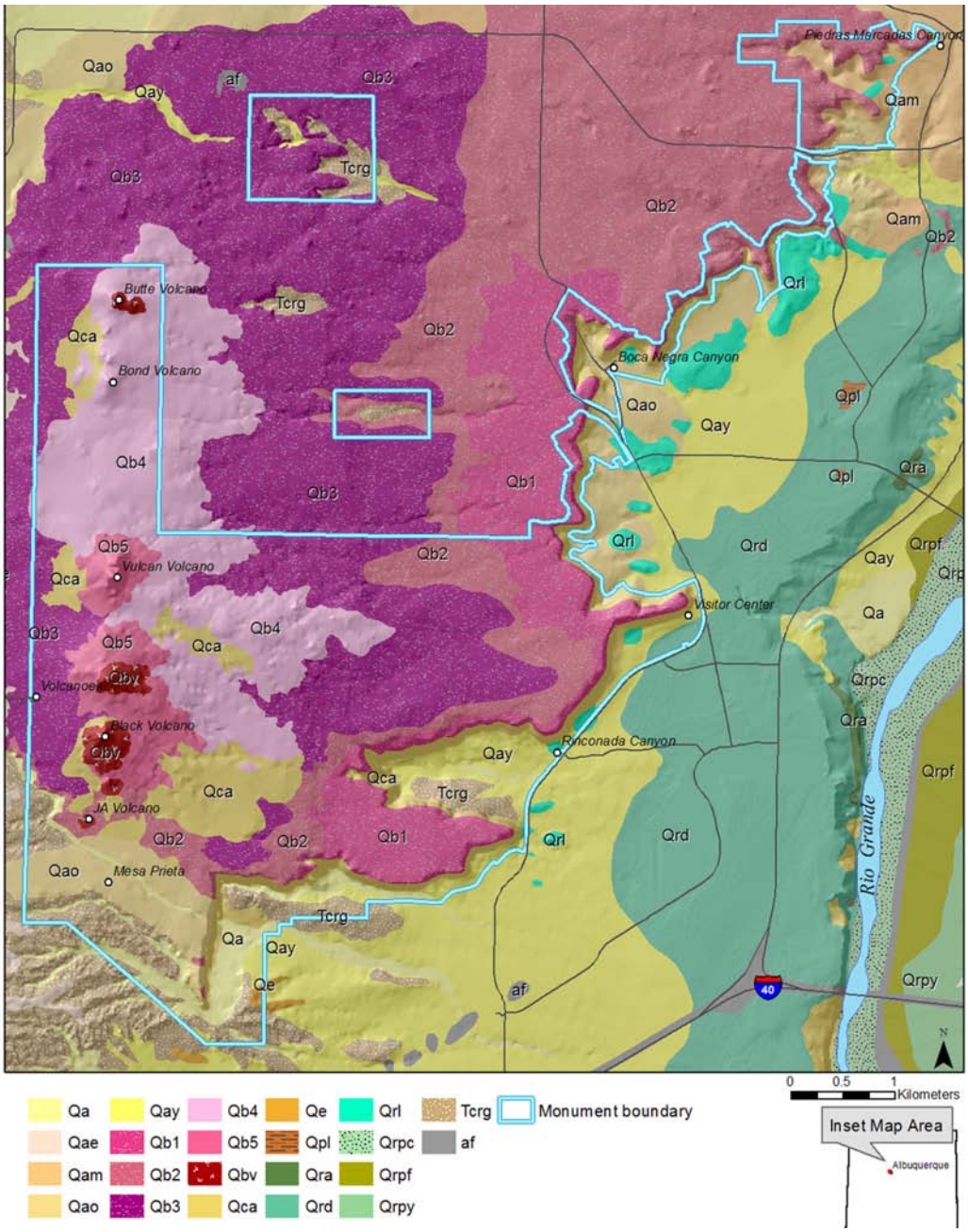


Figure 8. The geology of Petroglyph NM is dominated by the Albuquerque volcanic field with its five lava flows and five cones. There are relatively small areas of fluvial and aeolian deposits as well as Pliocene sand and gravel deposits (Ceja formation) in the southern sector of the park and exposed in the kapukas of the northern geologic windows (derived from Connell 2008).

Legend

Qa	Stream-valley alluvium	Qca	Colluvium & alluvium, undivided
Qae	Eolian sand & alluvium, undivided	Qe	Eolian sand
Qam	Stream-valley alluvium, undivided intermediate subunits	Qpl	Playa-lake deposits
Qao	Stream-valley alluvium, undivided older subunits	Qra	Arenal Fm
Qay	Stream-valley alluvium, younger subunits	Qrd	Los Duranes Fm
Qb1	Albuquerque volcanoes, flow 1	Qrl	Lomatas Negras Fm
Qb2	Albuquerque volcanoes, flow 2	Qrpc	Las Padillas Fm, channel deposits
Qb3	Albuquerque volcanoes, flow 3	Qrpf	Las Padillas Fm, floodplain deposits
Qb4	Albuquerque volcanoes, flow 4	Qrpy	Qrpy Las Padillas Fm, younger channel & floodplain
Qb5	Albuquerque volcanoes, flow 5	Tcrg	Ceja Fm, upper sand & gravel mbr
Qbv	Albuquerque volcanoes, vent	af	Disturbed land & artificial fill

part of the Rio Grande rift (fig. 9) (Peate et al. 1996). Basalt magma made its way up through the fractured rocks of this fault complex (particularly the Zia and County Dump faults) forming a line of north-to-south trending cinder cones (Butte, Bond, Vulcan, Black Cone, and JA), along with several scattered smaller vents. The first three of the five lava flows were more fluid and covered the most area across the volcanic field as a whole. However, within the park, the area distribution among flows was more equitable. The first eruption covered the Pliocene Ceja Formation (tcrg) and the associated Llano de Albuquerque geomorphic surface, as well as the younger terrace and valley alluvium deposits to the east. The second eruption was larger and expanded the field to the northeast. During the third eruption, the lava was more viscous and covered less area overall, creating steeper slopes than the earlier flows. This trend continued with flows four, five, and six and the building of the associated cones.

A significant feature of the lava flows with respect to vegetation pattern are the pressure ridges that extend out from the volcanoes and occasionally outcrop onto the mesa. A pressure ridge is an elongated uplift of the congealing crust of a lava flow due to the pressure of underlying and still fluid lava. The result is a raised mound of hardened lava rock, usually a relatively narrow but long ridge.

In some areas, the underlying Ceja formation and Llano de Albuquerque geomorphic surface are exposed. Specifically, in the Northern and Southern geologic windows, the older rocks and soils are exposed as "kapukas" along the drainages (kapuka is the Hawaiian term for an older island of lava amongst younger lava and commonly used in the continental U.S. to denote islands of non-volcanic rocks in a lava field). Along the eastern edge of the lava flows, the underlying sedimentary formations have been eroded so that large blocks

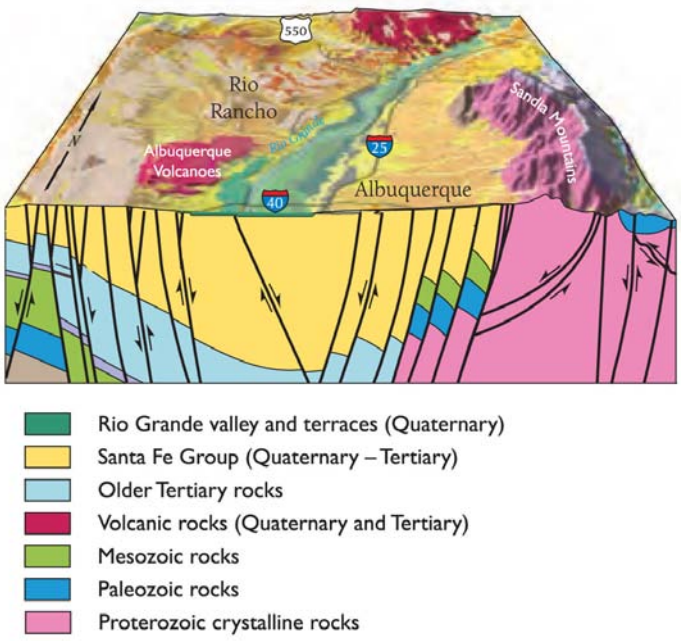


Figure 9. The Albuquerque Volcanos volcanic field of Petroglyph NM has its origins in the extrusion of basalt magma through the complex fracture zone of the Rio Grande rift valley (from: Connell and Love 2009).

of basalts have broken off and tumbled downslope to create a steep escarpment composed of boulders and rubble (it is along this escarpment in the desert varnish of the larger basalt rocks that the majority of the petroglyphs were carved). Out and away from the base of the escarpment and along the southern boundary, the landscape is dominated by late Pleistocene and Holocene stream valley alluviums of the Rio Grande Valley Group. These are often overlain by recent wind-blown sand deposits that can form somewhat unstable local sand sheets and dune fields.

In the Southwest, the degree of soil development as a function of aeolian depositon and basalt weathering on lava flow surfaces and cones is correlated to the age of the underlying flow (Peate et al. 1996). Hence, the greatest degree of soil development in PETR would be expected on Flow 1, which is the earliest, and the least on Flow 5. In fact, however, the more developed soils are associated with deeper wind deposited sediments on both the windward side of the volcanoes and to the immediate lee

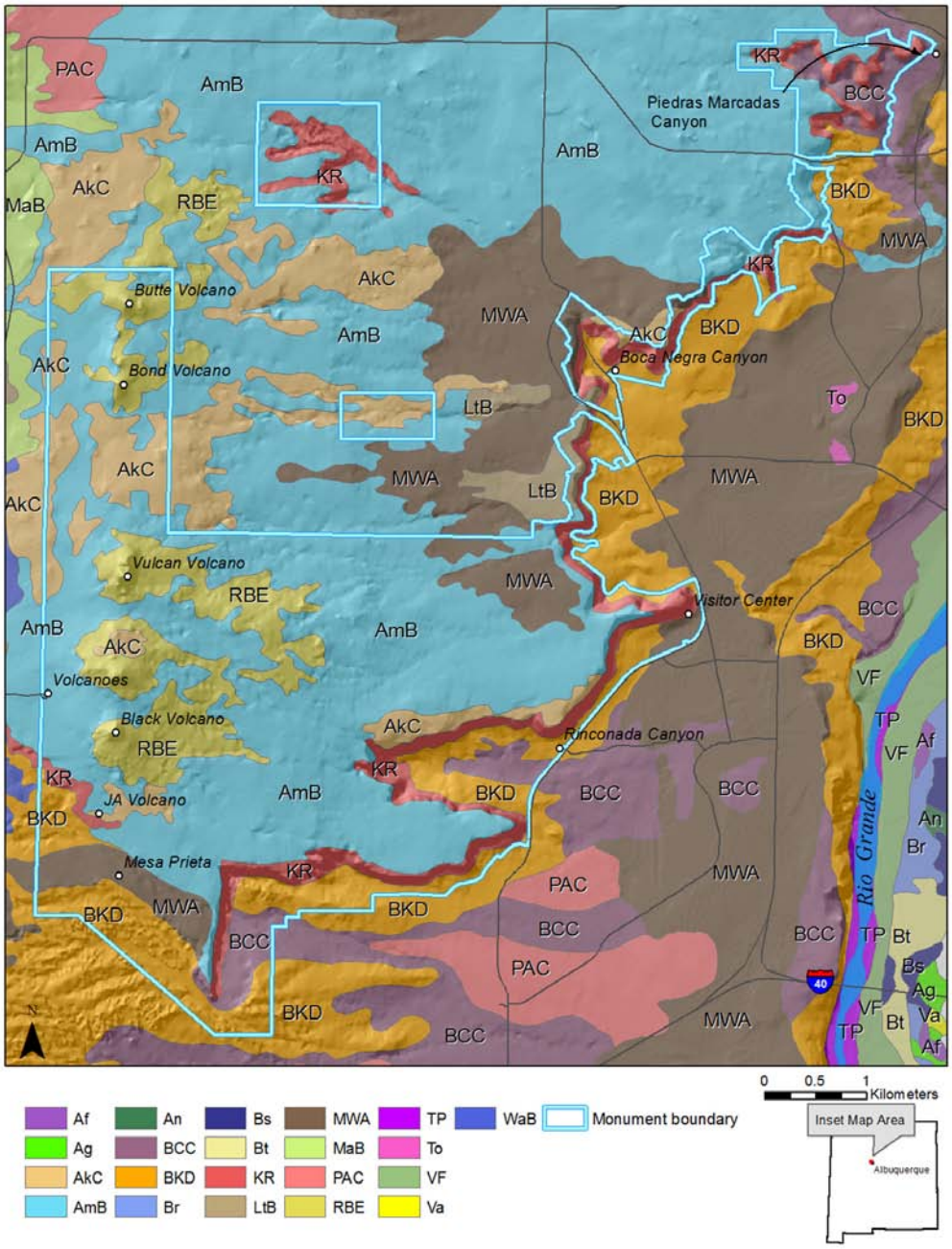
side of the cones and associated younger lava flows. The aeolian deposits actually thin out down slope to the east and, by the time the rim of the lava escarpment is reached, much of the oldest flow basalt is exposed with little or no soil development. The soils map of Hacker et al. (1977) conforms in a general sense to the lava flows as they were later mapped by Cornell (2006), but a higher resolution soils map is needed to explore further the relationship to the underlying geology and soil development (fig. 10).

1.3.4 Previous botanical and vegetation studies

Previous botanical and vegetation studies of PETR are limited. In 1996, Parmenter et al. (1996) conducted a survey of the biological resources of the park that included a section on the plants and the general vegetation pattern. They identified 192 plant taxa among 40 families based on their field surveys, and without vouchers. The list also included 29 species identified by Barlow-Irick (1993) in an earlier survey of threatened and endangered species. While providing information on individual species distribution, they identified three general vegetation types: 1) Southwestern grassland of the mesa top; 2) Plains-Mesa Sand Scrub along the base of the escarpment; and 3) rocks and boulder of the escarpment, volcanoes, escarpment rims, and basalt outcrops. With respect to the Southwestern grassland, they stated that *Bouteloua gracilis* (blue grama), *Bouteloua eriopoda* (black grama), *Hilaria jamesii* (galleta), *Oryzopsis hymenoides* (Indian ricegrass), *Sporobolus cryptandrus* (sand dropseed), and *Aristida* sp. (threeawns) were the most common species in the Southwestern grassland, and that *Stipa* spp. (needle and thread grass) and *Muhlenbergia* spp. (muhly grass) were frequent. Other common species included broom *Gutierrezia sarothrae* (snakeweed), *Artemisia frigida* (fringed sage), *Hymenopappus flavescens* (white ragweed), *Machaeranthera canescens* (hoary tansyaster), *Thelesperma megapotamicum* (Hopi tea), *Psilostrophe tagetina* (woolly paperflower), *Yucca glauca* (small soapweed yucca), *Dimorphocarpa wislizenii* (spectaclepod), *Atriplex canescens* (fourwing saltbush), *Salsola kali* (prickly Russian thistle), and *Spheralcea* sp. (globemallows).

For Plains-Mesa Sand Scrub, Parmenter et al. (1996) indicated that *Artemisia filifolia* (sandsage) was the dominant, along with *Atriplex canescens* (fourwing saltbush), *Ephedra torreyana* (Torrey jointfir), *Psorothamnus scoparius* (broom dalea) and other common shrubs, along with the grasses *Sporobolus* spp. (dropseeds), and *Oryzopsis hymenoides*. The rocky escarpments were characterized by scattered shrubs such as *A. canescens, Aloysia wrightii* (Wright's beebrush), *Rhus trilobata* (skunkbush), and grasses such as *Muhlenbergia porteri* (bush muhly), *Setaria leucopila* (streambed bristlegrass), and *Enneapogon desvauxii* (nineawn pappusgrass).

Cully (2002) conducted a plant species inventory based on 62, 100-m^2 plots distributed in 2001 across the park. She identified some 90 taxa among four general habitats of the park (chaparral, desert scrub, grassland, and urban vegetated).



Legend

Af	Agua loam	LtB	Latene sandy loam, 1 to 5 percent slopes
Ag	Agua silty clay loam	MWA	Madurez-Wink association, gently sloping
AkC	Akela-Rock outcrop complex, 1 to 9 percent slopes	MaB	Madurez loamy fine sand, 1 to 5 percent slopes
AmB	Alemeda sandy loam, 0 to 5 percent slopes	PAC	Pajarito loamy fine sand, 1 to 9 percent slopes
An	Anapra silt loam	RBE	Rock outcrop-Akela complex, 10 to 50 percent slopes
BCC	Bluepoint loamy fine sand, 1 to 0 percent slopes	TP	Torrifluvents, frequently flooded
BKD	Bluepoint-Kokan association, hilly	To	Tome very fine sandy loam
Br	Brazito fine sandy loam	VF	Vinton and Brazito soils, occasionally flooded
Bs	Brazito silty clay loam	Va	Vinton loamy sand
Bt	Brazito complex	WaB	Wink fine sandy loam, 0 to 5 percent slopes
KR	Kokan-Rock outcrop association		

Figure 10. Soils of Petroglyph NM as mapped by Hacker et al. (1977).

2 Vegetation classification

Vegetation classifications are ground-based descriptions of vegetation patterns that take into account floristic composition and abundance, site characteristics, and ecological dynamics. A consistent, ecologically based vegetation classification is the foundation for the development of an information–rich vegetation map. For PETR, we used extensive field sampling and analysis to develop a hierarchical classification following the National Vegetation Classification Standard (FGDC 2008). The outcome was the identification and description of a suite of plant associations that are singularly, or in combination, components of map units, depending on cartographic standards and constraints, and the targeted uses of the map (see Chapter 3). Below we describe the methods we used to develop the vegetation classification for PETR and provide an overview and discussion.

2.1 Classification method: The National Vegetation Classification Standard

The classification system used in SCPN vegetation mapping projects is based on the National Vegetation Classification Standard (NVCS) adopted by the Federal Geographic Data Committee in 1997 and updated in 2008 (FGDC 1997 & 2008). The 2008 revised standard adopted by the FGDC contains substantial revisions to the upper levels of the NVCS hierarchy (Version 2; FGDC 2008) and now includes eight levels (table 1). The upper three levels indicate physiognomic characteristics that reflect geographically widespread (global) topographic and edaphic factors. The middle three levels are new to the NVCS hierarchy and focus on largely biogeographic and habitat factors, along very broad, regional-to-continental topographic, edaphic, and disturbance gradients. The lower two levels, alliance and association, are distinguished by differences in floristic composition. Alliances are physiognomically distinct groups of plant associations sharing one or more differential or diagnostic species (Mueller-Dombois and Ellenberg 1974). These are commonly the dominant(s) found in the uppermost strata of the vegetation. The plant association is the fundamental unit of the classification and, following the International Botanical Congress of 1910, is defined as a community of definite floristic composition (i.e., a repeating assemblage of species), uniform physiognomy, and habitat conditions (Mueller-Dombois and Ellenberg 1974). NPS classification and mapping now follow the FGDC (2008) standard and focus on the group and plant association levels (the alliance level is in flux within the classification because of the heterogeneity nationally and internationally in the application of the concept).

The NVCS provides a framework for levels of classification but does not provide descriptions of vegetation types at all levels. The actual National Vegetation Classification (NVC) is maintained in a database by NatureServe and the network of affiliated natural heritage programs and conservation data centers for use by government agencies, including the NPS, along with NGOs and the public. The NVC database tracks plant communities defined for the U.S. down to the association level and provides at least initial narrative descriptions of most alliances and associations. The database is available online through NatureServe Explorer (http://www.natureserve.org/explorer), which provides public access to regularly updated versions of the NVC plant community listings and descriptions. NatureServe's documentation of alliances and associations is the most accessible national listing currently available. However, the plant community descriptions within the NVC are not complete, and projects like the one described in this report continually add to the documentation and

Table 1. National Vegetation Classification hierarchy for terrestrial vegetation following the FGDC (2008) standard

Level	Level name	Criteria	Example
Upper levels			
1	Formation Class	Broad combinations of general dominant growth forms that are adapted to basic temperature (energy budget), moisture, and/or substrate or aquatic conditions.	Mesomorphic Shrub and Herb Vegetation (Shrubland and Grassland)
2	Formation Subclass	Combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate or aquatic conditions.	Temperate and Boreal Shrub and Herb Vegetation (Temperate and Boreal Shrubland & Grassland)
3	Formation	Combinations of dominant and diagnostic growth forms that reflect global macroclimatic factors as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.	Temperate Shrub and Herb Vegetation (Temperate Shrubland & Grassland)
Mid levels			
4	Division	Combinations of dominant and diagnostic growth forms and a broad set of diagnostic plant taxa that reflect biogeographic differences in composition and continental differences in mesoclimate, geology, substrates, hydrology,and disturbance regimes.	*Andropogon – Stipa – Bouteloua* Grassland & Shrubland Division (North American Great Plains Grassland & Shrubland)
5	Macrogroup	Combinations of moderate sets of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences in composition and subcontinental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii – Schizachyrium scoparium –Sorghastrum nutans* Grassland & Shrubland Macrogroup (Great Plains Tall Grassland & Shrubland)
6	Group	Combinations of relatively narrow sets of diagnostic plant species (including dominants and co-dominants), broadly similar composition, and diagnostic growth forms that reflect biogeographic differences in composition and sub-continental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii – Sporobolus heterolepis* Grassland Group (Great Plains Mesic Tallgrass Prairie)
Lower levels			
7	Alliance	Diagnostic species, including some from the dominant growth form or layer, and moderately similar composition that reflect regional to subregional climate substrates, hydrology, moisture/nutrient factors, and disturbance regimes.	*Andropogon gerardii* – (*Calamagrostis canadensis –Panicum virgatum*) Herbaceous Alliance (Wet-mesic Tallgrass Prairie)
8	Association	Diagnostic species, usually from multiple growth forms or layers, and more narrowly similar composition that reflect topo-edaphic climate, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii – Panicum virgatum – Helianthus grosseserratus* Herbaceous Vegetation (Central Wet-mesic Tallgrass Prairie)

listing of NVC types.

2.2 Field methods

Vegetation sampling was designed to capture as wide a variety of vegetation types as possible within the seasonal time frame available for field work (typically during the rainy season between July 15 to October 15 when botanical expression is at its best). We planned the four- to six-week sampling campaigns to optimize field crew efficiency while still capturing as wide a range of vegetation types as possible on any given day. To do this, we employed a cluster sampling approach in which a series of daily routes for the sampling crews were created in a GIS using the digital orthophotography and preliminary vegetation maps. The choice of location for eight to ten sampling points per route were driven by differences in vegetation, soils, and geologic pattern, plus logistics, i.e., what could be accomplished in one day's travel time by vehicle and foot by a field crew (sampling days were ten hours long to further increase daily efficiency). Routes were distributed as widely as possible throughout the study area. While using the GIS was an excellent planning tool that took much of the guesswork out of plot placement, final plot locations were field-based decisions predicated on positioning the sampling point in homogenous stands of vegetation and habitat.

Field crews were composed of two to three people, including a senior technician crew chief, who was responsible for botany and vegetation sampling. The second and third members were junior technicians responsible for gathering tree and fuels data, photographs, and Global Positioning System (GPS) locations. Plots were established in large stands of vegetation representative of the typical vegetation at a site (greater than one ha). Plots were generally 400 m^2 and square, but occasionally other sizes and shapes were used to fit the structure of a community, especially along drainages where vegetation stands conform to the channel shape.

For standard plots, we compiled a list of all vascular plant species, stratified by life form (tree, shrub, subshrub, grass and forb layers) and strata height, and estimated the cover for each species using a modified Domin-Krajina Scale (table 2) (Mueller-Dombois and Ellenberg 1974). Total non-overlapping cover was also recorded by stratum. We noted site attributes for plots, including slope percent, aspect, slope shape, surface rock type, and ground cover (percent rock, gravel, bare soil and litter), as well as species composition and site conditions. Plot locations were recorded with a Garmin GPS Model 12 with +/- 10 m accuracy. For each plot, we took at least four photos in the four cardinal directions from plot center, with each photo containing a placard that noted the project, sampling date, and plot number. The compass direction and focal length of each shot was logged for future reference. See the NHNM field survey handbook and examples of sampling forms and detailed descriptions of sampling procedures in Appendix A.

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

Cover class	Canopy cover (%)	Canopy cover midpoint (%)	Area within m^2 per 400 m^2 plot
+0	[Undefined]	[0.001]	[Outside plot]
+	<0.05	0.01	<0.04
1	<0.1	0.05	≥0.04 and <0.5
2	<1	0.5	≥0.5 and <4
3	1–4	2.5	≥5 and <20
4	5–10	7.5	≥20 and <40
5	10–25	17.5	≥40 and <100
6	25–33	29.0	≥100 and <132
7	33–50	41.5	≥132 and <200
8	50–75	62.5	≥200 and <300
9	>75	87.5	≥300

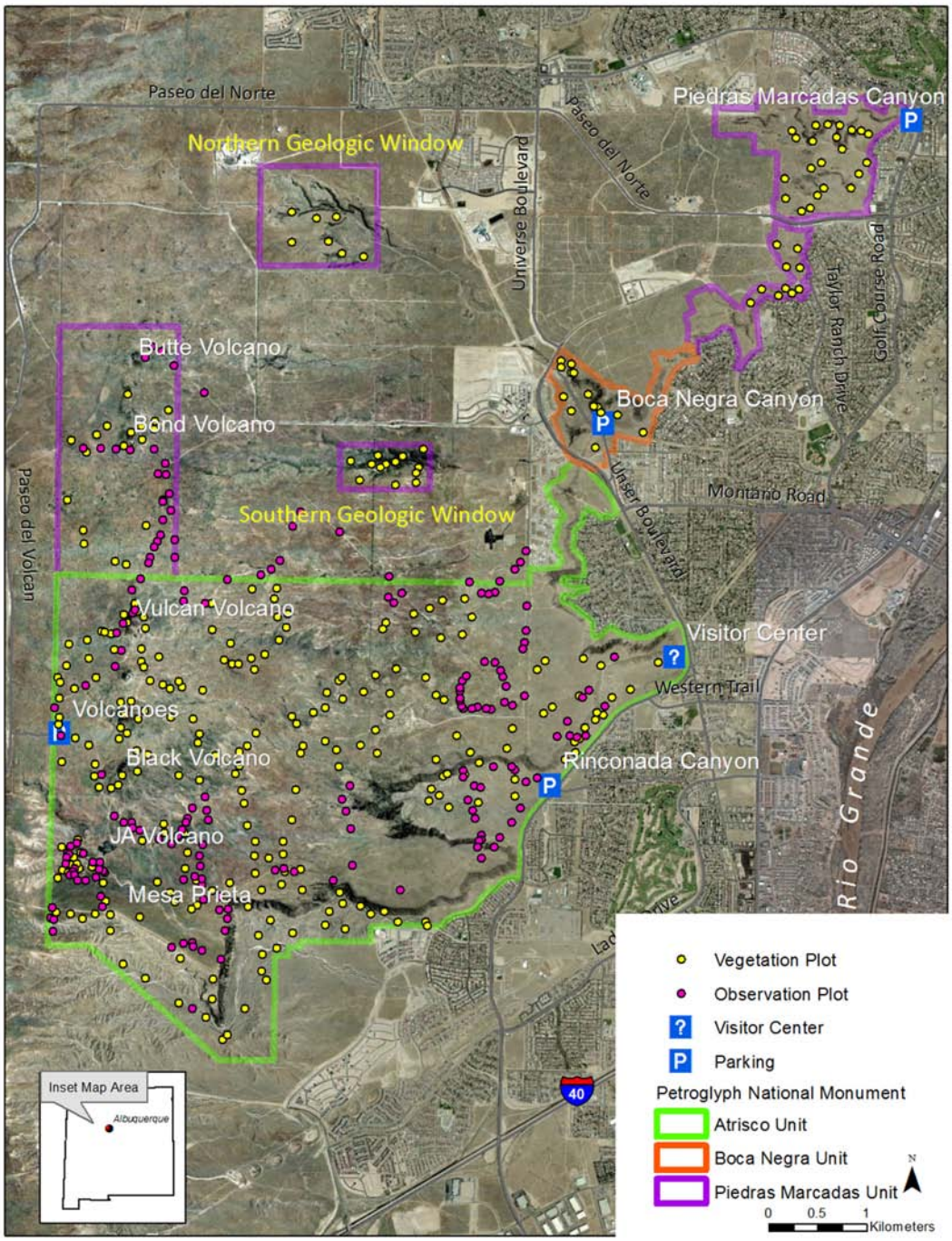


Figure 11. Distribution of vegetation plots used for classification and mapping of Petroglyph NM. Of the 499 plots collected, 314 were quantitative vegetation plots and 185 were semi-quantative observations points.

We primarily used standard plots to support vegetation classification development, and three to five can be established in a day. To maximize ground control of the mapping process, we employed stripped-down mapping plots (quick plots) for which we recorded only the cover of dominant species in each strata, along with a reduced set of site parameters. Anywhere from 6 to 12 of these quick plots can be established in a day, depending on logistics (all accuracy assessment plots were of this style). Lastly, we utilized simple observation points (OPs) for which we recorded GPS locations, plant association designation, and brief qualitative descriptions. Data were collected from 499 plots for the classification and mapping portion of the project (fig. 11). Of these, 94 were standard plots, 219 were quick plots, and 186 were observation points.

When necessary, we collected plant

voucher specimens to confirm field identifications. These are currently housed at the University of New Mexico Herbarium. NHNM botanist Yvonne Chauvin identified specimens to the lowest level possible, given the material at hand, and assigned names according to the PLANTS database (USDA-NRCS 2009) and the Integrated Taxonomic Information System (ITIS). Qualifying specimens that meet UNM's collection standards were accessioned with both UNM accession numbers and NPS record numbers linked to the Herbarium and NPS databases. A species list derived from the plot data is provided in Appendix B.

All vegetation and site data were entered into the Microsoft Access NHNM Ecology database. Quality control procedures included error checking computer routines and manual read-backs. Each record contains a comprehensive documentation of the plot location and dimensions, vegetation composition, tree stand structure, site characteristics, vegetation classification, and photo points. All plot data and associated location information and metadata were transferred to a stand-alone NPS-developed Microsoft Access relational database (PLOTS_v3_BE_ PETR.MDB). While no structural changes were made to the NPS database template, we did add selected fields that allow the tracking back of all data to the NHNM database.

2.3 Vegetation analysis

To develop the vegetation classification, we analyzed the plot data using standard tabular comparison techniques (Becking 1957, Mueller-Dombois and Ellenberg 1974, Ludwig and Reynolds 1988, McCune and Grace 2002). These analyses were based primarily on species-level canopy-cover values, with some grouping at the genus level where taxonomic units were ambiguous (abundance scalar values were converted to percent-cover mid-point values). Data on site characteristics, such as elevation, slope, aspect, and landform, were also considered in the analysis. In general, we classified each plot into a particular plant association (PA) based on codominance and/or other groups of differential species. We also assigned phases of associations, as necessary, to further define the character of the plant community.

In the new NVCS (FGDC 2008), associations were assigned to groups based on a working classification developed by NatureServe in collaboration with government agencies and Natural Heritage network ecologists. The resulting hierarchical classification was reviewed by NatureServe ecologists responsible for maintenance and consistency of the NVCS. Currently, the NVCS continues to be revised to meet the new standard, and not all groups have been defined. Hence, we had the opportunity here to propose new groups for review as part of the analysis (described below). Final summary floristic and site tables by plant association were computed and served as the basis for the plant association descriptions and dichotomous keys presented in this report.

2.4 Classification results

While the elevation range within PETR is relatively limited, the complex features of the Albuquerque volcanic field and the peripheral non-volcanic terrain provides a setting for a diverse set of vegetation communities. We identified 34 plant associations (PAs) within the park, most of which are semi-arid grasslands and shrublands, but others included dry-wash riparian woodlands and shrublands, and juniper woodlands. In Table 3, we present the PAs ordered by the NVCS hierarchy, along with their classification status, number of PETR plots, and NatureServe/NHNM database code. Fourteen PAs were considered established or provisional types according to the NVC, i.e., they are well documented, either in the park or in the region, and have been entered in the NVC database and assigned a Nature-

Table 3. A hierarchical vegetation classification for the Petroglyph NM (PETR) following the National Vegetation Classification System of seven levels: Class, Subclass, Formation, Division, MacroGroup, Group, and Plant Association (see table 1 for hierarchical level definitions). At the plant association level, the classification status of a plant association is indicated as either established (E) in the national classification or a provisional park special (P) association pending review. The "n" refers to the number of quantitative plots gathered for the association on PETR (excludes semi-quantitative observation points). "SCode" refers to the plant association database code (CEGL codes are NatureServe database codes for nationally/globally recognized associations; NPS or NHNM codes are provisional associations from Natural Heritage New Mexico's database). "Map Units" refers to the vegetation map units in which the plant association is considered to be either a primary component (1), secondary component (2), or related inclusion (Ri) (see table 5).

Group	Association	Classification status	# of plots	Code	Map unit
Class: 1. Forest and Woodland (Mesomorphic Tree Vegetation) Subclass: 1.C Temperate Forest Formation: 1.C.2 Cool Temperate Forest Division: 1.C.2.c Western North American Cool Temperate Scrub Woodland & Shrubland					
Macrogroup: MG027. Rocky Mountain Two-needle Pinyon - Juniper Woodland					
G252. Southern Rocky Mountain Juniper Woodland & Savanna Group	*Juniperus monosperma* / *Bouteloua eriopoda* Woodland	E	5	CEGL000709	1A, 6C
Class: 2. Shrubland & Grassland (Mesomorphic Shrub & Herb Vegetation) Subclass: 2.C Temperate & Boreal Shrubland & Grassland Formation: 2.C.1 Temperate Grassland, Meadow & Shrubland Division: 2.C.1.b Great Plains Grassland & Shrubland					
Macrogroup: MG052. Great Plains Sand Grassland & Shrubland					
G069 Great Plains Sand Shrubland Group	*Artemisia filifolia* / *Hesperostipa neomexicana* Shrubland	E	1	NHNM000341	2A
	Artemisia filifolia Rockland Shrubland	P	2	NHNM000842	4A
	Artemisia filifolia / Sparse Undergrowth Shrubland	P	18	NHNM000345	1A, 2A, 4B, 5A, 5B
	Artemisia filifolia / *Sporobolus cryptandrus* Shrubland	E	6	CEGL002179	2A, 4B, 5A, 5B
	Artemisia filifolia / *Pleuraphis jamesii* Shrubland	P	X	NHNM000343	2A

Table 3. *continued*

Group	Association	Classification status[1]	# of plots	Code	Map unit
Macrogroup: MG053. Great Plains Shortgrass Prairie & Shrubland					
G144 Great Plains Shortgrass Prairie Group	*Hesperostipa neomexicana - Sporobolus cryptandrus* Herbaceous Vegetation	P	3	NHNM000178	6B
	Hesperostipa neomexicana Mixed Prairie Herbaceous Vegetation	E	19	CEGL001711	6A, 6B, 6C
Class: 3 Semi-Desert (Xeromorphic Scrub & Herb Vegetation) Subclass: 3.A Warm Semi-Desert Scrub & Grassland Formation: 3.A.1 Warm Semi-Desert Scrub & Grassland Division: 3.A.1.a North American Warm Desert Scrub & Grassland					
Macrogroup: MG086. Chihuahuan Desert Scrub					2J
G287. Chihuahuan Stabilized Coppice Dune & Sand Flat Scrub Group	*Artemisia filifolia / Bouteloua eriopoda* Shrubland	E	6	CEGL001077	2A, 4B
	Psorothamnus scoparius / Sporobolus flexuosus Shrubland	E	11	CEGL001695	4B, 2A
G286. Chihuahuan Succulent Desert Scrub Group	*Aloysia wrightii / Muhlenbergia porteri* Rockland Shrubland	P	3	NHNM000332	4A
Macrogroup: MG087. Chihuahuan Semi-Desert Grassland					
G491. Chihuahuan Sandy Plains Semi-Desert Grassland	*Bouteloua eriopoda - Sporobolus flexuosus* (*S. cryptandrus, S. contractus*) Herbaceous Vegetation	P	16	NHNM000065	7A, 7B, 8C, 8F
	Sporobolus flexuosus - Sporobolus contractus Herbaceous Vegetation	E	12	CEGL001696	7B, 8B
GSW1. Chihuahuan Semi-Desert Foothill Grassland Group	*Bouteloua eriopoda* Cinder Herbaceous Vegetation	P	12	NHNM000845	8A, 8D
	Bouteloua eriopoda - Hesperostipa neomexicana Herbaceous Vegetation	E	33	CEGL001753	6A, 6B, 6C, 7A, 8A, 8B
	Bouteloua eriopoda - Muhlenbergia porteri - Setaria leucopila Mixed Herbaceous Rockland Vegetation	P	10	NHNM000063	3B, 8E

Table 3. *continued*

Group	Association	Classification status[1]	# of plots	Code	Map unit
G490. Chihuahuan Semi-Desert Grassland	*Bouteloua eriopoda* / Lava Flow Herbaceous Vegetation	P	12	NHNM000836	8D
	Bouteloua eriopoda Semi-desert Herbaceous Vegetation	E	14	CEGL001752	6B, 7A,8C, 8F
Macrogroup: MG092. North American Warm-Desert Xero-Riparian					
G541. Warm Semi-Desert Shrub & Herb Wash-Arroyo Group	*Celtis laevigata* var. *reticulata* Canyon Woodland	P	3	NHNM000813	5A
	Chilopsis linearis - Artemisia filifolia Shrubland	P	7	NHNM000385	5B
	Fallugia paradoxa Arroyo Wash Shrubland	E	4	CEGL002716	1A, 5A
Class: 3 Semi-Desert (Xeromorphic Scrub & Herb Vegetation) Subclass: 3.B Cool Semi-Desert Scrub & Grassland Formation: 3.B.1 Cool Semi-Desert Scrub & Grassland Division: 3.B.1.a Western North American Cool Semi-Desert Scrub & Grassland					
Macrogroup: MG171. Great Basin & Intermountain Dry Shrubland & Grassland					
G311. Intermountain Semi-Desert Grassland & Steppe Group	*Bouteloua eriopoda - Pleuraphis jamesii* Herbaceous Vegetation	E	25	CEGL001751	7A, 7B, 8A, 8B, 8F
	Hesperostipa neomexicana - Pleuraphis jamesii Herbaceous Vegetation	P	4	NHNM000176	6A, 7A
	Pleuraphis jamesii - Scleropogon brevifolius Herbaceous Vegetation	P	3	NHNM000224	7C
	Pleuraphis jamesii - Sporobolus cryptandrus Herbaceous Vegetation	P	27	NHNM000227	7A, 7B, 8B
	Pleuraphis jamesii Herbaceous Vegetation	E	15	CEGL001777	7A, 7B, 7C, 8B, 8E, 8F
Macrogroup: MG170. Great Basin & Intermountain Dwarf Sage Shrubland & Steppe					
G308. Intermountain Low & Black Sagebrush Shrubland & Steppe Group	*Artemisia bigelovii* / *Bouteloua eriopoda* Dwarf-shrub Herbaceous Vegetation	E	7	CEGL001741	8A, 8D
Macrogroup: MG093. Great Basin Saltbrush Scrub					

Table 3. *continued*

Group	Association	Classification status[1]	# of plots	Code	Map unit
G300. Intermountain Shadscale - Saltbush Scrub Group	*Atriplex canescens* Cinder Shrubland	P	7	NHNM000841	3B, 9A
	Atriplex canescens Lava Flow Shrubland	P	2	NHNM000837	3A, 8D, 9A
	Atriplex canescens Rockland Shrubland	P	7	NHNM000839	3B, 4A
	Atriplex canescens / *Pleuraphis jamesii* Shrubland	E	4	CEGL001288	3A
	Atriplex canescens / Sparse Shrubland	P	1	NHNM000354	3A, 4B, 5A, 5B, 9A
	Atriplex canescens / *Sporobolus flexuosus* (*S. cryptandrus, S. contractus*) Shrubland	P	7	NHNM000356	3A, 4B, 9A
Class: 6. Nonvascular & Sparse Vascular Rock Vegetation (Lithomorphic Vegetation)					
Subclass: 6.C Semi-Desert Nonvascular & Sparse Vascular Vegetation					
Formation: 6.C.1 Warm Semi-Desert Cliff, Scree & Rock Vegetation					
Division: 6.C.1.a North American Warm Semi-Desert Cliff, Scree & Rock Vegetation					
Macrogroup: MG117. North American Warm Semi-Desert Cliff, Scree & Rock Vegetation					
G569. North American Warm Semi-Desert Cliff, Scree & Rock Vegetation [Placeholder]	Sparse Vegetation / Bare Ground	P	NA	NPS_NM073	5A, 5B
	Sparse Vegetation / Boulder Rockland	P	2	NPS_NM013	4A, 8E, 9A
	Sparse Vegetation / Lava Flow	P	1	NPS_NM067	8D, 9A
	Sparse Vegetation / Sand	P	NA	NHNM000851	2A, 3A, 4B, 5A, 5B, 8B, 9A
Class: 0. Miscellaneous Vegetation					
Subclass: 0.0 Miscellaneous Vegetation					
Formation: 0.0.0 Miscellaneous Vegetation Formation					
Division: 0.0.0 Miscellaneous Vegetation Division					
Macrogroup: MGSWU. Miscellaneous Southwestern Vegetation Macrogroup					
GSWU. Miscellaneous Southwestern Vegetation Group	Ruderal Disturbance Vegetation	P	5	NPS_NM027	8D, 9A

Serve database code. Another 20 have limited documentation within and outside the park, and are considered "Park Specials," which require further documentation before being officially included in the NVC. For the established and park special associations, we provide local descriptions of floristic composition site characteristics along with diagnostic keys in Appendices C and D. Lastly, we have cross-walked each PA to the map units in which they are either a primary or secondary component, related inclusion, or a contrasting inclusion (see Chapter 3 for a description of map unit structure and table 5).

Below, we summarize information on the composition, structure, and environments of vegetation communities within the park in the context of the new NVCS hierarchy. We focus on the middle tiers of the hierarchy (Division, Macrogroup, and Group), with brief summaries of plant association (PA) composition and distribution (see table 3).

2.4.1 Grasslands

The most prominent vegetation feature at PETR was the grassland that dominated the mesa lava platform— the adjacent plateau composed of late Pleistocene alluvium. Grassland also occurred sporadically on sandy substrates below the mesa escarpment. These were semi-arid grasslands dominated or co-dominated by *Achnatherum hymenoides* (Indian ricegrass), *Bouteloua eriopoda* (black grama), *Hesperostipa neomexicana* (New Mexico needlegrass), *Muhlenbergia porteri* (bush muhly), *Pleuraphis jamesii* (galleta), *Scleropogon brevifolius* (burrograss), *Setaria leucopila* (streambed bristlegrass), *Sporobolus cryptandrus* (sand dropseed), and *S. flexuous* (mesa dropseed) among the 25 grasses recorded for the grassland zone. While grasses dominated, shrubs and subshrubs were often common (although generally comprised less than 10% cover). The most common shrubs were *Artemisia bigelovii* (Bigelow's sagebrush), *Artemisia filifolia* (sand sagebrush), *Atriplex canescens* (fourwing saltbush), *Krascheninnikovia lanata* (winterfat), *Gutierrezia sarothrae* (broom snakeweed), and *Yucca baileyi* var. *intermedia*. Cacti, such as *Opuntia phaeacantha* (tulip pricklypear), *Opuntia polyacantha* (plains pricklypear), and *Cylindropuntia imbricata* (tree cholla) also were found in grasslands. In addition, over 70 forbs were recorded among the various grassland associations.

Petrified Forest National Monument lies at the juncture of three major biogeographic regions—the Colorado Plateau, Southern Great Plains, and Chihuahuan Desert—and the grasslands in the park reflected a complex mosaic of plant associations representative of each of the regions. The Colorado Plateau grasslands were represented by five associations from the Intermountain Semi-Desert Grassland & Steppe Group (G311) that were dominated by *Pleuraphis jamesii*, with *Bouteloua eriopoda, Hesperostipa neomexicana, Scleropogon brevifolius*, or *Sporobolus cryptandrus* as codominants (fig. 12). The *Pleuraphis jamesii - Sporobolus cryptandrus* Herbaceous Vegetation and *Bouteloua eriopoda - Pleuraphis jamesii* Herbaceous Vegetation PAs were most often associated with sandy soils deposited by winds on top of the basalt lava flows and hills.

Figure 12. To the south and west of the volcanoes in Petroglyph NM there are large expanses of Intermountain Semi-Desert Grassland & Steppe that are dominated by *Pleuraphis jamesii* (galleta) and a mix of other semi-arid grasses (photo by E. Muldavin).

Pleuraphis jamesii Herbaceous Vegetation and *Pleuraphis jamesii - Scleropogon brevifolius* Herbaceous Vegetation PAs typically occurred in swales and depressions with somewhat heavier soils than the surrounding sandy sites. The latter also were associated with relatively thin soils towards the distal end of the mesa (lava flow 5) approaching the escarpment. In contrast, the *Hesperostipa neomexicana - Pleuraphis jamesii* Herbaceous Vegetation PA occurred on more gravelly soils associated with the slopes leading up to the volcanoes (lava flows 4 and 5). Similarly, the *Hesperostipa neomexicana - Sporobolus cryptandrus* Herbaceous Vegetation and *Hesperostipa neomexicana* Mixed Prairie Herbaceous Vegetation PAs of the Great Plains Shortgrass Prairie Group (G144) formed large patches on the gravelly and rocky slopes of the cones extending down to the lower mesa (fig. 13). On the rockiest sites, such as on lava pressure ridges and lava tube collapse features, the *Artemisia bigelovii* / *Bouteloua eriopoda* Dwarf-shrub Herbaceous Vegetation PA of the Intermountain Semi-Desert Grassland & Steppe Group (G308) often dominated (fig. 14). Given the nature of the substrate, this was a localized, small patch community.

We classified the remaining seven grassland associations as Chihuahuan semi-desert grasslands, primarily because of the dominance of *B. eriopoda*. They included the *Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus)* Herbaceous Vegetation and *Sporobolus flexuosus - Sporobolus contractus* Herbaceous Vegetation PAs of the Chihuahuan Sandy Plains Semi-Desert Grassland Group (G491) that formed the matrix communities on sandy soils across much of the southern portion of the mesa and occasionally below the escarpment (fig. 15). These grasslands were intermixed with nearly monotypic stands of *B. eriopoda,* i.e., the *Bouteloua eriopoda* Semi-desert Herbaceous Vegetation and *Bouteloua eriopoda* / Lava Flow Herbaceous Vegetation PAs of the Chihuahuan Semi-Desert Grassland Group (G490). The latter was most prevalent on lava flows 1 and 2, where, as one approaches the escarpment, the soils thin out, exposing extensive amounts of basalt lava at the surface (fig. 16). The *Bouteloua eriopoda - Muhlenbergia porteri - Setaria leucopila* Mixed Herbaceous Rockland Vegetation PA of the Chihuahuan Semi-Desert Foothill Grassland Group (GSW1) was found amongst the boulders of

Figure 13. Grasslands dominated by *Hesperostipa neomexicana* (New Mexico feathergrass) are representatives of the Great Plains Shortgrass Prairie Group. In Petroglyph NM they cloak the slopes of the volcanoes and extend down to the lower mesa, particularly in the northern portion of the park (photo by Y. Chauvin).

Figure 14. The *Artemisia bigelovii* (Bigelow's sagebrush) / *Bouteloua eriopoda* grasslands Dwarf-shrub Herbaceous Vegetation PA is an example of the Intermountain Semi-Desert Grassland & Steppe Group and typically occurs in Petroglyph NM on rocky lava pressure ridges within the matrix of other grasslands (photo by E. Muldavin).

Figure 15. *Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus)* Herbaceous Vegetation is a common association within Chihuahuan Sandy Plains Semi-Desert Grassland. In Petroglyph NM, it is most prevalent in the southeastern portion of the mesa (photo by Y. Chauvin).

Figure 16. The *Bouteloua eriopoda* / Lava Flow PA is a member of the Chihuahuan Semi-Desert Grassland Group and occurs in Petroglyph NM on the thinner soils with extensive exposed lava near the edge of the mesa (photo by E. Muldavin).

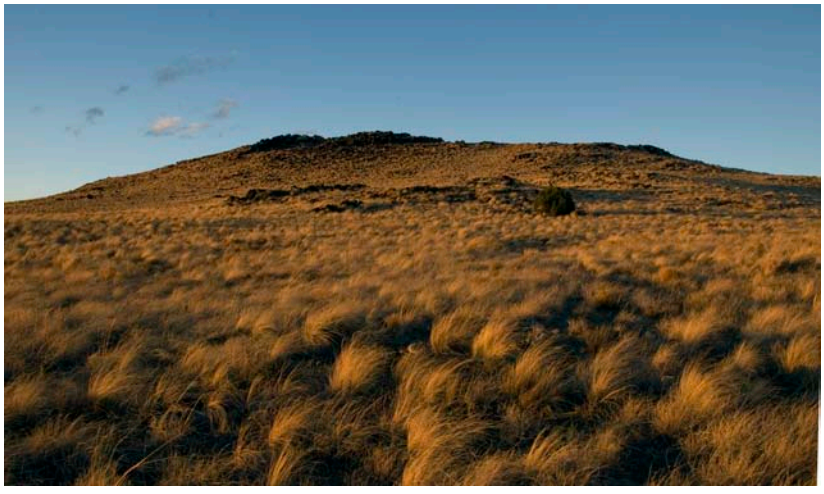


Figure 17. The *Bouteloua eriopoda - Hesperostipa neomexicana* grasslands belong to the Chihuahuan Semi-Desert Foothill Grassland Group and are common in Petroglyph NM on the slopes of the volcanoes and nearby younger lava flows (photo by E. Muldavin).

the escarpment itself, and usually on northerly aspects. In contrast, the other two members of this group, *Bouteloua eriopoda* Cinder Herbaceous Vegetation and *Bouteloua eriopoda - Hesperostipa neomexicana* Herbaceous Vegetation were the dominant PAs of the volcanic cones (lava flows 4 and 5), forming large patches among the cobbles and rocks of the steeper slopes (fig. 17).

In general, PETR grasslands, despite the intensive gazing that began in the 19th century and continued until the park was established in 1990, are in exceptional condition with respect to canopy cover and diversity. Shrub encroachment appears limited and tied to specific edaphic conditions, such as deeper soils of drainages or in the fissures of rock outcrops. Grass cover across the associations averaged 30% and ranged as high as 60%--clearly sufficient fuels to support fire throughout most of the mesa. Fires naturally occur in these semi-arid grasslands, and although historical and current frequencies have not been fully investigated, they are likely to occur at intervals between 10 and 30 years, depending on fuel accumulation (McPherson 1995).

2.4.2 Shrublands

In PETR, shrublands occurred as scattered patches among the grasslands of the mesa, but were most prevalent on the lava escarpment and on sandy deposits found along its base. Total shrub canopy cover ranged from as low as 10% to as high as 75%. The shrublands were dominated by species typical of the the three major biogeographic regions that intersect at the park: *Psorothamnus scoparius* and *Aloysia wrightii* from the Chihuahuan Desert; *Artemisia filifolia*, primarily from Great Plains; and *Atriplex canescens* and *Artemisia bigelovii* from the Colorado Plateau, along with azonal elements such as *Fallugia paradoxa* (Apache plume) that have a more generalized distribution. Understories were variable, with some 70 grasses and forbs identified among shrub associations.

Some associations had well developed grass layers while others were sparse, with little or no herbaceous growth.

Shrublands often formed a complex matrix across the landscape. For example, the *Atriplex canescens* / *Pleuraphis jamesii* Shrubland and *Atriplex canescens* Lava Flow Shrubland PAs were intermixed among the mesa grasslands, typically on lava flows 1 and 2. (fig. 18) In the former, grass canopy cover was usually over 10%, and that may have included significant amounts of *B. eriopoda* and *Sporobolus cryptandrus*. In the latter, herbaceous cover was sparse because these sites had shallower soils with extensive exposed basalt lava rock and gravels at the lower edges of the mesa (often intermixed with the *Bouteloua eriopoda* / Lava Flow PA described above). In contrast, the *Atriplex canescens* Cinder Shrubland was found at the higher elevations on the rocky slopes of the volcanic cones. Grass cover here was also low, but *Muhlenbergia porteri* could be common. *M. porteri* also dominated the herbaceous cover of the escarpment as part of the *Atriplex canescens* Rockland Shrubland PA. Other common grasses in this PA included *Setaria leucopila* and *Enneapogon desvauxii* (nineawn pappusgrass). This association was usually found on southerly aspects of the escarpments, in contrast to the *Bouteloua eriopoda – Muhlenbergia porteri – Setaria leucopila* Mixed Herbaceous Rockland Vegetation PA on northerly aspects (fig. 19). A limited occurrence of the *Aloysia wrightii* / *Muhlenbergia porteri* Rockland Shrubland PA was also found on south-facing slopes of the escarpment, mostly in the Rinconada area (fig. 20). While *A. wrightii* does occur on the Colorado Plateau, it is primarily a warm-desert species, with the center of its distribution in the Sonoran and Chihuahuan Deserts (hence, the association was classified as part of the Chihuahuan Succulent Desert Scrub Group (G286).

Off the lava flows to the east are large accumulations of wind-blown sandsheet

Figure 18. The *Atriplex canescens* Lava Flow Shrubland PA is a member of the Intermountain Semi-Desert Grassland & Steppe Group and is usually found in Petroglyph NM at the distal ends of the lava flows (1 and 2) at the mesa edge where little sand has accumulated (photo by Y. Chauvin).

Figure 19. The *Bouteloua eriopoda - Muhlenbergia porteri - Setaria leucopila* Mixed Herbaceous Rockland Vegetation is common on the volcano slopes and rocky escarpment slopes in Petroglyph NM and is part of the Chihuahuan Semi-Desert Foothill Grassland Group (photo by A. Kennedy).

Figure 20. The *Aloysia wrightii* / *Muhlenbergia porteri* Rockland Shrubland, a far northern extension of Chihuahuan Succulent Desert Scrub Group (G286) is known from the south-facing slopes of the escarpment in the Rinconada area of Petroglyph NM (photo by E. Muldavin).

Figure 21. The *Atriplex canescens* / *Sporobolus flexuosus (S. cryptandrus, S. contractus)* Shrubland PA is often intermixed with other sand shrub communities in Petroglyph NM, such as the *Psorothamnus scoparius* / *Sporobolus flexuosus* Shrubland of the Chihuahuan Stabilized Coppice Dune & Sand Flat Scrub Group (photo by Y. Chauvin).

Figure 22. The *Artemisia filifolia* / *Sporobolus cryptandrus* Shrubland PA often occurs in Petroglyph NM in sand-filled drainages below the escarpment, but is also intermingled among *Atriplex canescens* and *Psorothamnus scoparius* upslope and on dunes (photo by Y. Chauvin).

deposits and dunes. The *Artemisia filifolia* Rockland Shrubland was typically found along the base of the escarpment adjacent to the dunelands. Boulders are still prevalent but sand has blown up among them creating sites where sand sagebrush could become established. Out away from the escarpment, the *Atriplex canescens* / *Sporobolus flexuosus (S. cryptandrus, S. contractus)* Shrubland PA is prevalent on low dunes and sandsheets (fig. 21). Here, grass cover seldom exceeded 5%, and was dominated by sand-tolerant species, such as sand dropseeds *(Sporobolus contractus*, *S. cryptandrus*, and *S. flexuosus)*, *Setaria leucopila* and *Enneapogon desvauxii*. Following wet winters, annual grasses, such as *Munroa squarrosa* (false buffalograss) and *Bouteloua barbata* (six-weeks grama) may be abundant. On some sandy sites, grasses and forbs were minimal (less than 1% cover) and were classified as *Atriplex canescens* / Sparse Shrubland, Both associations were usually found in a mix with other dune elements, such as the *Artemisia filifolia* / *Bouteloua eriopoda* Shrubland and *Psorothamnus scoparius* / *Sporobolus flexuosus* Shrubland (both belonging to the Chihuahuan Stabilized Coppice Dune & Sand Flat Scrub Group (G287)). The *Psorothamnus scoparius* / *Sporobolus flexuosus* Shrubland was often found on the deepest sands. The *Artemisia filifolia* / Sparse Undergrowth Shrubland, and *Artemisia filifolia* / *Sporobolus cryptandrus* Shrubland PAs often occurred in the drainages among the dunes (fig. 22). *A. filifolia*-dominated associations also occurred in sandy drainage areas in the grasslands on the mesa.

Dry washes, both on and off the mesa, supported a separate set of associations from the Warm Semi-Desert Shrub & Herb Wash-Arroyo Group (G541), which is adapted to the ephemeral, high water flows from runoff following summer thunderstorms. Stands of the *Chilopsis linearis* (desert willow) – *Artemisia filifolia* Shrubland and *Fallugia paradoxa* Arroyo Wash Shrubland PAs were found intermixed on sand bars and terraces adjacent to the active channel (fig. 23). The *Celtis laevigata* var. *reticulata* (netleaf hackberry) Canyon Woodland was restricted to the drainages and canyons of the escarpment and is an uncommon association in northern New Mexico.

Whether the shrublands of PETR reflect grassland degradation followed by shrub invasion is unclear. Within

the grasslands of the mesa, shrublands were patchy or found only in specific sites, such as drainages, suggesting that edaphic conditions may be playing a larger role in their distribution than disturbance (some patches may reflect intense past disturbances such as livestock holding pens or adjacency to water tanks). The age of the sandscrub shrublands below the escarpment is unknown, but historical analysis elsewhere in New Mexico has indicated that sandy plains grasslands can be degraded to shrublands dominated by *A. filifolia* or *Prosopis glandulosa* (honey mesquite) (Buffington and Herble 1964; Yanoff and Muldavin 2008). On the other hand, the sandsheets and dunelands on PETR may be a natural occurrence, reflecting normal deposition of sands and silts on the lee side of the mesa by the prevailing southwesterly winds.

2.4.3 Woodlands

On PETR, there were scattered, open-canopied stands of *Juniperus monosperma* (oneseed juniper) that belong to the Southern Rocky Mountain Juniper Woodland and Savanna Group (G252). We identified one association—the *Juniperus monosperma / Bouteloua eriopoda* Woodland—a savanna type characterized by very open canopies (10–25%) of *J. monosperma* and grassy inter-canopy spaces dominated by *Bouteloua eriopoda* or *Hesperostipa neomexicana* bunch grasses (fig. 24, grass cover ranged between 5 and 25%). While *B. eriopoda* and/or *H. neomhexicana* dominated, other common grasses included *Bouteloua hirsuta* (hairy grama), *Pleuraphis jamesii,* and *Sporobolus cryptandrus.* This minor association was found intermixed among the mesa grasslands, either within drainages (lower mesa) or on exposed lava pressure ridges and collapse features (higher up the mesa towards the cones).

These juniper associations are part of the Juniper Series of Layser and Schubert (1979), and the *Juniperus monosperma* Association within the Pinyon-Juniper Series of Brown et al. (1979) described for the Southwest in general. Later, Larson and Moir (1987) identified several specific one-seed juniper associations for southern New Mexico, and Dick-Peddie (1993) identified a Oneseed Juniper Series with eight associations which includes this association.

Dick-Peddie (1993) referred to the series as ecotonal vegetation between

Figure 23. The *Fallugia paradoxa* (Apache plume) Arroyo Wash is a Warm Semi-Desert Shrub & Herb Wash-Arroyo Group. It occurs along drainages in Petroglyph NM, often in mosaic with other dry-wash shrublands such as *Chilopsis linearis* (desert willow) - *Artemisia filifolia* Shrubland. Stream flows are typically ephemeral, in response to summer thunderstorms (photo by Y. Chauvin).

Figure 24. The *Juniperus monosperma / Bouteloua eriopoda* Woodland is a member of the Southern Rocky Mountain Juniper Woodland and Savanna Group and, in Petroglyph NM, forms small stands on the mesa in association with drainages or rocky slopes (photo by Y. Chauvin).

dense woodlands and true grasslands that may be affected by fire frequencies. Fire is an important disturbance factor in pinyon-juniper woodlands, and most recently, Romme et al. (2009) provided an overview of fire's role in the dynamics and structuring of western U.S. pinyon-juniper woodlands. They recognized the "savanna woodlands" as a separate element with a specific fire regime of high-frequency, low-intensity surface fires. Whether the woodland fire regime on PETR has been significantly altered from pre-settlement conditions is not known.

2.5 Classification discussion

Daubenmire (1974) suggested that plant communities integrate all impinging environmental conditions and, hence, the classification and description of plant associations provides a framework for understanding the ecological composition and structure of a given landscape. Accordingly, we used plant associations in the mapping process to define map unit components—providing the information linkage between a vegetation community's spatial distribution and its ecology. By grouping land areas based on their ability to support similar associations, general management observations and recommendations can be made for each grouping. In addition, resource managers have found that the classification of vegetation into plant associations has provided them with the insight and the ability to predict vegetation changes in response to various disturbance processes.

However, the development of a vegetation classification is an incremental process of successive approximation (Shimwell 1971). For PETR, we suggest that further work is needed to 1) describe edge-of- range associations from the Colorado Plateau, Great Plains, and Chihuahuan Deserts and 2) delineate understory patterns and species distributions among the dominant Rocky Mountain forests and woodlands, with a focus on further defining the "Group" level of the classification and revising the alliances within the new FGDC (2008) NVCS hierarchy.

2.6 Vegetation communities of conservation interest

As a predominantly grassland park, PETR is an important northern node in a limited network of southwestern reserves that support grasslands. This unofficial network runs primarily from north to south within the Rio Grande Rift Valley (see figure 3), beginning in PETR, then continuing through Sevilleta National Wildlife Refuge, White Sands Missile Range, Fort Bliss (Otero Mesa), Guadalupe Mountains National Park, and then skipping to Big Bend National Park. Of particular interest are the *Hesperostipa neomexicana* grasslands that cloak much of the northern portion of the monument. These grasslands have been classified as part of the Great Plains Shortgrass Prairie Group and are considered vulnerable (G3 rank), yet there are no known populations that are protected in the Great Plains region. While these grasslands are scattered across the reserves listed above, the largest protected stands are likely to be in PETR. The *Bouteloua eriopoda*-dominated grasslands are also considered vulnerable in the Southwest and Mexico due to the intensive grazing pressure of the last 150 years. The large stands in the southern portion of PETR represent a major occurrence at the northern edge of these Chihuahuan Semi-Desert Grasslands. Overall, while there is evidence of past grazing in the species composition of the PETR grasslands, they are currently in excellent condition as reflected in their species richness (100+ grasses and forbs), high herbaceous canopy cover, and little evidence of ongoing site degradation.

3 Petroglyph National Monument Vegetation Map

3.1 Mapping process overview

We developed the vegetation map for Petroglyph National Monument (PETR) using a strategy that combined automated digital image classification and direct analog image interpretation of aerial photography and satellite imagery. Initially, the aerial photography and satellite imagery were processed and entered into a GIS, along with ancillary spatial layers. We developed a working map legend of ecologically-based vegetation map units using the NVCS classification described in Chapter 2 as the foundation. The intent was to develop map units that targeted the plant-association level wherever possible, within the constraints of image quality, information content, and resolution. With the provisional legend and ground-control points provided by the field-plot data (the same data used to develop the vegetation classification), we conducted heads-up screen digitizing of polygons based on image interpretation, and supervised image classifications. The outcome was a vegetation map composed of a suite of map units defined by plant associations and represented by sets of mapped polygons with similar spectral and site characteristics.

The key mapping standards of the National Vegetation Mapping Program (http://biology.usgs.gov/npsveg/), require that spatial data be provided with a horizontal positional accuracy meeting National Map Accuracy Standards at the 1:24,000 scale, i.e., each well-defined object in the spatial database must be within 1/50-of-an-inch display scale or within 12.2 m (40 ft) of its actual location. In addition, each vegetation map class (unit) should meet or exceed 80% accuracy at the 90% confidence level, and the minimum mapping unit (MMU) should be 0.5 ha (1.24 ac). Details of the accuracy assessment for the PETR vegetation map are provided in Chapter 4.

3.2 Mapping methods

3.2.1 Data sources and processing

3.2.1.1 Aerial photography

Aerial photography was the foundation imagery for the vegetation map. The photo-bases were from the 1:2,400 scale photo mapping project of Bernalillo County, which also covered PETR. These photos were acquired from March 12 to May 21, 2010 as a digital three-band natural color dataset (with the blue, green, and red wavelength portions of the visible spectrum partitioned into Bands 3, 2 and 1 respectively). As a part of their original processing these files had been ortho-rectified into quarter section photo-tiles with a half-foot spatial resolution, and projected into a Transverse Mercator Projection, NAD83 Datum, HARN spheroid as an .ECW data format. For this project, the particular photo-tiles covering PETR were imported into an ERDAS Imagine (v. 2010) .img format, mosaicked together and re-projected into a UTM projection, Zone 13, WGS84 spheroid, with a 0.16 m spatial resolution.

The resulting photo-mosaic provided a high-spatial detail, geometrically accurate, up-to-date photo map of PETR. The radiometric fidelity was consistent throughout PETR; unfortunately, visible wavelengths tend to be highly correlated with limited spectral information. This was especially true in this case, as the images were acquired over a landscape which varied little with its barren-to-desert vegetative cover under typical dry, spring-like conditions—from a vegetation mapping point of view, the imagery was spectrally featureless.

3.2.1.2 Satellite imagery

In order to accentuate the vegetative distinctions of the landscape, and to complement the digital aerial photography, we used two different types of satel-

lite imagery: DigitalGlobe's QuickBird imagery and Landsat Thematic Mapper (TM) imagery. QuickBird imagery was acquired over PETR on August 17, 2006. QuickBird data consists of four-band, multi-spectral imagery at 2.4 meters spatial resolution (table 4) as well as a 0.6 meter spatial panchromatic band (0.4–0.9 μms). Despite having the best spatial resolution, the panchromatic band integrates spectral reflectance over the visible and near infrared wavelengths into just one output response per pixel. The multi-spectral satellite imagery, on the other hand, records the different reflectance values for each of the four spectral bands, denoting the variations in surface materials such as rocks, plants, soils, and water. Variations in plant reflection and absorption due to biochemical composition produce distinct spectral "signatures" (Jensen 2007). These signatures provide a quantitative measure of reflectance at specific wavelengths, which can be analyzed statistically to develop a vegetation map of spectrally similar plant communities, as well as to visually enhance photo-interpretation through its greater spectral capabilities.

The Quickbird imagery was further processed to create a Normalized Difference Vegetation Index (NDVI) from the near-infrared and visible red bands. The NDVI emphasizes vigorous green plant growth by comparing a strong chlorophyll reflectance in the near-infrared wavelengths (Band 4) against chlorophyll absorption in the visible red wavelengths (Band 3). On this particular imagery, it emphasized monsoon-related green-up of C4 warm-season grasses, particularly *Pleuraphis jamesii* in contrast to a lack of green response for cool-season C3 *Hesperostipa neomexicana*.

All of these images were combined into a single image, which was then classified using a supervised classification process. Polygon-based seeds derived from previously collected field data were used to gather image statistics for each plot; this statistical data was used to classify the rest of the imagery through a maximum likelihood decision rule. The resulting classification was recoded into vegetation community-based map units.

Despite being geo-corrected, the Quickbird imagery was acquired off-nadir, which can generate significant geometric errors when compared to the orthorectified photography, mostly in areas of high relief, such as along the lava cliffs and the cones, especially at the scale of mapping (1:6,000 to 1:3,000). The difference between the images may have been as high as 20 m in some locations, and negligible in others. Because of this, the classification was used to provide basic locational information as to where the communities exist and where the community boundaries are, but all polygon development was based on the aerial photography.

Table 4. Multi-spectral band descriptions for QuickbirdQ and LandsatL satellite imagery used in the mapping of Petroglyphs NM

Landsat band	Wavelength (μms)	Surface response
Band 1Q,L	Visible Blue (0.45-0.52)	Absorption by most materials except saline or sandy soils.
Band 2Q,L	Visible Green (0.52-0.6)	Minor green vegetation reflectance peak.
Band 3Q,L	Visible Red (0.63-0.69)	Green vegetation absorption, but senescent vegetation reflectance and iron-stained soils reflect in these wavelengths.
Band 4Q,L	Near-Infrared (0.76-0.9)	Green vegetation reflectance peak.
Band 5L	Mid-Infrared (1.55-1.75)	Woody vegetation has less reflectance than herbaceous vegetation due to shadowing.
Band 7L	Mid-Infrared (2.08-2.35)	Hydrated vegetation, wet soil, and clayey soils have strong absorption features in these wavelengths.

In addition, we used two multi-spectral satellite Landsat Thematic Mapper (TM) images. Despite its coarser spatial resolution of 30 m, the Landsat imagery provides data in the mid-infrared wavelengths not available in Quickbird imagery (table 4). More importantly, because TM data is now in the public domain, it is now feasible to acquire several images to better detect differences in phenology between the plant communities. For PETR, two images bracketing pre-monsoon green-up and mid-monsoon green-up were chosen. These images were from June 14, 2010 and August 17, 2010.

The TM data were further processed to create four vegetation indices, which enhanced various vegetation or ecosystem characteristics using the two time periods represented by the scenes. These were the Normalized Difference Senescent Vegetation Index (NDSVI), the NDVI, a moisture index, and a vegetative moisture index. These indices were computed as follows:

NDSVI = ((Band 5 – Band 3) / (Band 5 + Band 3) + 1) × 100

NDVI = ((Band 4 – Band 3) / (Band 4 + Band 3) + 1) × 100

Moisture Index = ((Band 5 – Band 7) / (Band 5 + Band 7) + 1) × 100

Vegetative Moisture Index = ((Band 4 – Band 5) / (Band 4 + Band 5) + 1) × 100

In general, band ratios are designed to divide a reflectance peak by an absorption low to distinguish unique surface features. Due to the potential differences between image data ranges, the difference between bands is normalized against the total data range of the image bands. The adding of "1" and multiplying by "100" in each equation takes the original result, which would be a positive or negative fractional value centered around 0, and turns it into a positive integer value centered around 100.

The NDSVI enhances the spectral characteristics of senescent vegetation (specifically grasses), which have a relatively low reflectance response in the red wavelengths (Band 3) and a high reflectance in the mid-infrared wavelengths (Band 5). The moisture index compares relatively high reflectance values in the shorter wavelengths of the mid-infrared (Band 5) against strong absorption at the longer wavelengths of the mid-infrared (Band 7) caused by water molecules found in soil and vegetation. Similarly, the vegetative moisture index enhances shadowing and leaf-water content in plants.

In this case, the most informative of the indices were the multi-temporal NDVIs, as expected. Once again, green-up was most notable in the August NDVI in the areas dominated by the galleta sandy grassland and New Mexico feathergrass lava grasslands. Given the 30 m resolution, the TM image was used primarily to corroborate the QuickBird interpretation.

3.2.1.3 Ancillary spatial datasets

In addition to the imagery, standard spatial datasets such as digital elevation models, digital raster graphics (DRGs) of 1:24,000 scale USGS topographic maps, roads, ownership, soils, etc., were brought into the geographic information system (GIS). In particular, a recently completed digital geologic map for the Albuquerque area that included PETR was imported to aid the vegetation mapping (Connell, 2006). Although the geology was mapped at 1:24,000 scale, the map helped to discern vegetation community boundaries that seem to be associated with different age lava flows and other rock units.

3.2.2 Vegetation map units and legend development

The development of map units (map classes) and construction of a map legend is an iterative process that integrates the ecological vegetation classification units (plant associations, groups, etc.)

described above with their spatial distribution as determined by the remote sensing imagery and on-the-ground reconnaissance work. Following NPS guidelines, our goal was to develop map units that utilize the plant-association level of the national classification, but this was contingent on our ability to discern differences in the available imagery at that level using various remote sensing techniques.

Initially, we used simple aerial-photo interpretation to develop a working legend of plausible map units based on the true color and infrared photography, and ground-control sample points. While some units were defined by one or two primary plant associations and were relatively simple, others were either structured or unstructured complexes of plant associations. Structured complexes are composed of two or more plant associations that either 1) form fine-scale patterns, not separable at the scale of mapping (i.e., below the minimum map unit size of 0.5 ha), or 2) are not separable spectrally, but whose spatial organization within the unit are understood to some degree. In unstructured complexes, however, the environmental/spatial relationships among spectrally similar associations are poorly understood. For example, the New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland described below is an unstructured complex made up of four grassland plant associations that form a complex mosaic driven by unknown site factors. In contrast, the Black Grama-Bigelow Sagebrush Foothill-Volcano Grassland is a structured complex that includes the Artemisia bigelovii / Bouteloua eriopoda Dwarf-shrub Herbaceous Vegetation association, which grows on small basalt rock outcrops within the grassland matrix, and are too small to map at the target scale.

We hierarchically structured the legend into two tiers:

- a basic lower Level 2 composed of simple map units or complexes as defined by plant associations
- an upper Level 1, which groups the Level 2 map units where possible following the Group level of the NVCS as currently implemented by NatureServe and the Ecological Society of America National Vegetation Panel (FGDC 2008).

The Level 1 grouping allows the map to be comparable at regional scales to other mapping efforts, such as Gap and Landfire (Keane et al 2002; Prior-Magee 2007).

For each map unit, the most predominant associations (collectively greater than 50% of the aerial extent of the unit) are identified as primary components of the unit, while associations known to be less common from ground reconnaissance (collectively <50% of the area) are designated as secondary components. In addition, those associations estimated to occupy less than an estimated 10% of the area of unit are designated as inclusions. Related inclusions are floristically similar to the primary and secondary components, but are relatively rare (and usually not found in other map units). Contrasting inclusions of very different associations can also occur, usually as small patches. These are typically major components of other map units, are generally considered mapping errors, and are not listed. The designation of associations occurring in a map unit as primary or secondary components is based upon the frequency distribution of plots among the plant associations for that unit. That is, each plot was intersected with the map layer in the GIS and then each map unit attributed based on the distribution of plots among plant associations for that unit.

The hierarchical working legend formed the foundation for subsequent image analysis and classification. Based on the results of the image analysis and subsequent heads-up screen editing, we further refined the legend, both by

lumping and splitting the draft units. The map went through several iterations as ground data was gathered through the years and new imagery was acquired.

3.2.3 Final map development

All of the imagery and ancillary spatial data layers were compiled into a geodatabase using ArcGIS (v. 10). Using the draft legend as the guide, Level 2 map unit polygons were drawn using heads-up digitizing in ArcGis, based on 499 ground control plots, the various image classification, and photo-interpretation. While the minimum mapping requirements were 1:24,000 scale with map unit delineations or polygons 0.5 ha or larger, given the relatively small size PETR, an operational scale of 1: 12,000 was chosen for the output of poster-size maps of around ten square feet. The minimum mapping polygon size was also reduced to 2,500 m^2. Throughout the mapping process, map units were evaluated for coherence and the legend modified accordingly. Final map products included the geodabase and 1:12,000 poster maps at Level 1 and Level 2.

We developed the PETR vegetation map and its associated legend with nine Level 1 and 25 Level 2 map units (table 5). In figures 25 and 26, we present Level 1 and Level 2 maps respectively at a reduced scale for ease of interpretation in the report. Full-size maps at 1:12,000 scale are available as both a PDF and a shape file for GIS use at http://biology.usgs.gov/npsveg/products/parkname.html. Where possible, the Level 1 units correspond to the Group level of the NVCS. The exception was the Mixed Semi-Desert Shrubland (4), which, as the name implies, was somewhat heterogeneous with respect to plant association and group composition, but the map units themselves were spatially coherent. Also, the Non-natural Vegetation and Other Landcover (9) unit is not explicitly represented in the NVCS.

At Level 2, there are 21 vegetation units and four generalized land-cover units. In Table 5, each Level 2 map unit is defined in terms of component plant associations—primary components, secondary components, and related inclusions, and is tied by database code to the national vegetation classification in Table 1. Conversely, in Table 3, the plant associations are cross-referenced to the Level 2 map units of Table 5. While some units are more heterogeneous than others, we attempted to keep the map units as monophyletic as possible, that is, to minimize the overlap of associations from one unit to the next. The map-unit name reflects the primary component associations of the unit. A complete annotated legend with summary descriptions of the units, distribution maps, aerial photos of map unit polygons, and representative photos is provided in Appendix E. To aid cross-referencing between map units and associations, a NVC Association lookup table, organized by macrogroup, is provided in Appendix F.

3.3 Mapping discussion

The combination of land-use history, geology, soils, and processes, like fire and drought, have likely shaped much of the vegetation pattern of PETR. Yet, a general biogeographic pattern emerged that reflects PETR's position at the transition between three major biomes. Chihuahuan Desert grasslands dominated by black grama were predominant in the southeastern portion of the park while Intermountain Semi-Desert Grassland (Colorado Plateau), galleta-dominated grasslands were more prevalent in the southwestern and western portions. Surprisingly, Great Plains Shortgrass Prairie represented by New Mexico feathergrass grasslands strongly dominated the northeastern sector of the mesa. The latter probably represent one of the largest intact occurrences in New Mexico. In addition, geology, in combination with prevailing winds, likely plays a role in plant distribution. Some units are more common, or more restricted to one or

continued on page 40...

Table 5. A hierarchical legend for the Petroglyph National Monument Vegetation Map, composed of two nested levels, L1 and L2, along with component plant associations and their database code that make up each map unit and their database code (see table 1). Under "Type," each association is designated either as a primary component (1), secondary component (2) or related inclusion (Ri). The number of polygons representing the level 2 map unit is indicated, along with total area in hectares and acres.

Map unit					# of	Area	
L1	L2	Map unit name	Association	Type	polygons	(ha)	(ac)
		WOODLANDS			**18**	**21.8**	**53.9**
1		Southern Rocky Mountain Juniper Woodland and Savanna			**18**	**21.8**	**53.9**
	A	Oneseed Juniper Savanna Woodland Draw			18	21.8	53.9
			Juniperus monosperma / *Bouteloua eriopoda* Woodland	1			
			Fallugia paradoxa Arroyo Wash Shrubland	2			
			Artemisia filifolia / Sparse Undergrowth Shrubland	Ri			
		SHRUBLANDS			**285**	**581**	**1436**
2		Great Plains Sand Shrubland			**59**	**60.5**	**149.5**
	A	Sand Sagebrush Mesa Shrubland			59	60.5	149.5
			Artemisia filifolia / *Bouteloua eriopoda* Shrubland	1			
			Artemisia filifolia / *Hesperostipa neomexicana* Shrubland	2			
			Artemisia filifolia / *Sparse Undergrowth* Shrubland	2			
			Artemisia filifolia / *Sporobolus cryptandrus* Shrubland	Ri			
			Artemisia filifolia / *Pleuraphis jamesii* Shrubland	Ri			
			Psorothamnus scoparius / *Sporobolus flexuosus* Shrubland	Ri			
			Sparse Vegetation / Sand	Ri			
3		Intermountain Shadscale-Saltbush Scrub			**29**	**40.9**	**101**
	A	Fourwing Saltbush Mesa Shrubland			19	26.5	65.4
			Atriplex canescens / *Pleuraphis jamesii* Shrubland	1			
			Atriplex canescens / *Sporobolus flexuosus (S. cryptandrus, S. contractus)* Shrubland	2			
			Atriplex canescens Lava Flow Shrubland	Ri			
			Atriplex canescens / Sparse Shrubland	Ri			
			Sparse Vegetation / Sand	Ri			
	B	Fourwing Saltbush Foothilll-Volcano Shrubland			10	14.4	35.6

Table 5. *continued*

Map unit L1	Map unit L2	Map unit name	Association	Type	# of polygons	Area (ha)	Area (ac)
			Atriplex canescens Rockland Shrubland	1			
			Atriplex canescens Cinder Shrubland	2			
			Bouteloua eriopoda - Muhlenbergia porteri - Setaria leucopila Mixed Herbaceous Rockland Vegetation	2			
4		Mixed Semi-Desert Shrubland			**147**	**368.5**	**910.5**
	A	Fourwing Saltbush-Sand Sagebrush-Lava Cliff Shrubland			65	111.3	275.1
			Atriplex canescens Rockland Shrubland	1			
			Artemisia filifolia Rockland Shrubland	1			
			Aloysia wrightii / *Muhlenbergia porteri* Rockland Shrubland	2			
			Sparse Vegetation / Boulder Rockland	Ri			
	B	Sand Sagebush-Broom Dalea-Fourwing Saltbush Sand Shrubland			82	257.1	635.4
			Artemisia filifolia / Sparse Undergrowth Shrubland	1			
			Artemisia filifolia / *Sporobolus cryptandrus* Shrubland	1			
			Psorothamnus scoparius / *Sporobolus flexuosus* Shrubland	1			
			Atriplex canescens / *Sporobolus flexuosus (S. cryptandrus, S. contractus)* Shrubland	2			
			Artemisia filifolia / *Bouteloua eriopoda* Shrubland	Ri			
			Atriplex canescens / Sparse Shrubland	Ri			
			Sparse Vegetation / Sand	Ri			
5		Warm Semi-Desert Shrub & Herb Wash-Arroyo			**50**	**111.4**	**275.3**
	A	Apache Plume-Sand Sagebrush Dry Wash Shrubland			46	61.2	151.2
			Fallugia paradoxa Arroyo Wash Shrubland	1			
			Artemisia filifolia / Sparse Undergrowth Shrubland	2			
			Artemisia filifolia / *Sporobolus cryptandrus* Shrubland	2			
			Atriplex canescens / Sparse Shrubland	Ri			
			Celtis laevigata var. *reticulata* Canyon Woodland	Ri			
			Sparse Vegetation / Bare Ground	Ri			
			Sparse Vegetation / Sand	Ri			
	B	Desert Willow-Sand Sagebrush Dry Wash Shrubland			4	50.3	124.2

Table 5. *continued*

Map unit L1	Map unit L2	Map unit name	Association	Type	# of polygons	Area (ha)	Area (ac)
			Chilopsis linearis - Artemisia filifolia Shrubland	1			
			Artemisia filifolia / Sparse Undergrowth Shrubland	2			
			Artemisia filifolia / Sporobolus cryptandrus Shrubland	2			
			Atriplex canescens / Sparse Shrubland	Ri			
			Sparse Vegetation / Bare Ground	Ri			
			Sparse Vegetation / Sand	Ri			
		GRASSLANDS			495	2221	5489
6		Great Plains Shortgrass Prairie			**60**	**550.8**	**1360.9**
	A	New Mexico Feathergrass-Black Grama Gravelly Grassland			12	13.1	32.4
			Bouteloua eriopoda - Hesperostipa neomexicana Herbaceous Vegetation	1			
			Hesperostipa neomexicana Mixed Prairie Herbaceous Vegetation	2			
			Hesperostipa neomexicana - Pleuraphis jamesii Herbaceous Vegetation	Ri			
	B	New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland			41	503.8	1244.9
			Bouteloua eriopoda - Hesperostipa neomexicana Herbaceous Vegetation	1			
			Hesperostipa neomexicana Mixed Prairie Herbaceous Vegetation	2			
			Hesperostipa neomexicana - Sporobolus cryptandrus Herbaceous Vegetation	Ri			
			Bouteloua eriopoda Semi-desert Herbaceous Vegetation	Ri			
	C	New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland with Juniper			7	33.8	83.6
			Bouteloua eriopoda - Hesperostipa neomexicana Herbaceous Vegetation	1			
			Juniperus monosperma / Bouteloua eriopoda Woodland	2			

Table 5. *continued*

Map unit L1	Map unit L2	Map unit name	Association	Type	# of polygons	Area (ha)	Area (ac)
			Hesperostipa neomexicana Mixed Prairie Herbaceous Vegetation	Ri			
7		Intermountain Semi-Desert Grassland			**150**	**911**	**2251.1**
	A	Galleta-Black Grama-New Mexico Feathergrass Mesa Grassland			97	612.2	1512.8
			Pleuraphis jamesii - Sporobolus cryptandrus Herbaceous Vegetation	1			
			*Pleuraphis jamesi*i Herbaceous Vegetation	1			
			Bouteloua eriopoda - Pleuraphis jamesii Herbaceous Vegetation	2			
			Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus) Herbaceous Vegetation	2			
			Bouteloua eriopoda Semi-desert Herbaceous Vegetation	2			
			Hesperostipa neomexicana - Pleuraphis jamesii Herbaceous Vegetation	Ri			
			Bouteloua eriopoda - Hesperostipa neomexicana Herbaceous Vegetation	Ri			
	B	Galleta-Sand Dropseed Mesa Grassland			35	267	659.9
			Pleuraphis jamesii - Sporobolus cryptandrus Herbaceous Vegetation	1			
			Sporobolus flexuosus - Sporobolus contractus Herbaceous Vegetation	1			
			Pleuraphis jamesii Herbaceous Vegetation	2			
			Bouteloua eriopoda - Pleuraphis jamesii Herbaceous Vegetation	Ri			
			Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus) Herbaceous Vegetation	Ri			
	C	Galleta-Burrograss Mesa Swale Grassland			18	31.8	78.5
			Pleuraphis jamesii Herbaceous Vegetation	1			
			Pleuraphis jamesii - Scleropogon brevifolius Herbaceous Vegetation	2			

Table 5. *continued*

Map unit L1	Map unit L2	Map unit name	Association	Type	# of polygons	Area (ha)	Area (ac)
8		Chihuahuan Semi-Desert Grassland			**285**	**759.5**	**1876.8**
	A	Black Grama-Bigelow Sage Foothill-Volcano Grassland			25	196.7	486.1
			Bouteloua eriopoda Cinder Herbaceous Vegetation	1			
			Artemisia bigelovii / Bouteloua eriopoda Dwarf-shrub Herbaceous Vegetation	1			
			Bouteloua eriopoda - Hesperostipa neomexicana Herbaceous Vegetation	2			
			Bouteloua eriopoda - Pleuraphis jamesii Herbaceous Vegetation	Ri			
	B	Sand Dropseed-Mixed Grass Sand Grassland			58	64.6	159.7
			Sporobolus flexuosus - Sporobolus contractus Herbaceous Vegetation	1			
			Pleuraphis jamesii - Sporobolus cryptandrus Herbaceous Vegetation	2			
			Sparse Vegetation / Sand	2			
			Pleuraphis jamesii Herbaceous Vegetation	Ri			
			Bouteloua eriopoda - Pleuraphis jamesii Herbaceous Vegetation	Ri			
			Bouteloua eriopoda - Hesperostipa neomexicana Herbaceous Vegetation	Ri			
	C	Black Grama-Sand Dropseed Mesa Grassland			17	121.9	301.1
			Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus) Herbaceous Vegetation	1			
			Bouteloua eriopoda Semi-desert Herbaceous Vegetation	2			
	D	Black Grama/Sparse Vegetation Mesa Grassland			52	204.7	505.8
			Bouteloua eriopoda / Lava Flow Herbaceous Vegetation	1			
			Artemisia bigelovii / Bouteloua eriopoda Dwarf-shrub Herbaceous Vegetation	2			
			Bouteloua eriopoda Cinder Herbaceous Vegetation	Ri			
			Sparse Vegetation / Lava Flow	Ri			
			Sparse Vegetation / Bare Ground	Ri			

Table 5. *continued*

Map unit L1	Map unit L2	Map unit name	Association	Type	# of polygons	Area (ha)	Area (ac)
			Ruderal Disturbance Vegetation	Ri			
			Atriplex canescens Lava Flow Shrubland	Ri			
	E	Black Grama-Bush Muhly-Streambed Bristlegrass Lava Cliff Grassland			89	71.9	177.6
			Bouteloua eriopoda - Muhlenbergia porteri - Setaria leucopila Mixed Herbaceous Rockland Vegetation	1			
			Pleuraphis jamesii Herbaceous Vegetation	2			
			Sparse Vegetation / Boulder Rockland	Ri			
	F	Black Grama-Sparse Vegetation Gravelly Foothill Grassland			44	99.7	246.5
			Bouteloua eriopoda Semi-desert Herbaceous Vegetation	1			
			Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus) Herbaceous Vegetation	2			
			Bouteloua eriopoda - Pleuraphis jamesii Herbaceous Vegetation	2			
			Pleuraphis jamesii Herbaceous Vegetation	Ri			
9		Non-natural Vegetation and other landcover			**55**	**75.9**	**187.5**
	A	Disturbed Ground-Ruderal Vegetation			32	64.1	158.5
			Ruderal Disturbance Vegetation	1			
			Atriplex canescens Cinder Shrubland	2			
			Atriplex canescens / Sparse Shrubland	2			
			Atriplex canescens / *Sporobolus flexuosus* (*S. cryptandrus, S. contractus*) Shrubland	2			
			Atriplex canescens Lava Flow Shrubland	Ri			
			Sparse Vegetation / Boulder Rockland	Ri			
			Sparse Vegetation / Lava Flow	Ri			
			Sparse Vegetation / Sand	Ri			
	B	Residential/Built-Up Land			7	4.8	11.9
	C	Road			7	6.4	15.8
	D	Recreation Site			4	0.4	1.1
	E	Public Building			5	0.1	0.2

...continued from page 33

more of the five lava flows than others. For example, the Fourwing Saltbush Foothilll-Volcano Shrubland (3B) was only found on the volcanic vents and lava flow 5, whereas Galleta-Sand Dropseed Mesa Grassland (7B) was more prevalent on lava flows 2 and 3 and where there were significant deposits of windblown sand from the west (mediated by the volcanic vents themselves). Others, such as the Black Grama-Bush Muhly-Streambed Bristlegrass Lava Cliffs Grassland (8E) or Black Grama-Sparse Vegetation Gravelly Foothill Grassland (163), while tied to landforms or specific soils, have a specific floristic composition.

Overall, the combination of the annotated legend (Appendix G) and the detailed floristic and site descriptions of individual plant associations (Appendix F) provide for a vegetation map that is rich in ecological information and that can serve multiple purposes in the management of the park and the broader network of parks.

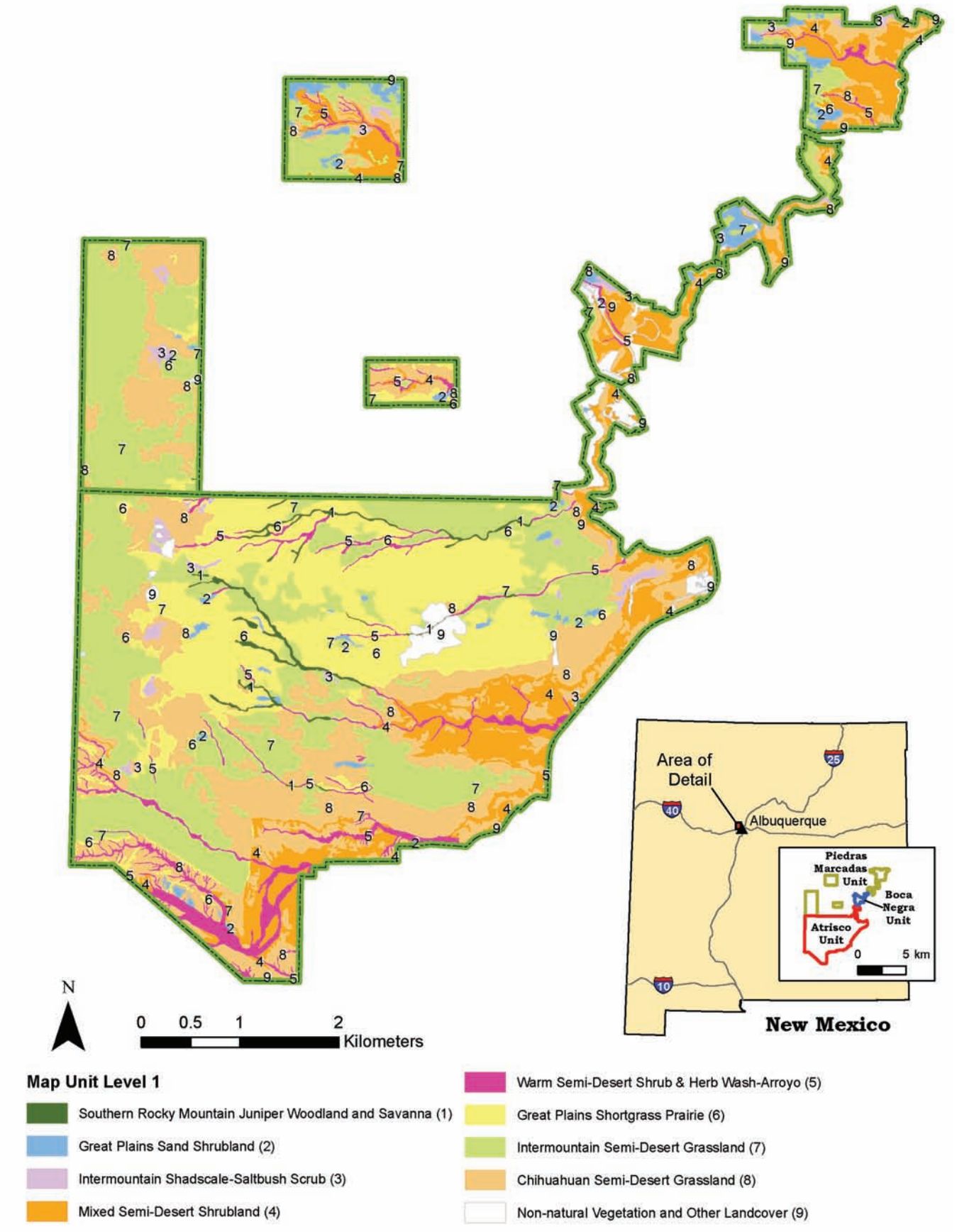


Figure 25. A vegetation map of Petroglyph NM portraying the Level 1 units (see table 5 for map unit definitions). A full-scale, 1:12,000 version is available at http://biology.usgs.gov/npsveg/products/parkname.html.

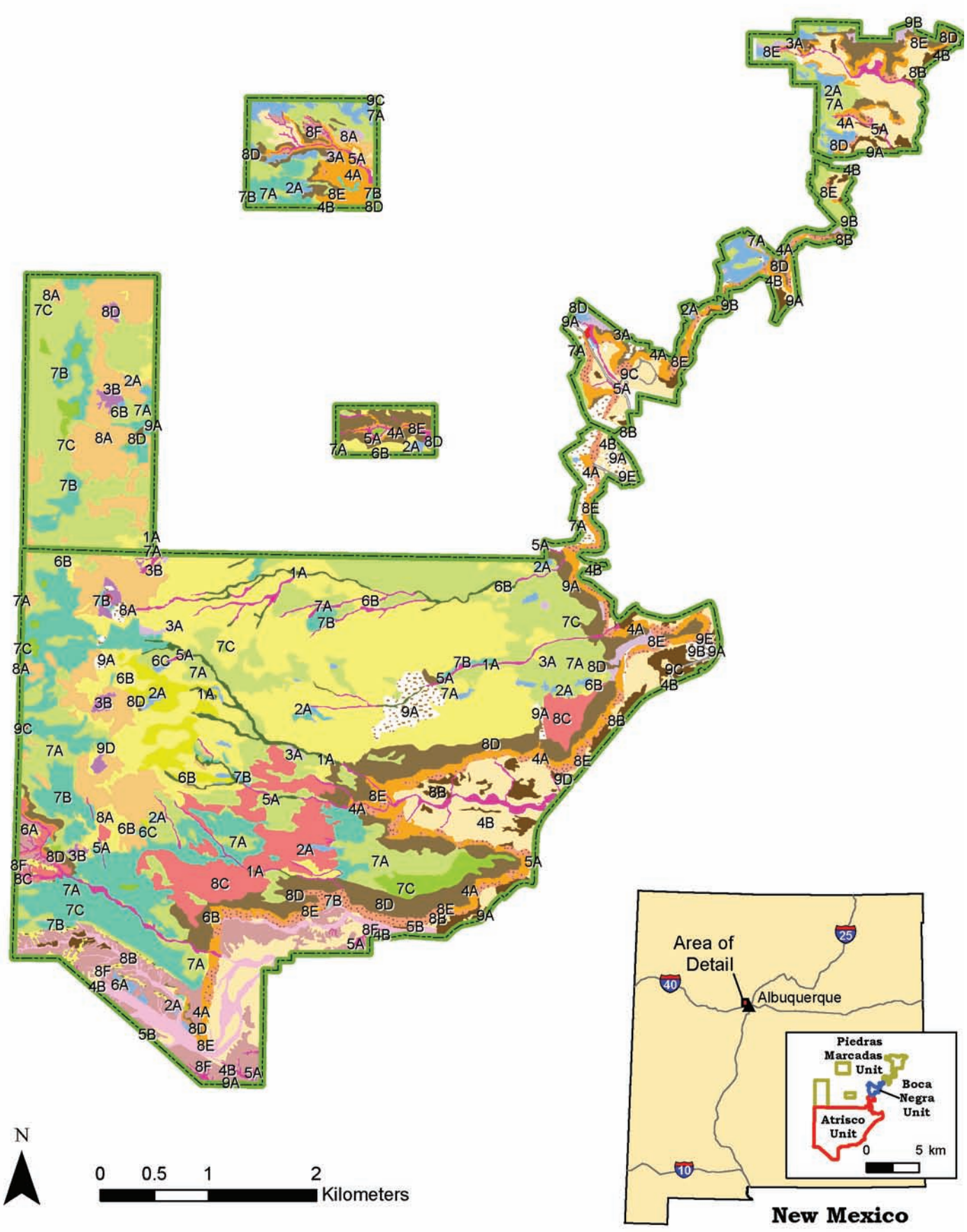

N
0 0.5 1 2
Kilometers
Area of Detail
Albuquerque
25
40
10
Piedras Marcadas Unit
Boca Negra Unit
Atrisco Unit
0 5 km
New Mexico

Figure 26. A vegetation map of Petroglyph NM portraying the Level 2 units (see table 5 and Appendix E for map unit definitions). A full-scale, 1:12,000 version is available at http://biology.usgs.gov/npsveg/products/parkname.html.

4 Accuracy assessment

We assessed the thematic accuracy of the PETR vegetation map following the USGS-NPS guidelines (Lea and Curtis 2010). Under these guidelines, the goal is to achieve overall and individual map unit accuracies greater than 80% from both the producers' and users' perspectives. We tested both Level 1 (NVCS Group) and Level 2 of the legend hierarchy, and also scaled up to broad physiognomic classes of forest, woodland, shrubland, and grassland. We report the results of the accuracy assessment here and make recommendations on the use of the map in the context of users' and producers' errors detected among the map units at various levels of the hierarchy.

Positional accuracy is usually omitted from USGS-NPS National Vegetation Mapping Program products because vegetation seldom splits along discrete edges that can be positively located in the field. The subjectivity involved in this effort, plus the high resolution and accuracy of the ortho-photo imagery, usually permits the assumption that all products derived from them are well within National Map Accuracy Standards for 1:12,000 scale maps (±10 m or ±30 feet). Given that resources were limited, and following the recommendations of Cogan (2007), we did not assess the positional accuracy. But there are known issues in the PETR map with respect to spatial correspondence among the various image layers used. Discrepancies range from near zero to as high as 15 m depending on location and terrain relief, and this was taken into account when evaluating a given sampling point accuracy.

4.1 Accuracy assessment methods

Overall, 21 Level 2 vegetation units were available for sampling, representing a sampling goal of 420 plots at an average rate of 20 plots per map unit. We created a sampling pool of randomized points across the park and selected plots based on both individual map unit targets and logistics. We designed sampling tracks that a field person could reasonably cover in a single ten-hour day (including vehicle travel). For units with large aerial extent we targeted at least 30 sample points, but we also attempted to not fall below ten for less common units. Following the NPS guidelines, multiple samples were allowed within any given polygon and were considered independent samples.

We conducted the accuracy assessment (AA) sampling in the spring and summer of 2011. To support field sampling, we created paper maps at a 1:12,000 scale with target sample points and the underlying imagery and topography, but no designations or delineations. The field crew used these as guidance in developing optimal sampling strategies with respect to map unit targets and logistics, and for reconnoitering in the field. In the field, crews would navigate to the point location and determine if the point was representative of the surrounding vegetation as a whole. If not, crews were allowed to move the point to a representative area and provide a justification for the move. The goal was to avoid sampling small patches or fragments of plant associations not typical of the target stand.

At the sample location, data was taken at a validation plot that included cover of the dominant species in each strata (trees, shrubs, subshrubs, grasses, and forbs), aspect (azimuth), slope (%), a brief description of the polygon landscape and composition relative to the sampling point, the GPS location (+/- 10 m precision), and four representative digital photos. Data were collected from a total of 469 AA plots (fig. 27).

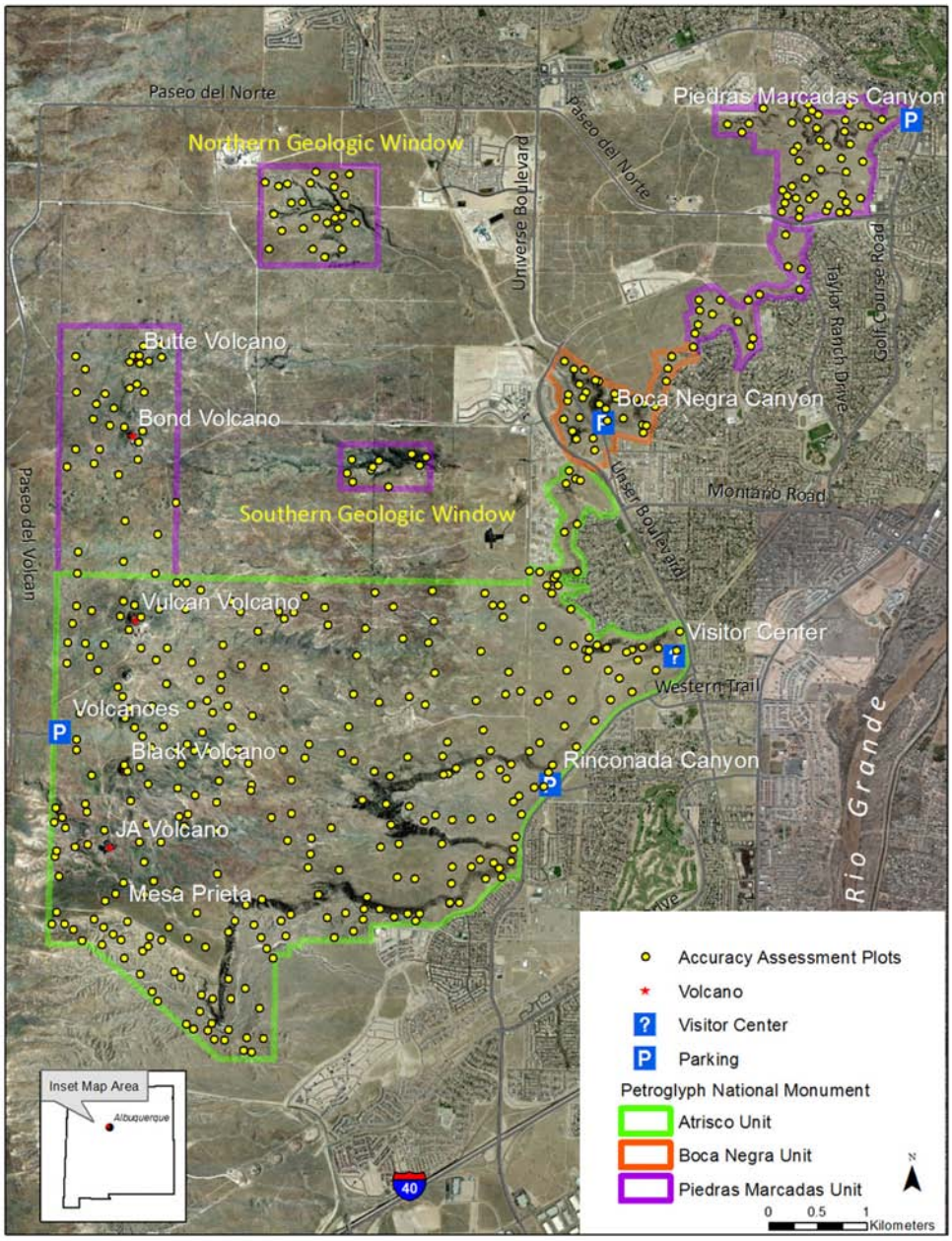


Figure 27. Distribution of the 469 accuracy assessment points for the Petroglyph National Monument Vegetation Map.

4.2 Analysis methods

Initially, we classified each AA point into a plant association following the PETR vegetation classification and dichotomous key (table 3 and Appendix C). AA points were then assigned to a map unit, according to the plant association composition of the unit as reflected in the map unit descriptions (table 5, Appendix E). In most cases, assignments were from either the primary or secondary components of the map units, and occasionally related inclusions (<5%). Contrasting inclusions were considered errors. When errors occurred, the sample point was assigned to either the adjacent polygon map unit that made thematic sense (spatial concordance), or, if not, to the most closely related map unit with respect to composition and environment based on the map unit descriptions in Appendix E. When AA points fell within 10 m of a polygon boundary (that is, within the expected positional accuracy error range), they were assessed with

respect to both the polygon and the adjacent one for accuracy. If we detected new plant associations that were not part of the original legend, these were labeled as "AA incidentals" and were counted as producer errors.

For each level of the map legend, we calculated both a users' and producers' accuracy (Congalton and Green 1999). Producers' accuracy reflects how well the map unit delineations represent the vegetation type on the ground, and not some other vegetation type (e.g., that juniper woodlands are mapped accurately based on the field validation point locations). This provides the mapmaker with a measure of how well the mapping product meets specifications. In contrast, the users' accuracy demonstrates how well the map performs when used in the field. For example, a juniper woodland encountered on the ground is mapped as such and not as some other map unit. This provides the user, regardless of training, a level of confidence that what one sees on the ground is actually the element as indicated by the map. In addition, we calculated the 90% confidence interval by map unit for each type of error.

To quantify overall accuracy, we calculated both an overall accuracy and an estimate of Kappa (Kappa Index) for each of the three map-unit levels in the legend. The overall accuracy is simply the total number of agreements between the map and reference data. The estimate of Kappa is another measure of agreement or accuracy varying from 0 to 1 (often presented as a percentage), where higher values indicate better agreement. The Kappa statistic (KHAT) is used to measure the difference between the actual agreement between the reference data and the map and the chance agreement between the reference data and a random map. KHAT indicates the extent to which the percentage-correct values of an error matrix are due to "true" agreement versus "chance" agreement (Congalton and Green 1999).

The results are presented in a series of contingency tables for each level of the legend, showing the producers' and users' errors by map unit with associated 90% confidence intervals, and the overall accuracy and the Kappa estimate for each level. These are also commonly referred to as "confusion" matrices.

The AA plots with their assigned plant association, map unit, and location were entered into Natural Heritage NM's (NHNM) Plot Database (MS Access-based) and then transferred to the tAA and tAA events tables in the NPS-developed Plot_v3_BE_PETR.mdb relational database.

4.3 Accuracy assessment results

Map accuracies are reported hierarchically in the form of individual contingency tables from broadest classes (woodland, shrubland, and grassland), followed by level 1 and then level 2 map units (tables 6, 7, and 8). At the broadest scale of the physiognomic classes of woodland, shrubland, and grassland, overall accuracy was 93.6% (table 6). While the woodland class, represented by a single level 2 map unit of 7A One-seed Juniper Savanna Woodland Draw, had no errors, it was difficult to assess because of the sparse distribution of trees and the often-narrow delineations that occurred along drainages. Accordingly, the AA point assignments were less conservative than other classes in that when scattered trees were present in or near the plot, the point was considered accurate even when tree cover thresholds fell below 10% (trees were clearly evident when ground photos and the aerial imagery were visually inspected).

The accuracy of the Ruderal class, represented by a single level 2 class (9A), was high. While it is thematically a heterogeneous unit made of many different species and lifeforms, all other possibilities of grassland and shrubland were first eliminated before the assignments to this class were made. Most

Table 6. Accuracy assessment contingency table for the Petroglyph National Monument Vegetation Map at broadest scale of the physiognomic classes of woodland, shrubland, and grassland. We provide the Producers' and Users' accuracies with 10% confidence intervals where n = number of sampling points per class used to calculate "% Correct" by class. Also presented is the overall accuracy based on the total n, and the associated Kappa (KHAT) index.

	Polygon as validated in the field				Users' accuracy				
	Woodland	Shrubland	Grassland	Ruderal	n	% Correct	90% CI	90% CI-	90% CI+
Woodland	10	1			11	0.91	0.19	0.72	1.10
Shrubland		139	17		156	0.89	0.04	0.85	0.94
Grassland		11	280		291	0.96	0.02	0.94	0.98
Ruderal			1	10	11	0.91	0.19	0.72	1.10
n	10	151	298	10	469				
% Correct	100	92	94	100					
90% CI	0.05	0.04	0.02	0.05					
90% CI-	0.95	0.88	0.92	0.95					
90% CI+	1.05	0.96	0.96	1.05					

Overall accuracy = 0.936
Overall 90% CI = 0.020
Overall 90% CI- = 0.916
Overall 90% CI+ = 0.956
K hat = 0.871

errors occurred as cross-classifications between grasslands and shrublands and this carries down through the lower levels described below. Overall, the error rates suggest that accurately detecting shrubs among grasslands continues to be a challenge, particularly with respect to boundary conditions (i.e., when cover ranges between 10% and 25% for shrubs).

At Level 1, the NVCS Group level of the legend hierarchy and the primary target of the accuracy assessment, overall accuracy was 86.8% (83.8 k-hat) for the nine units. With respect to producer accuracies, two fell below the 80% accuracy level—Great Plains Sand Shrublands (2) and Great Plains Shortgrass Prairie (6). Great Plains Sand Shrublands, which are dominated by sand sagebrush (*A. filifolia*), mostly cross-classified with Intermountain Shadscale-Saltbush Scrub, which is dominated by fourwing saltbush (*Atriplex canescens*). However, fourwing saltbush is also known to be a common associate in the sand sagebrush shrublands, so errors are not surprising. In addition, the errors were primarily localized to small patch mesa-top shrublands that were delineated as separate units at Level 2 (2A and 3A in table 8). Hence, with respect to spatial extent, these are not large producer or user errors.

Great Plains Shortgrass Prairie (6), dominated by New Mexico feathergrass (*Hesperostipa neomexicana*), cross-classified with other major grassland Level 1 units—Intermountain Semi-Desert Grassland (7) dominated by galleta grass (*Pleuraphis jamesii*) and Chihuahuan Semi-Desert Grassland dominated by

Table 7. Accuracy assessment contingency table for the Petroglyph National Monument vegetation map at Level 1. We provide the Producers' and Users' accuracies with 10% confidence intervals where n = number of sampling points per class used to calculate "% Correct" by class. Also presented is the overall accuracy based on the total n, and the associated Kappa (KHAT) index. Below the table is a key to various Level 1 classes.

	Polygon as validated in the field									Users' accuracy				
Map unit	1	2	3	4	5	6	7	8	9	n	% Correct	90% CI	90% CI-	90% CI+
1	10				1					11	91	0.19	0.72	1.10
2		16								16	100	0.03	0.97	1.03
3		4	23				1			28	82	0.14	0.68	0.96
4				70			1	15		86	81	0.07	0.74	0.89
5					26					26	100	0.02	0.98	1.02
6			2		2	44		5		53	83	0.09	0.74	0.92
7		1	1			10	92	6		110	84	0.06	0.77	0.90
8			1	4		4	3	116		128	91	0.05	0.86	0.95
9								1	10	11	91	0.19	0.72	1.10
n	10	21	27	74	29	58	97	143	10	469	Overall accuracy	= 0.868		
% Correct	100	76	85	95	90	76	95	81	100		Overall 90% CI	= 0.027		
90% CI	0.05	0.18	0.13	0.05	0.11	0.10	0.04	0.06	0.05		Overall 90% CI-	= 0.841		
90% CI-	0.95	0.59	0.72	0.90	0.79	0.66	0.91	0.75	0.95		Overall 90% CI+	= 0.895		
90% CI+	1.05	0.94	0.98	1.00	1.01	0.86	0.99	0.87	1.05		K hat	= 0.840		

Key to map unit codes

1 Galleta-Black Grama-New Mexico Feathergrass Mesa Grassland

2 Great Plains Sand Shrubland

3 Intermountain Shadscale-Saltbush Scrub

4 Mixed Semi-Desert Shrubland

5 Warm Semi-Desert Shrub & Herb Wash-Arroyo

6 Great Plains Shortgrass Prairie

7 Intermountain Semi-Desert Grassland

8 Chihuahuan Semi-Desert Grassland

9 Non-natural Vegetation and Other Landcover

Table 8. Accuracy assessment contingency table for the Petroglyph National Monument vegetation map at Level 2. We provide the Producers' and Users' accuracies with 10% confidence intervals where n = number of sampling points per class used to calculate "% Correct" by class. Also presented is the overall accuracy based on the total n, and the associated Kappa (KHAT) index. Below the table is a key to various Level 2 classes.

	Polygon as validated in the field												
Map unit #	**1A**	**2A**	**3A**	**3B**	**4A**	**4B**	**5A**	**5B**	**6A**	**6B**	**6C**	**7A**	**7B**
1A	10						1						
2A		16											
3A		4	13									1	
3B				10									
4A					24								
4B						46						1	
5A							15	1					
5B								10					
6A									10				
6B			2				2			26			
6C											8		
7A		1	1						1	9		51	
7B													22
7C													
8A				1									
8B						1							
8C										1			
8D										1		3	
8E					3								
8F									2				
9A													
n	10	21	16	11	27	47	18	11	13	37	8	56	22
% Correct	100	76	81	91	89	98	83	91	77	70	100	91	100
90% CI	0.05	0.18	0.19	0.19	0.12	0.05	0.17	0.19	0.23	0.14	0.06	0.07	0.02
90% CI-	0.95	0.59	0.62	0.72	0.77	0.93	0.66	0.72	0.54	0.57	0.94	0.84	0.98
90% CI+	1.05	0.94	1.00	1.10	1.01	1.02	1.01	1.10	1.00	0.84	1.06	0.98	1.02

Key to map unit codes

1A Oneseed Juniper Savanna Woodland Draw

2A Sand Sagebrush Mesa Shrubland

3A Fourwing Saltbush Mesa Shrubland

3B Fourwing Saltbush Foothilll-Volcano Shrubland

4A Fourwing Saltbush-Sand Sagebrush-Lava Cliff Shrubland

4B Sand Sagebush-Broom Dalea-Fourwing Saltbush Sand Shrubland

5A Apache Plume-Sand Sagebrush Dry Wash Shrubland

5B Desert Willow-Sand Sagebrush Dry Wash Shrubland

6A New Mexico Feathergrass-Black Grama Gravelly Grassland

6B New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland

Table 8 *continued*

Polygons as validated in the field								Users' accuracy				
7C	**8A**	**8B**	**8C**	**8D**	**8E**	**8F**	**9A**	**n**	**% correct**	**90% CI**	**90% CI-**	**90% CI+**
								11	0.91	0.19	0.72	1.10
								16	1.00	0.03	0.97	1.03
								18	0.72	0.20	0.52	0.92
								10	1.00	0.05	0.95	1.05
		1			12			37	0.65	0.14	0.51	0.79
		1				1		49	0.94	0.07	0.87	1.01
								16	0.94	0.13	0.81	1.07
								10	1.00	0.05	0.95	1.05
			1			4		15	0.67	0.23	0.43	0.90
								30	0.87	0.12	0.75	0.99
								8	1.00	0.06	0.94	1.06
1	1		1	3				69	0.74	0.09	0.64	0.83
			1					23	0.96	0.09	0.86	1.05
18								18	1.00	0.03	0.97	1.03
	22				1			24	0.92	0.11	0.80	1.03
		12						13	0.92	0.16	0.76	1.08
			7					8	0.88	0.25	0.62	1.13
				34				38	0.89	0.10	0.80	0.99
					23			26	0.88	0.12	0.76	1.01
						17		19	0.89	0.14	0.75	1.04
		1					10	11	0.91	0.19	0.72	1.10
19	23	15	10	37	36	22	10	469				
95	96	80	70	92	64	77	100		Overall accuracy =			0.861
0.11	0.09	0.20	0.29	0.09	0.15	0.17	0.05		Overall 90% CI =			0.027
0.84	0.86	0.60	0.41	0.83	0.49	0.60	0.95		Overall 90% CI- =			0.834
1.06	1.05	1.00	0.99	1.01	0.78	0.94	1.05		Overall 90% CI+ =			0.889
									K hat =			0.852

6C New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland with Juniper

7A Galleta-Black Grama-New Mexico Feathergrass Mesa Grassland

7B Galleta-Sand Dropseed Mesa Grassland

7C Galleta-Burrograss Mesa Swale Grassland

8A Black Grama-Bigelow Sage Foothill-Volcano Grassland

8B Sand Dropseed-Mixed Grass Sand Grassland

8C Black Grama-Sand Dropseed Mesa Grassland

8D Black Grama-Sand Dropseed Mesa Grassland

8E Black Grama-Bush Muhly-Streambed Bristlegrass Lava Cliff Grassland

8F Black Grama-Sparse Vegetation Gravelly Foothill Grassland

9A Disturbed Ground-Ruderal Vegetation

black grama (*Bouteloua eriopoda*). While galleta was not considered to be an element of Great Plains Shortgrass Prairie (6), New Mexico feathergrass was included in Intermountain Semi-Desert Grassland (7) via a single mixed association: *Hesperostipa neomexicana - Pleuraphis jamesii* Herbaceous Vegetation in map unit 7A (table 10). Given that most of the errors were associated with 7A, this mixed association may explain the errors to some extent. Upon inspection, misclassified points, at least qualitatively, seem to be associated with mixed spectral signatures. The cross-classification with Chihuahuan Semi-Desert Grassland was also not surprising since black grama is found ubiquitously across the park grasslands and the qualitative spectral signature differences with New Mexico feathergrass are more subtle than that with galleta.

At Level 2, while overall accuracy was acceptable (86.1% ; 85.2 KHAT), some localized errors occurred. For example, New Mexico Feathergrass-Black Grama Gravelly Grassland (6A) and Black Grama-Sparse Vegetation Gravelly Foothill Grassland (8F) tended to cross-classify. These two units are intermixed along the southern boundary of park on the Ceja formation of old ancient sediments, and are primarily differentiated based on the presence or absence of New Mexico feathergrass, which, as stated above, is not easily differentiated spectrally from black grama. Despite the error rates, we would suggest keeping the units, and as better imagery becomes available, update the map accordingly. Another problematic unit was Black Grama-Bush Muhly-Streambed Bristlegrass Lava Cliff Grassland (8E). These grasslands of the lava flow escarpment rocklands were difficult to distinguish spectrally from the adjacent Fourwing Saltbush-Sand Sagebrush-Lava Cliff Shrubland (4A), particularly where a significant amount of blown sand had accumulated against the cliffs creating a bright spectral response but where there was little or no herbaceous cover. Again, this will likely be resolved with higher resolution imagery in the future, and we recommend that the escarpment units be retained.

5 Literature cited

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Appendix A: Natural Heritage New Mexico Vegetation Survey Handbook

We used the methods and datasheets from the Natural Heritage New Mexico Vegetation Survey Handbook during the collection of all vegetation plot data during the Bandelier National Monument Vegetation mapping project. This appendix contains the handbook and associated datasheets. The handbook is the 2008 version; no significant changes were made to the protocol during the life of the project.

Vegetation Survey Handbook

Natural Heritage New Mexico

Department of Biology, University of New Mexico

Plot Establishment Guidelines and Techniques (May 2002)

Locating a plot

How plots are located varies with the survey/experimental design. For mapping/classification purposes where the intent is to place a plot in a stand of homogeneous vegetation, aerial photos and/or field reconnaissance generally determine where a plot is going to be established. Plots should be allocated to cover the range of variation in a study area (with the help of soils/geology and topographic maps i.e. gradsect sampling), but for logistical purposes this usually still entails landscape cluster sampling by a team usually in a small target watershed with a variety of habitats and vegetation types (but clusters should be widely separated). Where a map/photo is available, plot locations can be determined beforehand with prescribed UTM locations (often used in map validation) and navigated to with a GPS.

Plot size and design

NHNM standard plots (STP) are typically 400 sq. meters and either circular with an 11.3 m radius or square and 20 m on a side. These are the typical dimension for a forest or closed woodland. They can vary in dimension depending on the vegetation type. For riparian types, long and narrow (10 x 40 m) plots, fitted into the linear structure of a river bar or terrace is a common design. In large, for open savanna or grassland types, the plots may need to be larger (50 x 50 m or more) to capture tree numbers successfully and sub-sampled to determine shrub/herbaceous cover. This sub-sampling is done with a series of 40, 1 m quadrat frames or a set of 3 to 5, 10 x 10 m quadrats in which species covers are estimated and then averaged. For small patch communities, i.e. vegetation around a spring or a cryptogam community, the plot size may be as small as a 10 x 10 by itself or even a single quadrat frame in the latter case. Use a cloth tape or a self winding "Spencer" tape to measure the boundaries.

Plot Types

Relevé plots (RP) are established in the same way as standard plots, but the species list includes species from the surrounding stand (homogeneous area). Both standard and relevé plots include an in depth floristic analysis that not only allows for community classification, but also provides species richness and diversity.

Quick plots (QP) are generally used for vegetation mapping ground control or rapid assessment. They are the same size as standard plots but only the dominant and most common species are recorded in each strata along with their abundance and total cover for the strata to ensure proper identification of the type to the plant association level. Site info includes as a minimum the GPS location, one photo showing the general character of the site, along with a brief description of the site. Other attributes may be included depending on the project.

Observation points (OPT) contain mostly qualitative data on an occurrence, including: location and community type, which may or may not include photos. These points are generally used as supplemental points for vegetation mapping or to record the location of other element occurrences.

Monitoring plots are variable, but the general design is two parallel 30 m transects spaced 5 m apart within a 13.3 x 30 m macroplot (400 sq. meters). 1 m quadrat frames are placed at every third meter and cover estimated to the nearest 1% class and the median height measured to the nearest 1 cm. Since the exact spot is re-measured over time, the tapes must drawn tight, through shrubs not around¸ and as near the ground as possible. The quads should be aligned along one side of the tape with the inside of the corner of the frame at the position mark on the tape. Precision is key to good data in monitoring, particularly grasslands.

Along each line, 150 point intercepts are read for basal cover (intercept at ground level) at every 20 cm, starting from a different random location on the line for each monitoring session.

Quadrat framing and point intercept are the most precise methods and other ocular estimates of cover must be calibrated to them (plot cover estimated using scalars).

Monumenting a plot

Typically, the plot will be monumented in the center of a circular or square plot; or sometimes at the corners of square or rectangular plots, or if there are transects such as in a monitoring plot, at each end of a transect. Monuments are usually 3/8“ rebar driven 0.5 m or more into the ground to ensure stability. They can extend anywhere from 5 cm to 1 meter above the surface depending on the circumstances. Where aesthetics is not an issue and for ease of relocation, the rebar should be covered with ½ inch PVC pipe that can act as visible extensions of the rebar. The rebar should be tagged with permanent steel tags that are wired near the base with baling wire or similar gauge. Where possible, have the tag flush with the ground.

Photo points

The intensity of photo documentation varies with the purpose of the project. At a minimum, there should be a single photo taken from above the center monument stake in a direction that best encompasses the character of the plot. Additional photos can be taken at 90 degree angles from each other around the central monument, or in the case of transects, from either end looking back along the line. Record the azimuth/direction of the photo and the focal length of lens being used. Photos taken off monuments back at the plot or at elements of special interest are not normally considered for repeat photography. For analysis, it helps to have a photo taken from off of the plot looking back to get an overview of the composition and structure.

Instructions and Forms

General Plot Description

(General Plot Desc. Form 2 or Standard Form - Page 1)

PLOT ID: (seven character alphanumeric code). **[Required]**

This is the master NMNHP record identification number for all sampling at the site. All subsequent sampling or other independent data at the site will be tied to this number. It must be unique and is formatted as follows:

Record in order: the year (2 digits), the first and second initial of lead surveyor as designated under the Surveyors field (2 characters) or the assignment as designated for the project (2 characters), and the plot ascension number (3 digits).

Example (lead surveyor): The 33rd plot sampled in 1991 by Hank Gleason would be entered as 91HG033.

Example (project assignment): The 54th plot sampled in 2003 at Bandelier would be entered as 03BD054.

Monitoring data are assigned sub-record monitoring numbers under the PLOT ID, as are any quadrat sample

numbers.

PLOT TYPE: [Required]

RP = Relevé or Reconnaissance plot. Full species list of both plot and stand are recorded and their abundance estimated, may also include Element Quality Ranking using the ranking form.

STP = Standard plot where all species within the plot are recorded and their abundance estimated, and enough site information to provisionally rank the quality of the occurrence.

QP = Quick plot where only the dominant and most common species recorded with their abundance to ensure proper identification of the type, and enough site information to provisionally rank the quality of the occurrence.

OPT = Observation point with mostly qualitative data on an occurrence, including: dominant species recorded with their abundance, location, community type and size; and at least one photos.

AP = Analytical plot. Full species list of both plot and stand with sub-sampling of abundance (usually quadrat based). May include Element Quality Ranking using the ranking form.

OVP = Observation video plot; community type or size is interpreted from either video or aerial photography.

OSP = Observation scope plot is used for surveys of plants growing on steep cliff faces that are otherwise inaccessible.

FSP = Floristic survey plot is used for general plant inventories when site information is not required and location encompasses an area greater than a standard size plot. Quantitative data is not recorded.

PROJECT: Project code— for example: LANL98. If no code is available, enter temporary project designation. **[Required]**

SUBPROJECT: Subproject code if applicable

MO DATE YEAR: Two digit month, day and year numbers. **[Required]**

EO/PA: Plant Association (community type) to which vegetation data refers to. Use six (seven) letter species acronyms. For example: PINPON/QUEGAM. Whoever makes the CT determination must date and initial the designation. Refer to the NMNHP vegetation classification for current types and acronyms. If the type does not appear to match any on the list, assign a temporary name and indicate your reasoning behind the assignment in the **PA COMMENT** field. If you are uncertain about what to call it, enter **UNCLASS**.

EO/PA Comment: Comments on plant association designation. Indicate whether it was assigned in the field or in the office; was vegetation key used or an analysis of the quantitative data etc. If you assigned a new acronym, indicate your reasons for the designation and any specific decision rules you have developed. If CT is questionable, make notes concerning the problem.

FIELD POINT ID: Alphanumeric code for GPS point assigned on field maps from GIS for plot location target (this is an approximate location based on imagery and should be evaluated for stand consistency prior to plot placement).

SURVEY SITE: Name assigned to the plot site at the time it is sampled, or the name of the site on a Survey Site form if it had been previously surveyed.

Naming guidelines:

1. Do not use element names in the site name
2. Use local place names when available or features on topographic maps.
3. Avoid names that are too generalized such as “Spring Site” or “Flat Top Mountain.” Good examples: “Lower Big Gyp Mountain East”, “Animas Canyon Main Spring”
4. Avoid using temporary GIS-based designations such as “Site 6b” or “polygon 41”

SURVEYORS: Last names and initial of first name of sampling personnel, l**ed by the person responsible for botanical determinations.**

LOCATION/ DIRECTIONS: Provide a brief description or place name that further defines where the survey site is located, so that a person reading the plot does not have to reference a map to know approximately where the site is, e.g., “the upper north slope of Freelove Canyon.” Give the directions as necessary to ensure that the plot can be relocated with ease, as needed. Directions to remote areas can be given as arrow marked routes on a topo map, or by a sketch on the back of the form. Indicate if the route is marked on the back or on a topo map.

COUNTY and STATE: Abbreviations. (NMNHP code for the county assigned when entered into Biological Conservation Database – BCD).

MAP NAME: Map used to locate and mark plot, usually the USGS 7.5’ topographic quadrangle map name. If duplicate maps are used, indicate by adding 1, 2, 3 etc. at end of map name.

MARGNUM: Margin number on the field map associated with the mapped plot position. Each plot position within the map is marked with a dot and associated margin number. The margin number for the plot is also placed along the margin of the topographic map. Associated with each margin number is a margin note indicating the PlotID, CT acronym and, in parentheses, the 10,10 (described below).

10,10: The 10,10 is an imaginary grid over the topo map, (10 cells across and 10 cells down) to facilitate locating the dot at a later time on the map. For example, (5,6) indicates 5 cells across from left to right and 6 cells down from top to bottom. This would be almost half way across the map, and more than half way down.

GPS Unit: Write name and number of GPS unit used, such as: Garmin 1, 2, 3, etc. or Trimble 221230 (UNM Number).

GPS File: List the name of the file, either default point assigned by unit or name designated by user.

UTM: Enter **Easting** and **Northing** UTM coordinates and **Zone**. Datum as either **NAD27** or **WGS84**. If something else was used, please indicate such in the comment field.

PREC (PRECISION): +/- meters from GPS unit:

MONUMENT: If plot is permanently marked, indicate with what (rebar, PVC, etc.), where it is located (such as center of plot), and height of marker (note whether ft or m). Indicate if it was used as a photo point.

PHOTO PT.: Check off if there are plot photos. Indicate if there is a permanent photo point established and describe its location, e.g., “over the plot monument” or elsewhere and how it is monumented for repeat photography. Indicate the height of the camera (**CAM Ht**) from the surface of the ground to the mid-point of the lens.

LOG #: Indicate name or number assigned to the photo log. Check box for either digital or film pictures (D☐/ F☐).

PHOTOGRAPHER: record the initials of the person taking the photographs

PP1 – PP8: Photo points: Indicate each photo taken of, or from the plot, with indication of direction (**AZM**), focal length (**FocLen**) and subject (**Notes**). e.g., "looking N across entire plot" or "looking to the western horizon towards the Tularosa Basin." Photos should have plot numbers, date and project name on a chalk board, flip pad or something similar, and a reference to show scale, but preferably not people (at least not in the center of the picture). High precision repeat photo points should be done on a tripod and the height indicated along with the focal length of shot.

OTHER SITE PHOTOS: indicate if other photos were taken of the PA and surrounding landscape.

ELEV: Elevation *in feet* unless otherwise noted.

SLOPE %: Enter the angle of the slope on which the plot occurs in percent slope.

ASPECT: Enter the *azimuth (0-360 degrees)* of the slope aspect on which the plot occurs.

SLOPE SHAPE: Enter one of the following codes to indicate the vertical shape of the slope on which the plot lies.

- S straight or even
- R rounded or convex
- D depression or concave
- P patterned (micro relief of hummocks and swales)
- U undulating pattern or low ridges or knolls and draws
- X – other, explain in landform comments section.

LANDFORM: (six number code). Enter the landform name (or describe it as best you can in the comments field below) and the code as classified in the NMNHP Landform Classification Handout.

LANDFORM/GEOLOGY/SOIL COMMENTS: Additional comments of landforms and rock types in the EO and surrounding landscape and comments on soils including soil texture by feel using standard SCS techniques and the soil triangle and/or evidence of dune formation and/or erosion.

SITE /VEG SUMMARY: Is a description (a "word picture") of the site and community sampled. Indicate stand dominants, the structure and physiognomy of the community along with a landscape position and site features narrative (including geomorphology, soils and geology). Indicate successional status if known (e.g. climax (old growth); young second growth). Reserve other condition comments for Condition section below. Use clear, complete sentences and avoid extraneous personal comments that do not belong in a scientific database (no jokes please or comments in bad taste; these plots are long-term records that will be read again and again in the future).

Adjacent Communities: Indicate surrounding plant associations and the spatial relationships (e.g. the occurrence is a matrix community with other smaller patch communities within it, or vice versa). Indicate the width and nature of ecotones to other communities.

Disease/exotics: Dwarf mistletoe damage (give a rating of average % extent spread of within and among trees); insect damage (SPRUCE BUDWORM); fungal rot and rusts.

Animal use evidence: Wildlife browse damage, sightings and sign (bird calls, tracks, scat and animal disturbances such as beaver dens, gopher holes etc., and remember the insects).

Condition (Disturbance, Fragmentation, Erosion): Describe disturbances both natural and otherwise, their extent, intensity and time frame: livestock grazing utilization and impacts; roads, number and distance from; logging

and fuelwood cutting; buildings and obstructions; and fires, floods, landslides, significant recent erosion features, etc. Estimate frequency and degree of disturbance (light, moderate, heavy, etc.). Indicate degree of element fragmentation, i.e., reduced patch size and corridors, and other watershed -level impacts (dams, parking lots, settlements).

Distance: If relevant, note the distance in kilometers to the nearest human disturbance such as roads, dams, clear-cut, housing mine dump, etc.).

On the Standard Data Form the summary description is condensed space wise, but should include the above information from Site/Veg Summary to Distance.

SURFACE ROCK TYPE: Enter the code for the dominant surface rock type:

Igneous

ANDE	andesite
BASA	basalt (including obsidian)
DIGA	diorite to gabbro
GRBG	granite and biotite granite
IFAL	igneous felsic(acid) alluvium
IGTU	igneous type unknown
IMAL	igneous mafic(basic) alluvium
LATI	latite
MIIG	mixed igneous
PUMI	pumice
QUMO	quartz monzonite
RHYO	rhyolite
SCOR	scoria (porcelanite), clinker
TRSY	trachyte and syenite
WETU	welded tuff (tufa)

Metamorphic

ARGI	argilliate
BISC	biotite schist
CAAR	calcareous argillite
GNBG	gneiss and biotite gneiss
MEAL -	metamorphic alluvium
METU	type unknown
MIME -	mixed metamorphic
MISC	mica schist
PHYL	phyllite
QUAR	quartzite
SCHI	schist
SILI	siltite
SLAT	slate

Sedimentary

CACO	calcareous conglomerate
CASA	calcareous sandstone
CASH	calcareous shale

CASI	calcareous siltstone
CLAY	claystone
CONG	conglomerate
DOLO	dolomite
LIME	limestone
MISE	mixed sedimentary
MUDS	mudstone
RESH	red shale
SAND	sandstone
SCAL	sedimentary calcareous alluvium
SETU	type unknown
SHAL	shale
SILT	siltstone
SNCA	sedimentary non-calcareous alluvium

Miscellaneous

ASHT	ash (of any origin)
CLAL	clayey alluvium
DUNE	sand dunes
GLTI	glacial till, mixed origin
GRAL	gravelly alluvium
GYPS	gypsum
LOES	loess
MIAL	mixed alluvium (full range of textures)
MIRT	mix of two or more rock types
NONE	no surface rocks
NORE	not recorded
SAAL	sandy alluvium
SIAL	silty alluvium

PLOTDIM(m): Plot size and shape entered in meters.

L/R: Plot Radius or Length enter plot radius (for circular plots) or length (for rectangular plots). Indicate units of measurement. Note: a 400 m squared plot has a radius of 11.3 m (37.1 ft); a 100 m squared plot has a radius of 5.6 m (18.5 ft)

PLOT W: Enter width if a rectangular plot shape is used. Enter 0 (numeric) if a circular plot shape is used. Indicate units of measurement

OCC SIZE: (hectares/acres). Occurrence or total stand size surrounding the plot. Indicate if the area was estimated on the ground or from a map. This information is very important for accurate mapping.

EO/PA MAPPED: indicate whether or not the EO boundaries were mapped on an aerial photo, topo map, or sketched on the back of the form. **List number(s) of aerial photos used.** Use sketch maps to help explain relationship among stands and plots in the area as necessary. A solid line indicates an actual boundary and a **dashed** line indicates a boundary of unknown extent.

MANAGEMENT/CONSERVATION/ OTHER COMMENTS: Comment on any stewardship (new or additional) needed to ensure continued existence of the community occurrence, and chances (and means) of bring-

ing it about. Any other pertinent comments go here as well, e.g., "... clearing of competing vegetation has been tried in the past but without success". Comment on the conservation attributes of the occurrence, long-term viability and threats. Also, add miscellaneous comments from all sections. Again, no jokes please or comments in bad taste.

FORMS CHECKOFF: please indicate if other forms were used besides those given.

Forms: ☐ Floristics ☐ Trees ☐ Soils ☐ Quadrats ☐ Point/Line Intercept ☐ EO Assessment ☐ Site Evaluation

Floristic Inventory (Form 3)

PLOT ID: (seven character alphanumeric code). NMNHP standard record tracking number (see general description Form 2).

BOTANIST: Name of person responsible for assessing the botany.

DATE: Date of vegetation inventory. Two-digit month, day and year numbers.

GROUND SURFACE: Enter % cover fraction for each of the following types of cover as they occur over the surface of the plot (must add up to 100%).

- S exposed soil: particles < 1/16 in. (2 mm dia.)
- G – gravel: particles 1/16 to 3 in. dia. (2 mm to 7.5 cm dia.)
- R rock as composed of cobbles, stones and bed rock: particles > 3 in. (>7.5 cm dia.)
- L litter and duff. Litter includes dead and detached vegetation, freshly fallen leaves, needles, twigs < 2 in. (5 cm), bark, fruits, seeds; duff is decomposed litter (fermentation layer and humus layer)
- HCC – herbaceous canopy cover is the total combined canopy cover of forbs and graminoids, including attached litter and current years standing dead annuals, and does not include overlapping cover where canopies interlock
- WO – woody, downed debris: > 2 in. (5 cm dia.)
- M microphytic (cryptogams) crust cover; mosses, lichens and algae on soil surface (excludes cover found on logs, rocks and tree bases)
- WA – water, standing pools of water or streams if within the plot.

VEGETATION COMPOSITION AND ABUNDANCE CONVENTIONS: All species within the plot **and/or** in the stand, depending on plot type, are listed by Strata/lifeform categories (See the NMNHP species list for lifeform classification of individual species).

SPECIES NAME: Use the accepted acronyms from the current NMNHP species list or spell out the species scientific name. **Do not use common names.** If the species is not on the list, spell it out.

Tree species can occur in several height strata and should be listed separately under different acronyms representing different operating taxonomic units (OTU's). A number is attached to the end of the acronym to indicate which strata the OTU is from. For example: PINPON0 represents Pinus ponderosa seedlings of the forb layer, PINPON1 represents saplings < 1 in. dia. of the dwarf shrub layer, PINPON2 are saplings 1 in to 2 in. dia. of the shrub layer, and PINPON3 are mature trees of the tree layer.

If you do not know the name of a species, but know the genus or family, enter those acronyms or spell out the name. Otherwise indicate unknowns with the code UNIDT for unknown trees; UNIDS for unknown shrubs; UNIDDS for dwarf shrub, etc. for each different unknown species with in the different lifeforms. The

species ID number will differentiate them.

SPECIES ID NUMBER: Each species that is listed has a line number on the form associated with it by strata/life-form (T1, S3, G10, F20, etc.). Blank species number lines are available on the forb side of the form for additions: grasses, shrubs, and trees. **Circle the species number when a voucher has been taken for that species.**

Ht: Modal height of each species to the nearest meter for trees, nearest half meter for shrubs, and decimeter for grasses and forbs, but measured in meters. For example a 3dm high grass would be recorded on the data sheet as 0.3m.

P: Phenology. Use "*" for flowering or "@" for fruiting; "X" if it is a dead annual; and leave blank if vegetative.

VOUCHERS: When a voucher specimen is taken for species identification, the species ID number ***MUST BE CIRCLED*** on the plot sheet, and the plot number and species number put on the plant tag or collection sheet of the voucher.

Voucher Tag Format:

Plot ID	05YC001
Date	3/30/05
Species ID#	G5
Project	BAND-Val

If an unknown species from a previous data form is referred to on the current data sheet, **be sure the plot and species ID numbers** that the plant refers to are recorded on the current data sheet and the species ID number is **circled**. For example if you're at plot 05YC001 and you collect UNIDG5 (G5 should be circled on this plot form), then at plot 05YC004 you have the same unknown grass that is the 2nd grass on this data form; **circle G2** and write **05YC001-G5** after the species ID number. **If you know the genus or family, enter those acronyms or spell out the name** before the plot ID number.

Data sheet from 05YC004:

|G1_MUHMON_____ _____|_@|_20_|__.4||___ _____|__|____|____||

|G2_BROMUS - 05YC001-G5_____|__|___5|__.2||___ _____|__|____|____||

|G3_____|__|____|____||___ _____|__|____|____||

Circle G2

TREES: usually single bole with lateral branches, and with the potential to grow over 5 m tall (some may be less than 5 m such as various Juniperus spp.). See NMNHP species list for lifeform classification for verification.

SHRUBS: usually multi-stemmed woody species, spiny rosettes or succulents (cacti, yuccas and agave etc.) less than 5 m and greater than 0.5 m.

DWARF SHRUBS: usually multi-stemmed woody species, spiny rosettes and succulents (cacti, yuccas and agave etc.) less than 0.5 m. Small suffrutescent species that are only woody at or near the base or at the root-crown are usually considered forbs, e.g., *Eriogonum*. See the NMNHP species list for lifeform classification.

GRAMINOIDS: grasses and grass-like plants such as sedges and rushes, but not showy flowering monocots such as iris, lily or dayflower (Iridaceae, Liliaceae or Commelineceae).

FORBS: non-woody perennial and annual species that are not grass-like (includes monocots of the Iridaceae, Liliaceae, Commelineceae).

TOTAL COV. (BY STRATA): percent aerial cover for tree, shrub, dwarf shrub, graminoid and forb layers. This

the total canopy cover of a strata as projected over the surface, regardless of species, and does not include overlapping cover where canopies interlock within a strata. ***Note: cover cannot exceed 100%**. For graminoides an additional category is added for **% green** which includes the current years growth (green or tawny), but disregards the standing dead litter (grey).

COV.: percent cover for each species within the plot is estimated by either directly using the precision guidelines below, or the Modified Domin-Krajina scale in Table 1 (both are at the bottom of Floristics-Form 3 and Standard Data Form).

Be sure to check box on data sheet to indicate which cover type is used.

Percent Cover Estimation Precision Guidelines:

+0	species outside the plot, but within the stand
+-	< .05% (trace <0.2 m^2/400 m^2)
0.1%	.05 - < 0.5% (>0.2 m^2 - <2.0 m^2 /400 m^2)
0.5%	.5 - < 1% (>2.0 m^2 - <4.0 m^2 /400 m^2)
1-10%	to the nearest 1% (each % equals 4 m^2/400 m^2)
10-30%	to the nearest 5%
30-100%	to nearest 10%

Table 1. Cover scale. Domin-Krajina cover-abundance scale.

Scalar	Cover range	Concept	Midpoint value	Data value	m^2 / 400m^2
+0	N/A	Outside quadrat	0.001	.001	
+	<0.05%	Solitary or very few	0.025	.025	<.2m^2
1	0.05- 0.124%	very scattered	0.0875	0.1	0.2m^2 - <.5m^2
2	0.125- 0.99%	scattered	0.56	0.5	.5 m^2 - <4 m^2
3	1.0 - 4.9%	common	3.0	3.0	4m^2 - <20m^2
4	5.0 - 9.9%	well-represented			
	7.5	7.5	20m^2 - <40m^2		
5	10.0- 24.9%		17.5	17.5	40m^2 - <100m^2
6	25.0- 32.9%	abundant			
	29.0	29.0	100m^2 - <132m^2		
7	33.0 - 49.9%		41.5	41.5	132m^2 - <200m^2
8	50.0 -74.9%	luxuriant			
	62.5	62.5	200m^2 - < 300m^2		
9	75.0 - 94.9%		85.0	85.0	300m^2 - <380m^2
10	95.0 -100.0%	full cover	97.5	97.5	380m^2 - 400m^2

STANDARD DATA FORM

The Standard Data Form is a combination of the General Plot Description (Form 2) and the Floristic Inventory (Form 3) on a single page, with the data fields in the same order as the previous forms. This form can be used for Standard Plots, Quick Plots, and Observation Points.

STANDARD DATA FORM – Page 2 is a continuation of the floristic inventory portion of the data form when

more space is needed for additional species.

QUICK PLOT/OBSERVATION POINT FORM
This form is a condensed version of the Standard Data Form and has 3 observation points per page.

TREE INVENTORY FORM
In forested plots, the total number of trees is counted by species and size class. For each species and size class the count would be done using a dot/line matrix:

. . One dot is used as each of the four corners and represents one tree.
. . Lines are then used to connect the dots and cross from corner to corner.

 Each line also represents one tree. A complete box =’s 10 trees.

For each species, the size class is divided into three categories. The upper box is a count of the live trees in the stand. The two lower boxes are divided into stumps (which are trees that have been cut) and snags (which are standing dead trees).

TRANSECT POINT INTERCEPT FORM

Element Occurrence Condition Evaluation

The ranking of a plant community element occurrence (EO) within a site focuses on three sets of factors: condition, landscape, and size. These are based on concepts originally developed by the Natural Heritage Network and The Nature Conservancy, and derived from protocols developed by the New Mexico Natural Heritage Program as part of its statewide wetland/riparian assessment project. All factors are weighted based on their importance for evaluating ecosystem function and biodiversity value. These weights vary depending on the type of ecosystem being considered, e.g., riparian communities are weighted strongly on hydrological regime, whereas upland communities may receive more emphasis on fire regime. For the pilot project, weighting specifications were developed for upland plant community occurrences. Where information is lacking for any given variable it is not considered in the ranking process. The overall intent is to create a set of consistent criteria for each element that can be used universally to compare occurrences not just at the local level, but the regional and national as well.

Condition Factors
There are nine condition factors that relate directly to the status of a given element occurrence (Table 1); these factors are usually based on direct field measurements of representative stands within a site. Exotic encroachments are considered to be very important indicators of ecosystem health in riparian systems (10 weight) and moderate indicators in uplands (5 weight). There are separate categories for exotics in the canopy versus the understory because of their differing effects on ecosystem structure and function. Structural diversity and cover reflect changes to the expected natural expression of a community as a function of utilization, e.g., logging and fuelwood removals, grazing, etc. Similarly, species richness is a measure of departure from the norm as a result of disturbance. The measurement of fuel loads speaks to the possibility that a given EO might be adversely affected or catastrophically removed due to human-induced fire hazards (fuel loads might be weighted higher in a non-fire-adapted riparian system than in a fire-adapted upland one). Erosion, although a natural process, can also be accelerated as function of disturbance, but the effect of disturbance will vary from community to community. Streambank conditions apply to wetland/riparian occurrence only. Contaminants range potentially from excess nitrogen from sewage outfalls to radioactive dumps. Lastly, parasites and infestations (insect, fungal or microbial) are perhaps some of the best measures of ecosystem health.

Landscape Context Factors
Beyond immediate impacts, an element occurrence is also subject to landscape-level processes that affect its condition and perhaps more importantly its long-term sustainability. Accordingly, there are seven landscape-level

parameters considered in the ranking process that can be evaluated through a combination of field studies, historical inquiry and GIS-based map analysis. The first three center on the hydrologic regime and pertain primarily to wetland/riparian community assessment. Stream flow changes, lateral stream movement, and channel condition are best addressed through analysis of historical records, monitoring, and field assessment. Analogously, fire patch size and fire frequency can be addressed by a reconstruction of the past record through tree-ring fire-scar evidence and historical photography, as well as current stand structures as they might reflect fire history.

The last two parameters, landscape impact/fragmentation and landscape community diversity and function, can be evaluated to some degree through field studies. However, GIS-based map analysis can be a powerful evaluation tool because it can reveal the pattern and underlying structure of a site and the relationship of any given element to the landscape. This type of analysis requires detailed and accurate spatial information, e.g., good vegetation maps, road and impact coverages, high-resolution digital elevation models, etc.

Size Factor

Because of its importance in ecological assessment, size is considered independently of condition and landscape context. Greater size implies greater buffering against impacts and hence greater stability and long-term viability within the context of the natural dynamics of the ecosystem.

NHNM VEGETATION SURVEY - Standard Data Form – 2008

PLOT ID_____**PLOT TYPE**_____**PROJECT**_____**Subproject** _____ **MO**___**DAY**___**YEAR**_____
EO/PA_____
EO/PA Comment_____
FIELD POINT ID_____**MONUMENT** ☐
_____**MU**_____
SURVEY SITE_____ **SURVEYORS**_____
COUNTY_____ **NM/**____ **MAP NAME**_____ **- __ MARGNUM**___ **10,10** __,__
DIRECTIONS_____
GPS Unit_____ **GPS File**_____ **PREC**____**m UTM:EASTING** __ __ __ __ __ __ **NORTHING** __ __ __ __ __ __ __
Zone_____ **Datum: NAD83** ☐ **/ NAD27** ☐**; Other**_____**; Log#**_____D☐ / F☐ **Photographer**_____
PP1:Exp____**AZM**____**FocL**___ **Notes**_____ **PP3:Exp**____**AZM**____**FocL**___ **Notes**_____
PP2:Exp____**AZM**____**FocL**___ **Notes**_____ **PP4:Exp**____**AZM**____**FocL**___ **Notes**_____
Other Site Photos:_____
ELEV _____**ft., SLOPE** ___**%, ASPECT**____**, SLOPE SHAPE**_____/___**, Surface Rock Type**_____/_____
LANDFORM:_____/ __ __ __ __ __ __
Lndfrm/Geol/Soil Notes:_____
SUMMARY DESCRIPTION: ☐ **Site** ☐ **Veg** ☐ **Adjacent Com** ☐ **Disturb/Frag** ☐ **Animals** ☐ **Disease** ☐ **Management** ☐ **Condition**
_____
_____
_____
_____
_____
_____
_____
_____
PLOTDIM(M)L/R ____**W** ____ **EO Size**_____**Ha**__**/Ac**__ **Est**☐ **Map** ☐ **Condition**____ **Landscape Context**_____ ☐ **EOMapped**:_____
Comments:_____
Ground Surface Cover (%) Soil_____ Grav_____ Rock_____ Litter_____ HCC_____ Wood_____ Micro_____ Water_____=100%
Botanist:_____ ***CIRCLE YOUR VOUCHER NUMBERS***
Phenology: * = Flowering; @ = fruiting; X = dead annual ☐ Cover Scale or ☐ Percent Cover

TREES Total Cov____%	P	Cov	Ht(m)	GRAMINOIDS Tot Cov____%; Green____%	P	Cov	Ht(m)
T1				G1			
T2				G2			
T3				G3			
T4				G4			
T5				G5			
SHRUBS >.5m Total Cov____ %	P	Cov	Ht(m)	G6			
S1				G7			
S2				G8			
S3				FORBS Total Cover____%	P	Cov	Ht(m)
S4				F1			
S5				F2			
S6				F3			
S7				F4			
S8				F5			
DWARF SHRUBS < .5m Tot.Cov____ %	P	Cov	Ht(m)	F6			
DS1				F7			
DS2				F8			
DS3				F9			
DS4				F10			
DS5				F11			
DS6				F12			
DS7				F13			

USGS-NPS Vegetation Mapping Program
Bandelier National Monument

Ht= species modal height (trees nearest m, shrubs nearest .5m, grasses & forbs nearest dm), recorded in meters

Cover: +0=outside plot,in stand **2**=scattered, <1% (.5m^2 & <4m^2) **5**=10-<25%(40m^2 & <100m^2) **8**=50-<75%
Scale **+**=solitary/very few(<0.2m^2/400m^2) **3**=1-<5% (>4m^2 & <20m^2) **6**=25-<33%(100m^2 & <132m^2) **9**=75-<95%
1=very scattered (0.2m^2 -<.5m/400m^2) **4**=5-<10%(>20m^2 & <40m^2) **7**=33-<50% **10**=95-100%

Percent: +0=outside plot,in stand **0.5%**= scattered, <1% (.5m^2 & <4m^2) **30-100%** to nearest 10%
Scale **+**=solitary/very few(<0.2m^2/400m^2) **1-10%** to the nearest 1% (each % equals 4m^2/400m^2)
0.1%=very scattered (0.2m^2 -<.5m/400m^2) **10-30%** to the nearest 5%

☐ **Trees** ☐ **Soils** ☐ **Quadrats** ☐ **Point/Line Intercept** ☐ **EO Assessment Form** ☐ **Site Evaluation**

NHNM VEGETATION SURVEY—GENERAL PLOT DESCRIPTION FORM 2 (2008)

PLOT ID_____**PLOT TYPE**_____**PROJECT**_____**Subproject** _____ **MO**___**DAY**___**YEAR**_____
EO/PA_____
EO/PA Comment_____
FIELD POINT ID_____**MU**_____
SURVEY SITE_____ **SURVEYORS**_____
LOCATION/DIRECTIONS_____
_____
COUNTY_____ **NM/**_____ **MAP NAME**_____ - __
MARGNUM___ **10,10** __,__
GPS Unit_____ **GPS File**_____ **UTM: EASTING** _ _ _ _ _ _ **NORTHING** _ _ _ _ _ _ _
PREC_____ **Zone**_____ **Datum: NAD83** ☐ **/ NAD27** ☐**;**
Other_____
☐ **Monument/:**_____
☐ **Photo Pt:**_____**/Cam Ht**_____ **Log#**___D☐ / F☐ **Photographer**_____
PP1:AZM___**FocL**___**Exp**___**Notes**_____**PP5:AZM**___**FocL**___**Exp**___**Notes**_____
PP2:AZM___**FocL**___**Exp**___**Notes**_____**PP6:AZM**___**FocL**___**Exp**___**Notes**_____
PP3:AZM___**FocL**___**Exp**___**Notes**_____**PP7:AZM**___**FocL**___**Exp**___**Notes**_____
PP4:AZM___**FocL**___**Exp**___**Notes**_____**PP8:AZM**___**FocL**___**Exp**___**Notes**_____
Other Site Photos/com:_____
_____
ELEV _____ **ft. SLOPE** _____**% ASPECT**_____ **SLOPE SHAPE**_____/_____
LANDFORM:_____/ _ _ _ _ _ _
Landform/Geology/Soil Comment_____
_____
SURFACE ROCK TYPE_____/_____
SITE / VEG SUMMARY:_____
_____
_____
_____
_____
_____
_____
_____
Adjacent Communities:_____
_____
_____
_____
Disease:_____
_____
Animal Use Evidence:_____
_____
Condition (Disturbance, Fragmentation, Erosion):_____
_____
_____
_____
_____
Distance in km to nearest human disturbance (roads, dam, clearcut, housing, mine, dump, etc.):_____**km**
Comments:_____
_____

PLOTDIM (m) L/R ____W ____ Comments:_____
_____OCC Size ☐HA ☐AC, ☐ Ground Estimate ☐ Mapped Estimate Comments:_____
_____
☐ EO/PA Mapped:_____
Management/Conservation/Other Comments:_____
_____
Forms: ☐ Floristics ☐ Trees ☐ Soils ☐ Quadrats ☐ Point/Line Intercept ☐ EO Assessment ☐ Site Evaluation

TREE INVENTORY FORM – NHNM 2006

Plot ID:_____ Project_____ Subproject:_____ Surveyors:_____

Date:_____ - _____ - 200___

PLOTDIM (m) L/R ____W ____

Species Code	0-2" <4.5'	0-2" >4.5'	2-4"	4-6"	6-8"	8-10"	10-12"	12-14"	14-16"	16-18"	18-20"	>20"	DRC___ DBH___
													DRC___ DBH___
Stump→													DRC___ DBH___
													DRC___ DBH___
													DRC___ DBH___
													DRC___ DBH___
													DRC___ DBH___
													DRC___ DBH___
													DRC___ DBH___
													DRC___ DBH___
													DRC___ DBH___

Tree Species	DBH (in)	DCH (in)	Core Age	Tree Height (ft)	Comment		Tree Species	DBH (in)	DCH (in)	Core Age	Tree Height (ft)	Comment

DRC = diameter root crown; DBH = diameter breast height; DCH = diameter core height; measure trees > 20”

Appendix B: Petroglyph National Monument Plant Species List

Appendix B provides a list of plant species recorded on vegetation plots at Petroglyph National Monument during the vegetation mapping project, which took place between 2007 and 2011. Plant voucher specimens were collected to confirm field identifications as necessary and are currently housed at the University of New Mexico Herbarium. Natural Heritage New Mexico botanist Yvonne Chauvin identified the specimens to the lowest level possible given the material at hand. Names were assigned according to the PLANTS database (USDA-NRCS 2002) and the Integrated Taxonomic Information System (ITIS). Suitable quality specimens were accessioned with both UNM accession numbers and NPS record numbers tied to the Herbarium and NPS databases. Species are arranged alphabetically by life form and species, along with the common name, plant family, NHNM database acronym, the PLANTS database symbol, and the number of plot observations.

Plant species list for Petroglyph National Monument

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of observations
Tree	*Celtis laevigata* var. *reticulata*	netleaf hackberry	Ulmaceae	CELLAE	CELAR	4
Tree	*Juniperus monosperma*	oneseed juniper	Cupressaceae	JUNMON	JUMO	31
Tree	*Robinia pseudoacacia*	black locust	Fabaceae	ROBPSE	ROPS	1
Tree	*Ulmus pumila*	Siberian elm	Ulmaceae	ULMPUM	ULPU	1
Tall shrub	*Aloysia wrightii*	Wright's beebrush	Verbenaceae	ALOWRI	ALWR	3
Tall shrub	*Artemisia filifolia*	sand sagebrush	Asteraceae	ARTFIL	ARFI2	84
Tall shrub	*Atriplex canescens*	fourwing saltbush	Chenopodiaceae	ATRCAN	ATCA2	138
Tall shrub	*Brickellia californica*	California brickellbush	Asteraceae	BRICAL	BRCA3	5
Tall shrub	*Caesalpinia gilliesii*	bird-of-paradise shrub	Fabaceae	CAEGIL	CAGI	1
Tall shrub	*Chilopsis linearis*	desert willow	Bignoniaceae	CHILIN	CHLI2	9
Tall shrub	*Cylindropuntia imbricata*	tree cholla	Cactaceae	CLYIMB	CYIM2	1
Tall shrub	*Ephedra torreyana*	Torrey's jointfir	Ephedraceae	EPHTOR	EPTO	80
Tall shrub	*Ericameria nauseosa*	rubber rabbitbrush	Asteraceae	ERINAU	ERNA10	10
Tall shrub	*Ericameria nauseosa* var. *bigelovii*	rubber rabbitbrush	Asteraceae	ERINAU	ERNAB2	1
Tall shrub	*Eriogonum effusum*	spreading buckwheat	Polygonaceae	ERIEFF	EREF	4
Tall shrub	*Fallugia paradoxa*	Apacheplume	Rosaceae	FALPAR	FAPA	13
Tall shrub	*Krascheninnikovia lanata*	winterfat	Chenopodiaceae	KRALAN2	KRLA2	147
Tall shrub	*Lorandersonia pulchella*	southwestern rabbitbrush	Asteraceae	LORPUL	CHPU4	2
Tall shrub	*Lycium pallidum*	pale wolfberry	Solanaceae	LYCPAL	LYPA	5
Tall shrub	*Psorothamnus scoparius*	broom dalea	Fabaceae	PSOSCO	PSSC6	42
Tall Shrub	*Rhus microphylla*	littleleaf sumac	Anacardiaceae	RHUMIC	RHMI3	
Tall shrub	*Rhus trilobata*	skunkbush sumac	Anacardiaceae	RHUTRI	RHTR	4
Tall shrub	*Ribes cereum*	wax currant	Grossulariaceae	RIBCER	RICE	1
Tall shrub	*Yucca baileyi* var. *intermedia*	intermediate yucca	Agavaceae	YUCBAI	YUBAI	39
Tall shrub	*Yucca glauca*	soapweed yucca	Agavaceae	YUCGLA	YUGL	2
Dwarf shrub	*Artemisia bigelovii*	Bigelow's sagebrush	Asteraceae	ARTBIG	ARBI3	30
Dwarf shrub	*Artemisia frigida*	fringed sagewort	Asteraceae	ARTFRI	ARFR4	2
Dwarf shrub	*Dalea formosa*	featherplume	Fabaceae	DALFOR	DAFO	21

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of observations
Dwarf shrub	*Echinocereus fendleri*	pinkflower hedgehog cactus	Cactaceae	ECHFEN	ECFE	1
Dwarf shrub	*Echinocereus fendleri* var. *fendleri*	Fendler's hedgehog cactus	Cactaceae	ECHFEN	ECFEF2	2
Dwarf shrub	*Escobaria vivipara*	spinystar	Cactaceae	ESCVIV	ESVI2	7
Dwarf shrub	*Grusonia clavata*	club cholla	Cactaceae	GRUCLA	GRCL	23
Dwarf shrub	*Gutierrezia sarothrae*	broom snakeweed	Asteraceae	GUTSAR	GUSA2	258
Dwarf shrub	*Opuntia erinacea*	grizzlybear pricklypear	Cactaceae	OPUERI	OPER	1
Dwarf shrub	*Opuntia phaeacantha*	tulip pricklypear	Cactaceae	OPUPHA	OPPH	69
Dwarf shrub	*Opuntia polyacantha*	plains pricklypear	Cactaceae	OPUPOL	OPPO	130
Dwarf shrub	*Parthenium incanum*	mariola	Asteraceae	PARINC	PAIN2	2
Dwarf shrub	*Penstemon ambiguus*	gilia beardtongue	Scrophulariaceae	PENAMB	PEAM	3
Dwarf shrub	*Thymophylla acerosa*	pricklyleaf dogweed	Asteraceae	THYACE	THAC	6
Graminoid	*Achnatherum hymenoides*	Indian ricegrass	Poaceae	ACHHYM	ACHY	82
Graminoid	*Aristida adscensionis*	sixweeks threeawn	Poaceae	ARIADS	ARAD	1
Graminoid	*Aristida divaricata*	poverty threeawn	Poaceae	ARIDIV	ARDI5	5
Graminoid	*Aristida purpurea*	purple threeawn	Poaceae	ARIPUR	ARPU9	110
Graminoid	*Aristida purpurea* var. *fendleriana*	Fendler's threeawn	Poaceae	ARIPUR	ARPUF	1
Graminoid	*Bothriochloa laguroides* ssp. *torreyana*	silver beardgrass	Poaceae	BOTLAG	BOLAT	2
Graminoid	*Bouteloua aristidoides*	needle grama	Poaceae	BOUARI	BOAR	1
Graminoid	*Bouteloua barbata*	sixweeks grama	Poaceae	BOUBAR	BOBA2	24
Graminoid	*Bouteloua curtipendula*	sideoats grama	Poaceae	BOUCUR	BOCU	8
Graminoid	*Bouteloua curtipendula* var. *curtipendula*	sideoats grama	Poaceae	BOUCUR	BOCUC2	1
Graminoid	*Bouteloua eriopoda*	black grama	Poaceae	BOUERI	BOER4	205
Graminoid	*Bouteloua gracilis*	blue grama	Poaceae	BOUGRA	BOGR2	22
Graminoid	*Bouteloua* spp.	grama	Poaceae	BOUTEL	BOUTE	1
Graminoid	*Bromus tectorum*	cheatgrass	Poaceae	BROTEC	BRTE	3
Graminoid	*Dasyochloa pulchella*	fluffgrass	Poaceae	DASPUL	DAPU7	44
Graminoid	*Elymus elymoides*	bottlebrush squirreltail	Poaceae	ELYELY	ELEL5	48
Graminoid	*Enneapogon desvauxii*	nineawn pappusgrass	Poaceae	ENNDES	ENDE	5
Graminoid	*Eragrostis cilianensis*	stinkgrass	Poaceae	ERACIL	ERCI	1
Graminoid	*Hesperostipa neomexicana*	New Mexico needlegrass	Poaceae	HESNEO	HENE5	144
Graminoid	*Lycurus setosus*	bristly wolfstail	Poaceae	LYCSET	LYSE3	1
Graminoid	*Muhlenbergia arenacea*	ear muhly	Poaceae	MUHARE	MUAR	2
Graminoid	*Muhlenbergia arenicola*	sand muhly	Poaceae	MUHARE2	MUAR2	23
Graminoid	*Muhlenbergia porteri*	bush muhly	Poaceae	MUHPOR	MUPO2	50
Graminoid	*Muhlenbergia torreyi*	ring muhly	Poaceae	MUHTOR	MUTO2	8

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of observations
Graminoid	*Munroa squarrosa*	false buffalograss	Poaceae	MUNSQU	MOSQ	22
Graminoid	*Panicum miliaceum*	broomcorn millet	Poaceae	PANMIL	PAMI2	1
Graminoid	*Panicum obtusum*	vine mesquite	Poaceae	PANOBT	PAOB	1
Graminoid	*Pleuraphis jamesii*	galleta	Poaceae	PLEJAM	PLJA	177
Graminoid	*Scleropogon brevifolius*	burrograss	Poaceae	SCLBRE	SCBR2	14
Graminoid	*Setaria leucopila*	streambed bristlegrass	Poaceae	SETLEU	SELE6	24
Graminoid	*Sporobolus airoides*	alkali sacaton	Poaceae	SPOAIR	SPAI	2
Graminoid	*Sporobolus contractus*	spike dropseed	Poaceae	SPOCON	SPCO4	17
Graminoid	*Sporobolus cryptandrus*	sand dropseed	Poaceae	SPOCRY	SPCR	213
Graminoid	*Sporobolus flexuosus*	mesa dropseed	Poaceae	SPOFLE	SPFL2	74
Graminoid	*Sporobolus giganteus*	giant dropseed	Poaceae	SPOGIG	SPGI	1
Graminoid	*Tragus berteronianus*	spiked burr grass	Poaceae	TRABER	TRBE	1
Graminoid	*Vulpia octoflora*	sixweeks fescue	Poaceae	VULOCT	VUOC	3
Graminoid	*Vulpia octoflora* var. *octoflora*	sixweeks fescue	Poaceae	VULOCT	VUOCO	1
Forb	*Abutilon parvulum*	dwarf Indian mallow	Malvaceae	ABUPAR	ABPA3	2
Forb	*Acourtia nana*	desert holly	Asteraceae	ACONAN	ACNA2	2
Forb	*Allionia choisyi*	annual windmills	Nyctaginaceae	ALLCHO	ALCH	1
Forb	*Allionia incarnata*	trailing windmills	Nyctaginaceae	ALLINC	ALIN	14
Forb	*Amaranthus acanthochiton*	greenstripe	Amaranthaceae	AMAACA	AMAC	1
Forb	*Amaranthus torreyi*	Torrey's amaranthus	Amaranthaceae	AMATOR	AMTO6	1
Forb	*Ambrosia acanthicarpa*	flatspine burr ragweed	Asteraceae	AMBACA	AMAC2	1
Forb	*Aphanostephus ramosissimus*	plains dozedaisy	Asteraceae	APHRAM	APRA	2
Forb	*Aphanostephus ramosissimus* var. *humilis*	plains dozedaisy	Asteraceae	APHRAM	APRAH	1
Forb	*Artemisia ludoviciana*	white sagebrush	Asteraceae	ARTLUD	ARLU	9
Forb	*Artemisia ludoviciana* ssp. *albula*	white sagebrush	Asteraceae	ARTLUD	ARLUA	1
Forb	*Astragalus amphioxys*	Crescent milkvetch	Fabaceae	ASTAMP	ASAM5	1
Forb	*Astragalus amphioxys* var. *amphioxys*	Crescent milkvetch	Fabaceae	ASTAMP	ASAMA	2
Forb	*Astragalus lentiginosus* var. *diphysus*	freckled milkvetch	Fabaceae	ASTLEN	ASLED	18
Forb	*Astragalus nuttallianus*	smallflowered milkvetch	Fabaceae	ASTNUT	ASNU4	89
Forb	*Bahia absinthifolia*	hairyseed bahia	Asteraceae	BAHABS	BAAB	1
Forb	*Bahia pedata*	bluntscale bahia	Asteraceae	BAHPED	BAPE	6
Forb	*Baileya multiradiata*	desert marigold	Asteraceae	BAIMUL	BAMU	12
Forb	*Boerhavia spicata*	creeping spiderling	Nyctaginaceae	BOESPI	BOSP	6
Forb	*Brassicaceae*	mustard family	Brassicaceae	BRASSI2	BRASSI	1
Forb	*Chaetopappa ericoides*	rose heath	Asteraceae	CHAERI	CHER2	18
Forb	*Chamaesaracha arida*	greenleaf five eyes	Solanaceae	CHAARI	CHCO2	1
Forb	*Chamaesyce fendleri*	Fendler's sandmat	Euphorbiaceae	CHAFEN	CHFE3	3
Forb	*Chamaesyce glyptosperma*	ribseed sandmat	Euphorbiaceae	CHAGLY	CHGL13	1
Forb	*Chamaesyce micromera*	Sonoran sandmat	Euphorbiaceae	CHAMIC	CHMI7	1
Forb	*Chamaesyce revoluta*	threadstem sandmat	Euphorbiaceae	CHAREV	CHRE4	2
Forb	*Chamaesyce serpyllifolia*	thymeleaf sandmat	Euphorbiaceae	CHASER2	CHSE6	3
Forb	*Chamaesyce serpyllifolia* ssp. *serpyllifolia*	thymeleaf sandmat	Euphorbiaceae	CHASER2	CHSES	17

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of observations
Forb	*Chamaesyce serrula*	sawtooth sandmat	Euphorbiaceae	CHASER3	CHSE7	2
Forb	*Chamaesyce* spp.	sandmat	Euphorbiaceae	CHAMAE2	CHA-MA15	2
Forb	*Chenopodium incanum*	mealy goosefoot	Chenopodiaceae	CHEINC	CHIN2	8
Forb	*Chenopodium leptophyllum*	narrowleaf goosefoot	Chenopodiaceae	CHELEP	CHLE4	1
Forb	*Cirsium undulatum*	wavyleaf thistle	Asteraceae	CIRUND	CIUN	2
Forb	*Croton texensis*	Texas croton	Euphorbiaceae	CROTEX	CRTE4	9
Forb	*Cryptantha cinerea* var. *cinerea*	James' catseye	Boraginaceae	CRYCIN	CRCIC	3
Forb	*Cryptantha crassisepala*	hiddenflower	Boraginaceae	CRYCRA	CRCR3	12
Forb	*Cryptantha crassisepala* var. *elachantha*	thicksepal catseye	Boraginaceae	CRYCRA	CRCRE	1
Forb	*Cucurbita foetidissima*	buffalo gourd	Cucurbitaceae	CUCFOE	CUFO	1
Forb	*Cuscuta umbellata*	flatglobe dodder	Cuscutaceae	CUSUMB	CUUM	1
Forb	*Cymopterus acaulis* var. *fendleri*	mountain springparsley	Apiaceae	CYMACA	CYACF	1
Forb	*Dalea lanata* var. *terminalis*	woolly prairieclover	Fabaceae	DALLAN	DALAT	1
Forb	*Dalea nana*	dwarf prairieclover	Fabaceae	DALNAN	DANA	1
Forb	*Dalea scariosa*	Albuquerque prairie clover	Fabaceae	DALSCA	DASC4	1
Forb	*Datura wrightii*	sacred thornapple	Solanaceae	DATWRI	DAWR2	1
Forb	*Delphinium* spp.	larkspur	Ranunculaceae	DELPHI	DELPH	2
Forb	*Descurainia pinnata*	western tanseymustard	Brassicaceae	DESPIN	DEPI	1
Forb	*Descurainia* spp.	tansymustard	Brassicaceae	DESCUR	DESCU	8
Forb	*Dieteria canescens*	hoary aster	Asteraceae	DIECAN	MACA2	9
Forb	*Dieteria canescens* var. *glabra*	hoary tansyaster	Asteraceae	DIECAN	MACAG	2
Forb	*Dimorphocarpa wislizeni*	spectacle pod	Brassicaceae	DIMWIS	DIWI2	54
Forb	*Epixiphium wislizeni*	balloonbush	Scrophulariaceae	EPIWIS	EPWI2	1
Forb	*Erigeron divergens*	spreading fleabane	Asteraceae	ERIDIV	ERDI4	2
Forb	*Eriogonum abertianum*	Abert's buckwheat	Polygonaceae	ERIABE	ERAB2	5
Forb	*Eriogonum rotundifolium*	roundleaf buckwheat	Polygonaceae	ERIROT	ERRO2	1
Forb	*Erodium cicutarium*	redstem stork's bill	Geraniaceae	EROCIC	ERCI6	1
Forb	*Euphorbia exstipulata*	squareseed spurge	Euphorbiaceae	EUPEXS	EUEX4	3
Forb	*Gaillardia pulchella*	firewheel	Asteraceae	GAIPUL	GAPU	3
Forb	*Gaura coccinea*	scarlet beeblossom	Onagraceae	GAUCOC	GACO5	29
Forb	*Helianthus niveus* ssp. *canescens*	showy sunflower	Asteraceae	HELNIV	HENIC	1
Forb	*Helianthus petiolaris*	prairie sunflower	Asteraceae	HELPET	HEPE	8
Forb	*Heliotropium convolvulaceum*	phlox heliotrope	Boraginaceae	HELCON2	HECO5	2
Forb	*Hoffmannseggia drepanocarpa*	sickle-pod hog-potato	Fabaceae	HOFDRE	HODR	17
Forb	*Hymenopappus flavescens* var. *canotomentosus*	collegeflower	Asteraceae	HYMFLA	HYFLC	20
Forb	*Ipomopsis pumila*	dwarf ipomopsis	Polemoniaceae	IPOPUM	IPPU4	1
Forb	*Iva ambrosiifolia*	ragged marshelder	Asteraceae	IVAAMB	IVAM	1
Forb	*Kallstroemia parviflora*	warty caltrop	Zygophyllaceae	KALPAR	KAPA	6
Forb	*Kochia scoparia*	common kochia	Chenopodiaceae	KOCSCO	KOSC	1
Forb	*Krameria lanceolata*	trailing krameria	Krameriaceae	KRALAN	KRLA	1
Forb	*Lactuca serriola*	prickly lettuce	Asteraceae	LACSER	LASE	1
Forb	*Lappula occidentalis*	flatspine stickseed	Boraginaceae	LAPOCC	LAOC3	5

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of observations
Forb	*Lappula occidentalis* var. *occidentalis*	desert stickseed	Boraginaceae	LAPOCC	LAOCO	1
Forb	*Lepidium lasiocarpum*	shaggyfruit pepperweed	Brassicaceae	LEPLAS	LELA	3
Forb	*Lepidium* spp.	pepperweed	Brassicaceae	LEPIDI	LEPID	1
Forb	*Linum aristatum*	bristle flax	Linaceae	LINARI2	LIAR3	9
Forb	*Machaeranthera tanacetifolia*	tanseyleaf aster	Asteraceae	MACTAN	MATA2	7
Forb	*Melampodium leucanthum*	plains blackfoot	Asteraceae	MELLEU	MELE2	23
Forb	*Mentzelia multiflora* var. *multiflora*	Adonis blazingstar	Loasaceae	MENMUL	MEMUM2	14
Forb	*Mirabilis glabra*	smooth four o'clock	Nyctaginaceae	MIRGLA	MIGL3	1
Forb	*Mollugo cerviana*	threadstem carpetweed	Molluginaceae	MOLCER	MOCE	1
Forb	*Nama hispidum*	bristly nama	Hydrophyllaceae	NAMHIS	NAHI	8
Forb	*Nicotiana obtusifolia* var. *obtusifolia*	desert tobacco	Solanaceae	NICOBT	NIOBO	9
Forb	*Oenothera pallida*	pale eveningprimrose	Onagraceae	OENPAL	OEPA	2
Forb	*Oenothera pallida* ssp. *runcinata*	pale eveningprimrose	Onagraceae	OENPAL	OEPAR	1
Forb	*Orobanche ludoviciana*	Louisiana broomrape	Orobanchaceae	OROLUD	ORLU	1
Forb	*Palafoxia sphacelata*	othake	Asteraceae	PALSPH	PASP	1
Forb	*Pectis angustifolia* var. *angustifolia*	narrowleaf pectis	Asteraceae	PECANG	PEANA	2
Forb	*Pediomelum hypogaeum*	subterranean Indian breadroot	Fabaceae	PEDHYP	PEHY4	1
Forb	*Phacelia integrifolia* var. *integrifolia*	gypsum phacelia	Hydrophyllaceae	PHAINT	PHINI5	17
Forb	*Phacelia* spp.	phacelia	Hydrophyllaceae	PHACEL	PHACE	19
Forb	*Physalis hederifolia* var. *fendleri*	Fendler's groundcherry	Solanaceae	PHYHED	PHHEF	1
Forb	*Physaria fendleri*	Fendler's bladderpod	Brassicaceae	PHYFEN	LEFE	23
Forb	*Plantago patagonica*	woolly plantain	Plantaginaceae	PLAPAT	PLPA2	105
Forb	*Polanisia dodecandra* ssp. *trachysperma*	sandyseed clammyweed	Capparaceae	POLDOD	PODOT	2
Forb	*Pomaria jamesii*	James's hog-potato	Fabaceae	POMJAM	POJA5	18
Forb	*Portulaca oleracea*	common purslane	Portulacaceae	POROLE	POOL	7
Forb	*Portulaca pilosa*	kiss me quick	Portulacaceae	PORPIL	POPI3	4
Forb	*Portulaca* spp.	hogweed	Portulacaceae	PORTUL	PORTU	3
Forb	*Proboscidea louisianica*	devilsclaw	Pedaliaceae	PROLOU	PRLO	1
Forb	*Proboscidea sabulosa*	sanddune unicorn-plant	Pedaliaceae	PROSAB	PRSA2	1
Forb	*Psilostrophe tagetina*	woolly paperflower	Asteraceae	PSITAG	PSTA	5
Forb	*Psilostrophe tagetina* var. *tagetina*	woolly paperflower	Asteraceae	PSITAG	PSTAT	1
Forb	*Rumex hymenosepalus*	canaigre dock	Polygonaceae	RUMHYM	RUHY	22
Forb	*Rumex* spp.	dock	Polygonaceae	RUMEX	RUMEX	14
Forb	*Salsola tragus*	prickly Russian thistle	Chenopodiaceae	SALTRA	SATR12	88
Forb	*Sanvitalia abertii*	Albert's creeping zinnia	Asteraceae	SANABE	SAAB	1
Forb	*Scorzonera laciniata*	cutleaf vipergrass	Asteraceae	SCOLAC	SCLA6	4
Forb	*Senecio flaccidus* var. *flaccidus*	threadleaf ragwort	Asteraceae	SENFLA	SEFLF	19
Forb	*Senecio riddellii*	Riddell's ragwort	Asteraceae	SENRID	SERI2	1
Forb	*Solanum elaeagnifolium*	silverleaf nightshade	Solanaceae	SOLELA	SOEL	90
Forb	*Sphaeralcea angustifolia*	copper globemallow	Malvaceae	SPHANG	SPAN3	3

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of observations
Forb	*Sphaeralcea coccinea*	scarlet globemallow	Malvaceae	SPHCOC	SPCO	14
Forb	*Sphaeralcea hastulata*	spear globemallow	Malvaceae	SPHHAS	SPHA	90
Forb	*Sphaeralcea incana*	gray globemallow	Malvaceae	SPHINC	SPIN2	38
Forb	*Stephanomeria pauciflora*	brownplume wirelettuce	Asteraceae	STEPAU	STPA4	28
Forb	*Tetraclea coulteri*	Coulter's wrinklefruit	Verbenaceae	TETCOU	TECO	3
Forb	*Tetraneuris scaposa*	stemmy four-nerve daisy	Asteraceae	TETSCA	TESC2	1
Forb	*Thelesperma megapotamicum*	Hopi tea greenthread	Asteraceae	THEMEG	THME	16
Forb	*Tidestromia lanuginosa*	wooly tidestromia	Amaranthaceae	TIDLAN	TILA2	6
Forb	*Townsendia annua*	annual townsend daisy	Asteraceae	TOWANN	TOAN	3
Forb	*Tragia ramosa*	branched noseburn	Euphorbiaceae	TRARAM	TRRA5	1
Forb	*Trianthema portulacastrum*	desert horsepurslane	Aizoaceae	TRIPOR	TRPO2	1
Forb	*Tribulus terrestris*	puncturevine	Zygophyllaceae	TRITER	TRTE	2
Forb	*Xanthisma spinulosum*	lacy tansyaster	Asteraceae	XANSPI2	MAPI	93
Forb	*Zinnia grandiflora*	Rocky Mountain zinnia	Asteraceae	ZINGRA	ZIGR	20

Appendix C: Plant Association Key

Appendix C presents a dichotomous key for the plant associations at Petroglyph National Monument. The key uses either explicitly specified cover values for indicator species as part of the decision rules in each step, or specific adjectives that relate to species canopy cover as shown in Table C-1. There are separate keys for the major classes (e.g., woodlands, shrublands, etc.) as specified in the first key. Descriptions for each association can be found in Appendix D.

Table C-1. Text descriptors for canopy cover and density with associated quantitative ranges definitions.

Descriptor	Definition
Absent	Individuals are not found in stand
Present	Individuals found in stand
Accidental	Individuals very infrequent, occasional, or limited to special microsites
Scarce/Scattered (uncommon)	Canopy coverage <1%
Common	Canopy coverage >1%
Poorly represented	Canopy coverage <5%
Well represented	Canopy coverage >5%, but less than 10%
Abundant	Canopy coverage >10%, but less than 25%
Very abundant	Canopy coverage >25%, but less than 50%
Luxuriant	Canopy coverage >50%
Dominant	Cover is greater than any other species of the same life form
Codominant	Cover is as great as any other species of the same life form
Regeneration	Understory trees represented by established seedlings and/or saplings

Key to the major classes

A. Substrate of mostly rocks and boulders with total vegetation cover usually <10% or dominated by lithomorphic species: **Lithomorphic Vegetation**

Sparse Vegetation / Boulder Rockland

Sparse Vegetation / Lava Flow

Sparse Vegetation / Sand

Sparse Vegetation / Bare Ground

A. Total vegetation cover >10% and not dominated by lithomorphic species: **(B)**

B. Trees, represented by *Juniperus monosperma*, dominant, typically >25% canopy cover; or if <25%, clearly the dominant and/or the characteristic growth form: **KEY 1 –Woodlands** (page C-2)

B. Trees <10%, clearly not predominant: **(C)**

C. Shrubs >25%, or if <25%, clearly the dominant and/or the characteristic growth form: **KEY 2 – Shrublands** (page C-2)

C. Shrubs <25%, herbs clearly the dominant and/or characteristic growth form: **KEY 3 –Herbaceous Vegetation** (page C-3)

Key 1: Woodlands

1. *Bouteloua eriopoda* common to abundant, dominant or codominant: ***Juniperus monosperma* / *Bouteloua eriopoda* Woodland**

1. *Bouteloua eriopoda* poorly represented or absent: **Undescribed woodland association**

Key 2: Shrublands

1. *Celtis laevigata* var. *reticulata* well represented, dominant or codominant: ***Celtis laevigata* var. *reticulata* Canyon Woodland**

1. *Celtis laevigata* var. *reticulata* poorly represented or absent: **(2)**

2. (1) *Fallugia paradoxa* well represented, dominant or codominant: ***Fallugia paradoxa* Arroyo Wash Shrubland**

2. *Fallugia paradoxa* poorly represented or absent: **(3)**

3. (2) *Chilopsis linearis* well represented, dominant or codominant: ***Chilopsis linearis* - *Artemisia filifolia* Shrubland**

3. *Chilopsis linearis* poorly represented or absent: **(4)**

4. (3) *Psorothamnus scoparius* well represented, dominant or codominant; understory sparse or with scattered grasses that may include *Sporobolus* spp. , *Pleuraphis jamesii* or *Bouteloua eriopoda*: ***Psorothamnus scoparius* / *Sporobolus flexuosus* Shrubland**

4. *Psorothamnus scoparius* poorly represented or absent: **(5)**

5. (4) *Artemisia filifolia* well represented, dominant or codominant: **(6)**

5. *Artemisia filifolia* poorly represented or absent: **(10)**

6. (5) *Hesperostipa neomexicana* well represented (>5% canopy cover), dominant or codominant: ***Artemisia filifolia* / *Hesperostipa neomexicana* Shrubland**

6. *Hesperostipa neomexicana* poorly represented or absent: **(7)**

7. (6) *Sporobolus cryptandrus, S. flexuosus, S. contractus*, and/or *S. giganteus* well represented to abundant, codominant: ***Artemisia filifolia* / *Sporobolus cryptandrus* Shrubland**

7. *Sporobolus cryptandrus, S. flexuosus, S. contractus*, and/or *S. giganteus* poorly represented or absent: **(8)**

8 (7). *Bouteloua eriopoda, Muhlenbergia porteri* and/or *Setaria leucopila* poorly represented or absent; herbaceous undergrowth sparse; sites typically sandy: ***Artemisia filifolia* / Sparse Undergrowth Shrubland**

8. *Bouteloua eriopoda, Muhlenbergia porteri* and/or *Setaria leucopila* well-represented to abundant: (9)

9. (8) Escarpment sites with basalt boulders: ***Artemisia filifolia* Rockland Shrubland**

9. Not escarpment sites: ***Artemisia filifolia* / *Bouteloua eriopoda* Shrubland**

10. (5) Atriplex canescens well represented to abundant: **(11)**

10. *Atriplex canescens* poorly represented or absent: **(16)**

11 (10). *Pleuraphis jamesii* well represented: ***Atriplex canescens* / *Pleuraphis jamesii* Shrubland**

11. *Pleuraphis jamesii* poorly represented or absent: **(12)**

12. (11) *Sporobolus cryptandrus, S. flexuosus, S. contractus*, and/or *S. giganteus* common to abundant: ***Atri-***

***plex canescens / Sporobolus flexuosus* (*S. cryptandrus, S. contractus)* Shrubland**

12. S*porobolus cryptandrus, S. flexuosus, S. contractus*, and/or *S. giganteus* poorly represented or absent: **(13)**

13. (12) *Muhlenbergia porteri, Setaria leucopila* and/or *Bouteloua eriopoda* common to abundant: **(14)**

13. *Muhlenbergia porteri*, *Setaria leucopila* and/or *Bouteloua eriopoda* poorly represented or absent. **(15)**

14 (13). Stands on basalt boulder escarpment sites: ***Atriplex canescens* Rockland Shrubland**

14 . Stands on volcanic cinder or splatter volcanic cones or lava flows: ***Atriplex canescens* Cinder Shrubland**

15. (13) Stands on lava flows with extensive exposed basalt rock or gravels: ***Atriplex canescens* Lava Flow Shrubland**

15. Stands typically on sandy, sites with little or no herbaceous vegetation: ***Atriplex canescens* / Sparse Shrubland**

16. (10) *Aloysia wrightii* well represented to abundant: ***Aloysia wrightii / Muhlenbergia porteri* Rockland Shrubland**

16. *Aloysia wrightii* uncommon or absent:

17. (16) Ruderal or weedy species dominate on disturbed sites: **Ruderal Disturbance Vegetation**

Key 3: Herbaceous Vegetation

1. *Hesperostipa neomexicana* well represented (>5% cover), dominant or codominant: **(2)**

1. *Hesperostipa neomexicana* poorly represented or absent: **(5)**

2. (1) *Bouteloua eriopoda* well-represented to abundant, dominant or codominant: ***Bouteloua eriopoda - Hesperostipa neomexicana* Herbaceous Vegetation**

2. *Bouteloua eriopoda* poorly represented or absent: **(3)**

3. (2) *Pleuraphis jamesii* well represented to luxuriant: ***Hesperostipa neomexicana - Pleuraphis jamesii* Herbaceous Vegetation**

3. *Pleuraphis jamesii* poorly represented or absent : **(4)**

4. (3) *Sporobolus cryptandrus, S. flexuosus, S. contractus,* and/or *S. giganteus* well represented to abundant, codominant: ***Hesperostipa neomexicana - Sporobolus cryptandrus* Herbaceous Vegetation**

4. *Sporobolus cryptandrus, S. flexuosus, S. contractus,* and/or *S. giganteus* poorly represented or absent: ***Hesperostipa neomexicana* Mixed Prairie Herbaceous Vegetation**

5. (1) *Bouteloua eriopoda*, *Muhlenbergia porteri* and/or *Setaria leucopila* well-represented to abundant, dominant or codominant: **(6)**

5. B*outeloua eriopoda*, *Muhlenbergia porteri* and/or ***Setaria leucopila*** poorly represented or absent: **(12)**

6. (5) *Artemisia bigelovi*i well-represented to luxuriant and codominant: ***Artemisia bigelovii / Bouteloua eriopoda* Dwarf-shrub Herbaceous Vegetation**

6. *Artemisia bigelovii* poorly represented or absent: **(7)**

7. (6) *Pleuraphis jamesii* well represented, or codominant: ***Bouteloua eriopoda - Pleuraphis jamesii* Herbaceous Vegetation**

7. *Pleuraphis jamesii* poorly represented or absent: (8)

8. (7) *Sporobolus cryptandrus, S. flexuosus, S. contractus*, and/or *S. giganteus* well represented to abundant, codominant: ***Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus)*** **Herbaceous Vegetation**

8. *Sporobolus cryptandrus, S. flexuosus, S. contractus*, and/or *S. giganteus* poorly represented or absent: **(9)**

9. (8) *Muhlenbergia porteri* and/or *Setaria leucopila* well-represented to abundant, dominant; basalt escarpment sites: ***Bouteloua eriopoda - Muhlenbergia porteri - Setaria leucopila*** **Mixed Herbaceous Rockland Vegetation**

9. *Muhlenbergia porteri* and/or *Setaria leucopila* poorly represented or absent; not basalt escarpment sites: **(10)**

10. (9) Grasses other than *B. eriopoda* usually <5% of total cover with stands on lava flows: ***Bouteloua eriopoda*** **/ Lava Flow Herbaceous Vegetation**

10. Grasses other than *B. eriopoda* usually >5% of total cover on volcanic cinder or splatter cones or mesa plains: **(11)**

11. (10) Stands on mesa plains with sandy soils and little exposed basalt rock or gravels: ***Bouteloua eriopoda*** **Semi-desert Herbaceous Vegetation**

11. Stands on volcanic cinder or splatter cones with extensive exposed basalt rock or gravels: ***Bouteloua eriopoda*** **Cinder Herbaceous Vegetation**

12. (5) ***Pleuraphis jamesii*** well represented, dominant or codominant: **(13)**

12. *Pleuraphis jamesii* poorly represented or absent: **(15)**

13. (12) *Scleropogon brevifolius* well-represented: ***Pleuraphis jamesii - Scleropogon brevifolius*** **Herbaceous Vegetation**

13. *Scleropogon brevifolius* poorly represented or absent: **(14)**

14 (13). *Sporobolus cryptandrus, S. flexuosus, S. contractus*, and/or *S. giganteus* well represented to abundant, codominant: ***Pleuraphis jamesii - Sporobolus cryptandrus*** **Herbaceous Vegetation**

14. *Sporobolus cryptandrus, S. flexuosus, S. contractus*, and/or *S. giganteus* poorly represented or absent: ***Pleuraphis jamesii*** **Herbaceous Vegetation**

15 (12). *Sporobolus cryptandrus, S. flexuosus, S. contractus,* and/or *S. giganteus* well represented to abundant, codominant: ***Sporobolus flexuosus - Sporobolus contractus*** **Herbaceous Vegetation**

15. Other herbaceous species well represented. Ruderal grasses and forbs dominate; disturbed sites: **Ruderal Disturbance Vegetation**

Appendix D: Plant Association Descriptions for Petroglyph National Monument

As part of the Petroglyph National Monument (PETR) vegetation classification and mapping project, local plant association descriptions were written for 33 plant associations (PAs) identified for the park during the classification and mapping phase of the project (plant associations detected during the accuracy assessment phase are included). Local descriptions provide information on the park-level distribution, level of acceptable physiognomic and compositional variation, and the key ecological process and environmental/abiotic factors that are associated with a type (Grossman et al. 1998).

At this time, the PETR descriptions have not been integrated into the national database maintained by NatureServe, but where a given association is recognized in the National Vegetation Classification, the NatureServe database code (codes beginning "CEGL") has been provided that can be used to query NatureServe's Explorer website for additional information at a global level (http://www.natureserve.org/explorer). In this appendix, the arrangement of the plant associations follows a new hierarchy per FGDC (2008) and table 5 of the main report.

Plant Associations

I. Forest and Woodland (Mesomorphic Tree Vegetation)

Rocky Mountain Two-needle Pinyon - Juniper Woodland

Southern Rocky Mountain Juniper Woodland & Savanna Group

II. Shrubland & Grassland (Mesomorphic Shrub & Herb Vegetation)

Great Plains Sand Grassland & Shrubland

Great Plains Sand Shrubland Group

Great Plains Shortgrass Prairie & Shrubland

Great Plains Shortgrass Prairie Group

III. Semi-Desert (Xeromorphic Scrub & Herb Vegetation)

Chihuahuan Desert Scrub

Chihuahuan Stabilized Coppice Dune & Sand Flat Scrub Group

IV. Nonvascular & Sparse Vascular Rock Vegetation (Lithomorphic Vegetation)

North American Warm Semi-Desert Cliff, Scree & Rock Vegetation

North American Warm Semi-Desert Cliff, Scree & Pavement Sparse Vegetation Group

V. Miscellaneous Vegetation

Miscellaneous Southwestern Vegetation Macrogroup

Miscellaneous Southwestern Vegetation Group

I. Forest & Woodland (Mesomorphic Tree Vegetation)

Juniperus monosperma / Bouteloua eriopoda Woodland

One-seed Juniper / Black Grama Woodland

CODE	CEGL000709
PHYSIOGNOMIC CLASS	Forest and Woodland (1)
PHYSIOGNOMIC SUBCLASS	Temperate Forest (1.C)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.C.2)
PHYSIOGNOMIC DIVISION	Western North American Cool Temperate Scrub Woodland & Shrubland (1.C.2.c)
MACROGROUP	Rocky Mountain Two-needle Pinyon - Juniper Woodland (MG027)
GROUP	Southern Rocky Mountain Juniper Woodland & Savanna Group (G252)

DISTRIBUTION

Occasional on the northern mesa top, east of the volcanoes

ENVIRONMENTAL DESCRIPTION

This association occurs along drainage ways and in draws across the mesa top and on rocky upland sites where trees have become established on exposed lava pressure ridges in the grasslands matrix (the latter condition is mostly associated with the younger lava flow 4). The elevations range from 5,255 to 5,835 ft (1,602 to 1,779 m); slopes are gentle (3-8%), and aspects easterly.

VEGETATION DESCRIPTION

This open woodland is characterized by scattered *Juniperus monosperma* with a grassy understory where *Bouteloua eriopoda* is well represented and *Hesperostipa neomexicana* commonly co-dominates. *Bouteloua curtipendula*, *Sporobolus cryptandrus*, and *Bouteloua gracilis* are also common associates (12 graminoid species are known to occur in the association). Shrubs are scattered, and among the eight species reported, *Krascheninnikovia lanata* is the most common in upland settings and *Fallugia paradoxa* along drainages. Forbs are also scattered and variable, with 12 species recorded for the association.

MOST ABUNDANT SPECIES

Stratum	Species
Tree canopy	*Juniperus monosperma*
Herb	*Bouteloua eriopoda*
Herb	*Hesperostipa neomexicana*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 11EM205, 07PE046,11EM111, 08YC022, 11YC011, 11YC015

Local description author(s): E. Muldavin

II. Shrubland & Grassland (Mesomorphic Shrub & Herb Vegetation)

Artemisia filifolia / Hesperostipa neomexicana Shrubland

Sand Sagebrush / New Mexico Needlegrass Shrubland

CODE	NHNM000341
PHYSIOGNOMIC CLASS	Shrubland and Grassland (2)
PHYSIOGNOMIC SUBCLASS	Temperate & Boreal Shrubland & Grassland (2.C)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.C.1)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.C.1.b)
MACROGROUP	Great Plains Sand Grassland & Shrubland (MG052)
GROUP	Great Plains Sand Shrubland Group (G069)

DISTRIBUTION

Occasional on the upper mesa top and eastern slopes of the volcanoes

ENVIRONMENTAL DESCRIPTION

This association occurs on sandy deposits over basalt lava, often in drainage areas. Elevation was recorded as 5,562 ft (1,695 m) on a northeasterly aspect and gentle slope (<5%).

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Artemisia filifolia* with a grassy understory dominated by *Hesperostipa neomexicana*. *Pleuraphis jamesii* and *Bouteloua eriopoda* may also be common associates.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Artemisia filifolia*
Herb	*Hesperostipa neomexicana*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 11EM217

Local description author(s): E. Muldavin

Artemisia filifolia / Rockland Shrubland

Sand Sagebrush Rockland Shrubland

CODE	NHNM000842
PHYSIOGNOMIC CLASS	Shrubland and Grassland (2)
PHYSIOGNOMIC SUBCLASS	Temperate & Boreal Shrubland & Grassland (2.C)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.C.1)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.C.1.b)
MACROGROUP	Great Plains Sand Grassland & Shrubland (MG052)
GROUP	Great Plains Sand Shrubland Group (G069)

DISTRIBUTION

Common along the eastern escarpment of the mesa top.

ENVIRONMENTAL DESCRIPTION

This association occurs on steep (45%), basalt boulder-strewn escarpment slopes along the lower edge the Albuquerque Volcanic Field lava flow. Elevations were recorded between 5,228 and 5, 340 ft (1,594 and 1,628 m) on southerly to westerly aspects.

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Artemisia filifolia* with a sparse to grassy understory dominated by *Bouteloua eriopoda*, *Muhlenbergia porteri*, and *Setaria leucopila*. *Atriplex canescens* and *Gutierrezia sarothrae* are common shrub associates. Forbs are variable; the most consistent species are *Bahia pedata*, *Baileya multiradiata*, and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Artemisia filifolia*
Herb	*Bouteloua eriopoda*
Herb	*Muhlenbergia porteri*
Herb	*Setaria leucopila*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 107YC006, 07AK032

Local description author(s): E. Muldavin

Artemisia filifolia / Sparse Undergrowth Shrubland

Sand Sagebrush / Sparse Undergrowth Shrubland

CODE	NHNM000345
PHYSIOGNOMIC CLASS	Shrubland and Grassland (2)
PHYSIOGNOMIC SUBCLASS	Temperate & Boreal Shrubland & Grassland (2.C)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.C.1)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.C.1.b)
MACROGROUP	Great Plains Sand Grassland & Shrubland (MG052)
GROUP	Great Plains Sand Shrubland Group (G069)

DISTRIBUTION

Throughout the park.

ENVIRONMENTAL DESCRIPTION

This association occurs on sandy sites along drainage ways and in draws across the mesa volcanic field, dry-wash bottoms, and in sand dune areas below the escarpment. The elevations range from 5,142 to 5,664 ft (1567 to 1,726 m); slopes are generally gentle (<5%) but may range as high as 10%. Aspects are variable.

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of Artemisia filifolia with Psorothamnus scoparius and Atriplex canescens as common shrub associates. The shrub understories and intershrub spaces are sparsely vegetated. That is, perennial cover seldom exceeds 1% , but annuals, on years where rainfall is favorable, may be abundant (e.g., Allionia choisyi, Boerhavia spicata, Chamaesyce serpyllifolia, Cryptantha crassisepala, Dimorphocarpa wislizeni, Helianthus petiolaris, Hymenopappus flavescens, Hymenopappus flavescens, Linum aristatum, Nama hispidum, Phacelia integrifolia, Plantago patagonica, Portulaca oleracea, and Portulaca pilosa).

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Artemisia filifolia*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07AK055, 07AK056, 07AK098, 07AK052, 07PE039, 08YC001, 07PE059, 08SS039, 08SS036, 07YC004, 08YC031, 08YC015, 08YC030, 08SS053, 08SS028, 07PE058, 08SS054, 11EM028, 11EM102, 11EM107, 11EM179, 11EM008, 11EM011, 11EM018, 11EM085, 11EM016

Local description author(s): E. Muldavin

Artemisia filifolia / Sporobolus cryptandrus Shrubland

Sand Sagebrush / Sand Dropseed Shrubland

CODE	CEGL002179
PHYSIOGNOMIC CLASS	Shrubland and Grassland (2)
PHYSIOGNOMIC SUBCLASS	Temperate & Boreal Shrubland & Grassland (2.C)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.C.1)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.C.1.b)
MACROGROUP	Great Plains Sand Grassland & Shrubland (MG052)
GROUP	Great Plains Sand Shrubland Group (G069)

DISTRIBUTION

Common to the east and below the lava flow escarpment.

ENVIRONMENTAL DESCRIPTION

This association occurs on sandy sites along drainage ways and in draws across the mesa volcanic field, wash bottoms, and in sand dune areas below the escarpment. The elevations range from 5,150 to 5,715 ft (1570 to 1,742 m); slopes are generally gentle (<5%) but may range as high as 10%. Aspects are northerly to southeasterly.

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Artemisia filifolia* with *Psorothamnus scoparius* and *Atriplex canescens* as common shrub associates. The shrub understories and inter-shrub spaces are characterized by scattered grasses, and overall cover seldom exceeds 5%. The most common species are *Sporobolus cryptandrus* and *Sporobolus flexuosus; Achnatherum hymenoides* and *Bouteloua eriopoda* may also co-dominate. Annual forbs, on years where rainfall is favorable, may be abundant (e.g., *Aphanostephus ramosissimus*, *Astragalus nuttallianus*, *Dimorphocarpa wislizeni,* and *Plantago patagonica*).

MOST ABUNDANT SPECIES

Stratum	**Species**
Shrub/sapling (tall & short)	*Artemisia filifolia*
Herb	*Sporobolus cryptandrus*
Herb	*Sporobolus flexuosus*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 08SS030, 07PE036, 07AK044, 07AK038, 08SS052, 07PE026, 11EM029, 11EM020

Local description author(s): E. Muldavin

Artemisia filifolia / Pleuraphis jamesii Shrubland

Sand Sagebrush / James' Galleta Shrubland

CODE	NHNM000343
PHYSIOGNOMIC CLASS	Shrubland and Grassland (2)
PHYSIOGNOMIC SUBCLASS	Temperate & Boreal Shrubland & Grassland (2.C)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.C.1)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.C.1.b)
MACROGROUP	Great Plains Sand Grassland & Shrubland (MG052)
GROUP	Great Plains Sand Shrubland Group (G069)

DISTRIBUTION

Occasional along the lower portions of the lava flow, approaching the eastern escarpment.

ENVIRONMENTAL DESCRIPTION

This association occurs on basalt lava flows (primarily flows 1 and 2) that are covered with a thin veneer of wind-blown sand and silt deposits. The elevations range from 5,220 to 5,906 ft (1,591 to1,800 m); slopes are generally gentle (<5%) but may range as high as 10%. Aspects are variable.

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Artemisia filifolia* with *Atriplex canescens* as a common shrub associate. The shrub understories and intershrub spaces are characterized by scattered grasses. The most abundant is *Pleuraphis jamesii*, but *Bouteloua eriopoda* , *Sporobolus cryptandrus*, S*porobolus contractus*, and *Sporobolus flexuosus* may be well represented on occasion. Annual forbs, on years where rainfall is favorable, may be prevalent, but, in general, forb cover is less than 1%.

MOST ABUNDANT SPECIES

Stratum	**Species**
Shrub/sapling (tall & short)	*Artemisia filifolia*
Herb	*Pleuraphis jamesii*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: NA

Local description author(s): E. Muldavin

Hesperostipa neomexicana - Sporobolus cryptandrus Herbaceous Vegetation

New Mexico Needlegrass - Sand Dropseed Grassland

CODE	NHNM000178
PHYSIOGNOMIC CLASS	Shrubland and Grassland (2)
PHYSIOGNOMIC SUBCLASS	Temperate & Boreal Shrubland & Grassland (2.C)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.C.1)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.C.1.b)
MACROGROUP	Great Plains Shortgrass Prairie & Shrubland (MG053)
GROUP	Great Plains Shortgrass Prairie Group (G144)

DISTRIBUTION

Common on the northern portions of upper mesa top and slopes of the volcanoes.

ENVIRONMENTAL DESCRIPTION

This association occurs on the slopes of the volcanoes, extending down to the mesa flats. Sites are usually characterized by gravel and sand deposits over basalts lavas of lava flow 3 and 4. The elevations range from 5,375 to 5,797 ft (1,638 to 1,767 m); slopes are gentle (2–10%), and of southwestern aspect.

VEGETATION DESCRIPTION

This grassland is dominated by *Hesperostipa neomexicana* with sand dropseeds (S*porobolus cryptandrus, S. flexuosus*, and *S. contractus* well represented and often co-dominant. While overall grass cover may approach 40%, other grasses seldom exceed 1% cover. Shrubs are scattered and, among the seven species reported, *Krascheninnikovia lanata* can be well represented and *Gutierrezia sarothrae* abundant. Forbs are also scattered and variable, with 16 species recorded for the association. The most common and abundant are *Dimorphocarpa wislizeni* and *Zinnia grandiflora*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Hesperostipa neomexicana*
Herb	*Sporobolus cryptandrus*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots:07EL002, 07PE014, 07EL005, 11EM081, 11EM152, 11EM139

Local description author(s): E. Muldavin

Hesperostipa neomexicana Mixed Prairie Herbaceous Vegetation

New Mexico Needlegrass Mixed Prairie Herbaceous Vegetation

CODE	CEGL001711
PHYSIOGNOMIC CLASS	Shrubland and Grassland (2)
PHYSIOGNOMIC SUBCLASS	Temperate & Boreal Shrubland & Grassland (2.C)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.C.1)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.C.1.b)
MACROGROUP	Great Plains Shortgrass Prairie & Shrubland (MG053)
GROUP	Great Plains Shortgrass Prairie Group (G144)

DISTRIBUTION

Common on the mesa top, and occasional in the Mesa Prieta gravel hills and the Southern Geologic Window.

ENVIRONMENTAL DESCRIPTION

This association occurs on the mid slopes of the mesa. Sites are usually characterized by gravel and silt deposits over basalts lavas of lava flow 3 and 4. The elevations range from 5,328 to 5,864 ft (1,624 to 1,787 m); slopes are gentle (2–10%), with aspects that are predominantly northwesterly to southeasterly.

VEGETATION DESCRIPTION

This grassland is dominated by *Hesperostipa neomexicana* with cover as high as 40%, but other grasses are scattered and seldom exceed 5% cover and co-dominance. Shrubs are scattered, and among the 14 species reported, *Krascheninnikovia lanata* and *Ephedra torreyana* are common, along with *Gutierrezia sarothrae, Opuntia polyacantha*, and *Opuntia phaeacantha*. Forbs are also scattered and variable, with 23 species recorded for the association. The most common and abundant are *Sphaeralcea hastulata* and *Xanthisma spinulosum*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Hesperostipa neomexicana*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots:07EL027, 08SS027, 08SS031, 07PE031, 07SS029, 07AK043, 08SS048, 07AK011, 07PE010, 07AK019, 07SS013

07PE017, 07SS033, 07SS032, 07EL031, 11EM091, 11EM166, 11EM216, 11EM046, 11EM084, 11EM095, 11EM109, 11EM207, 11EM202, 11EM204

Local description author(s): E. Muldavin

III. Semi-Desert (Xeromorphic Scrub & Herb Vegetation)

Artemisia filifolia / Bouteloua eriopoda Shrubland

Sand Sagebrush / Black Grama Shrubland

CODE	CEGL001077
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Desert Scrub (MG086)
GROUP	Chihuahuan Stabilized Coppice Dune & Sand Flat Scrub Group (G287)

DISTRIBUTION

Occasional on the mesa top, and in the Mesa Prieta gravel hills and below the escarpment.

ENVIRONMENTAL DESCRIPTION

This association occurs on wind-deposited sandy substrates that overlie both the basalt lava flows of the mesa and on sandy deposits below the escarpment. The elevations range from 5,325 to 5,810 ft (1,623 to 1,771 m); slopes are gentle (1-8%), and aspects easterly (30-150°).

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Artemisia filifolia* with grassy understory inter-shrub spaces dominated by *Bouteloua eriopoda*. *Psorothamnus scoparius* is a common tall shrub associate and *Gutierrezia sarothrae*, *Ephedra torreyana* and *Yucca baileyi* var. *intermedias* can be common subshrubs. Among the other 13 graminoid species recorded for the association, the most common are *Achnatherum hymenoides* and *Pleuraphis jamesii*. Forb diversity is moderate (22 species) but variable; the most consistent species are *Xanthisma spinulosum, Chaetopappa ericoides, Gaura coccinea*, and *Sphaeralcea incana*.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Artemisia filifolia*
Herb	*Bouteloua eriopoda*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07PE024, 07AK012, 07PE020, 08YC005, 08YC023, 08YC014

Local description author(s): E. Muldavin

Psorothamnus scoparius / Sporobolus flexuosus Shrubland

Broom Smokebush / Mesa Dropseed Shrubland

CODE	CEGL001695
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Desert Scrub (MG086)
GROUP	Chihuahuan Stabilized Coppice Dune & Sand Flat Scrub Group (G287)

DISTRIBUTION

Occasional below the eastern mesa escarpment and volcanoes escarpment.

ENVIRONMENTAL DESCRIPTION

This association occurs on deep sands of the sand dune areas and sandy plains below the escarpment. The elevations range from 5,124 to 5,713 ft (1,562 to 1,741 m); slopes are gentle (0-7%), and aspects tend to be southerly.

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy (10-15% cover) of *Psorothamnus scoparius* with *Atriplex canescens* common to well represented, and sometimes co-dominant. *Artemisia filifolia* is poorly represented or absent. The shrub understories and inter-shrub spaces are characterized by scattered grasses and overall cover seldom exceeds 5%. The most common species are *Sporobolus cryptandrus* and *Sporobolus flexuosus*, and *Achnatherum hymenoides*, *Muhlenbergia porteri*, and *Bouteloua eriopoda* may be common. Annual forbs and grasses, on years where rainfall is favorable, may be abundant (e.g., *Bouteloua barbata*, *Munroa squarrosa*, *Vulpia octoflora*, *Aphanostephus ramosissimus*, *Astragalus nuttallianus*, *Chamaesyce serpyllifolia*, *Dimorphocarpa wislizeni*, *Phacelia integrifolia*, *Linum aristatum*, and *Plantago patagonica*).

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Psorothamnus scoparius*
Herb	*Sporobolus cryptandrus*
Herb	*Sporobolus flexuosus*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 08YC020, 07SS018, 07SS019, 08SS035, 07AK029, 08SS037, 07YC005, 08YC027, 07PE040, 07PE043, 07PE037, 11EM191, 11EM044, 11EM026, 11EM019, 11EM010

Local description author(s): E. Muldavin

Aloysia wrightii / Muhlenbergia porteri Rockland Shrubland

Wright's Beebrush / Bush Muhly Rockland Shrubland

CODE	NHNM000332
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Desert Scrub (MG086)
GROUP	Chihuahuan Succulent Desert Scrub Group (G286)

DISTRIBUTION

Known from the escarpment in Rinconada Canyon.

ENVIRONMENTAL DESCRIPTION

This association occurs on steep (55%), basalt, boulder-strewn escarpment slopes along at the lower edge the Albuquerque Volcanic Field lava flow. Elevations were recorded between 5,260 and 5,310 ft (1,603 and1,618 m) on southerly to westerly aspects.

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Aloysia wrightii* with a sparse to grassy understory dominated by *Bouteloua eriopoda*, *Muhlenbergia porteri*, and *Setaria leucopila*. *Atriplex canescens* and *Gutierrezia sarothrae* are common shrub associates. Forbs are variable; the most consistent species are *Allionia incarnata*, *Tetraclea coulteri*, *Nicotiana obtusifolia*, *Artemisia ludoviciana*, and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Aloysia wrightii*
Herb	*Bouteloua eriopoda*
Herb	*Muhlenbergia porteri*
Herb	*Setaria leucopila*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07PE044, 07PE042, 07PE041

Local description author(s): E. Muldavin

Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus) Herbaceous Vegetation

Black Grama - Mesa (Sand, or Spike) Dropseed Grassland

CODE	NHNM000065
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Semi-Desert Grassland (MG087)
GROUP	Chihuahuan Sandy Plains Semi-Desert Grassland Group (G491)

DISTRIBUTION

Common on the mesa top, and occasional in the Mesa Prieta gravel hills and below the escarpments.

ENVIRONMENTAL DESCRIPTION

This association occurs primarily as large stands to the south and midway down the mesa on lava flows 2 and 3, but occasionally occurs on the slopes of the volcanoes (lava flows 4 and 5). Sites are usually characterized by gravel and silt deposits over the basalt lavas. Elevations range from 5,342 to 5,797 ft (1,628 to 1,774 m); slopes are gentle (1-9 %), and primarily of northwesterly to northeasterly to southeasterly in aspect.

VEGETATION DESCRIPTION

This grassland is dominated by *Bouteloua eriopoda* with sand dropseeds (*Sporobolus cryptandrus* and *S. flexuosus*) well represented and often co-dominant. While overall grass cover may approach 40%, other grasses seldom exceed 1% cover. Shrubs are scattered, and among the 11 species reported, *Krascheninnikovia lanata* can be well represented and *Gutierrezia sarothrae* abundant. Opuntia polyacantha and *Ephedra torreyana* can also be common. Forbs are also scattered and variable, with 29 species recorded for the association. Among perennials, the most common and abundant are *Xanthisma spinulosum* and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Bouteloua eriopoda*
Herb	*Sporobolus cryptandrus*
Herb	*Sporobolus flexuosus*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07AK033, 07AK045, 07SS009, 11YC001, 07SS028, 07SS015, 07PE007, 07PE003, 07PE015, 07PE029, 07AK025, 07PE027, 11EM174, 11EM039, 11EM176, 11EM181, 11EM182, 11EM192, 11EM193, 11EM120, 11EM121, 11EM128, 11EM168, 11EM172, 11YC018, 11EM032, 11EM031, 11EM071, 11YC019, 11EM076, 11YC016, 11EM053, 11EM049, 11EM045, 11EM043, 11EM034, 11EM069, 11EM068, 11EM067, 11EM066, 11EM060, 11EM119, 11EM114, 11EM110, 11EM099, 11EM079, 11EM214

Local description author(s): E. Muldavin

Sporobolus flexuosus - Sporobolus contractus Herbaceous Vegetation

Mesa Dropseed - Narrow-spike Dropseed Herbaceous Vegetation

CODE	CEGL001696
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Semi-Desert Grassland (MG087)
GROUP	Chihuahuan Sandy Plains Semi-Desert Grassland Group (G491)

DISTRIBUTION

Common on the southern mesa top, but stands also occur below the escarpment along the eastern boundary and in the Mesa Prieta gravel hills.

ENVIRONMENTAL DESCRIPTION

This association occurs on sandy soils overlying basalt lavas (particularly on lava flow 3), and occasionally on the old alluvial sediments of the Ceja formation in the Mesa Prieta gravel hills area, and in the dune lands below the escarpment (occasionally on the footslope of the escarpment itself). The elevations range from 5,342 to 5,820 ft (1,628 to 1,774 m). Slopes are generally low, but can range as high as 30% on the footslopes of the escarpment. Aspects are variable.

VEGETATION DESCRIPTION

This grassland is dominated by *Sporobolus cryptandrus* and *S. flexuosus* with *Pleuraphis jamesii, Aristida purpurea*, *Achnatherum hymenoides*, and *Bouteloua eriopoda* present but clearly subordinate (11 grass species were recorded). Overall grass cover may approach 50%. Shrubs are scattered, and among the 10 species reported, *Krascheninnikovia lanata* is the most common along with the subshrub *Gutierrezia sarothrae* and the cacti *Opuntia phaeacantha* and *Opuntia polyacantha*. Forbs are also scattered and variable, with 17 species recorded for the association. Among perennials, the most common and abundant are *Xanthisma spinulosum* and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Sporobolus cryptandrus*
Herb	*Sporobolus flexuosus*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07EL017, 07EL013, 07SS017, 08SS041, 08SS051, 07EL003, 07SS006, 07PE006, 07SS004, 07AK006, 07SS026, 07AK020, 11EM160, 11EM165, 11EM161, 11EM108, 11EM162

Local description author(s): E. Muldavin

Bouteloua eriopoda Cinder Herbaceous Vegetation

Black Grama Cinder Herbaceous Vegetation

CODE	NHNM000845
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Semi-Desert Grassland (MG087)
GROUP	Chihuahuan Semi-Desert Foothill Grassland Group (GSW1)

DISTRIBUTION

Common on the volcanoes and downslope on exposed lava outcrops on the mesa top.

ENVIRONMENTAL DESCRIPTION

This association occurs on the western and southern slopes of volcanoes and occasionally on lava outcrops (pressure ridges and collapse features) downslope of the mesa top. Sites are typified by extensive exposed rocks and boulders composed of basalt cinder and scoria (10-30% of the ground cover). Elevations range from 5,607 to 5,941 ft (1,709 to 1,811 m); slopes are moderate (10-20%).

VEGETATION DESCRIPTION

This grassland is dominated by *Bouteloua eriopoda*, which ranges in canopy cover from 10% to as high as 40%, while other grasses are typically scattered and poorly represented (<5% cover overall). Of these, the most common are *Sporobolus cryptandrus, S. flexuosus, Aristida purpurea*, and *Hesperostipa neomexicana*. Shrubs are scattered and, among the eight species reported, *Krascheninnikovia lanata, Atriplex canescens*, and *Ephedra torreyi* are the most prevalent, along with *Gutierrezia sarothrae*. Forbs are also scattered and variable, with 17, species recorded for the association. Among perennials, the most common and abundant are *Xanthisma spinulosum, Physaria fendleri*, and S*tephanomeria pauciflora*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Bouteloua eriopoda*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07PE009, 07PE012, 07YC001, 07AK017, 07PE005, 07AK005, 07AK001, 07SS010, 07AK021, 07PE004, 07PE011, 07AK013, 07AK015, 11EM154, 11EM140, 11EM170, 11EM178, 11EM072, 11EM126, 11EM134, 11EM135, 11EM167

Local description author(s): E. Muldavin

Bouteloua eriopoda - Hesperostipa neomexicana Herbaceous Vegetation

Black Grama - New Mexico Needlegrass Herbaceous Vegetation

CODE	CEGL001753
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Semi-Desert Grassland (MG087)
GROUP	Chihuahuan Semi-Desert Foothill Grassland Group (GSW1)

DISTRIBUTION

Common on the mesa top, mostly in the northern portion; occasional below the escarpment.

ENVIRONMENTAL DESCRIPTION

This association occurs primarily on gravel and sand deposits over the basalt lavas of lava flows 3 and 4 of the mid mesa top, but may extend both upslope onto lower volcano slopes (lava flow 5) or extend downslope onto the older lava flows 1 and 2 to the edge of the escarpment. It is also known to occur below the escarpment on sandy soils of drainage ways. The elevations range from 5,150 to 5,862 ft (1,570 to 1,787 m); slopes range from gentle (<10%) to moderate (20-21%), with aspects that are predominantly northeasterly to southeasterly.

VEGETATION DESCRIPTION

This grassland is co-dominated by *Bouteloua eriopoda* and *Hesperostipa neomexicana* with canopy cover that averages 20-30% and may range as high as 60%. Other grasses seldom exceed 5% cover. Shrubs are scattered, and among the 15 species reported, *Krascheninnikovia lanata*, *Ephedra torreyana*, and *Yucca baileyi* var. *intermedia* are common, along with *Gutierrezia sarothrae, Opuntia polyacantha*, and *Opuntia phaeacantha*. Forbs are also scattered and variable, with 30 species recorded for the association. Among perennials, *Xanthisma spinulosum* and *Sphaeralcea coccinea* are the most consistent.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Bouteloua eriopoda*
Herb	*Hesperostipa neomexicana*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07PE035, 07PE054, 11YC009, 07PE028, 07PE055, 07EL026, 07PE056, 07PE053, 11YC006, 07EL028, 07PE051,07PE052, 07PE050, 07AK046, 07SS035, 07PE016, 07PE018, 07PE022, 11YC007, 07EL014, 07PE023, 11YC013, 11YC012, 11EM201, 11EM115, 11EM097, 11YC008, 11EM124, 11EM209, 11EM118, 11EM098, 11EM116, 11EM096, 11EM177, 11EM159,11EM158, 11EM145, 11EM141, 11EM127, 11EM117, 11EM206, 11EM103, 11EM104, 11EM218, 11EM220, 11EM221, 11EM073, 11EM093, 11EM094, 11YC014, 11EM101, 11EM123, 11EM212, 11EM215

Local description author(s): E. Muldavin

Bouteloua eriopoda - Muhlenbergia porteri - Setaria leucopila Mixed Herbaceous Rockland Vegetation

Black Grama - Bush Muhly - Streambed Bristlegrass Mixed Herbaceous Rockland Vegetation

CODE	NHNM000063
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Semi-Desert Grassland (MG087)
GROUP	Chihuahuan Semi-Desert Foothill Grassland Group (GSW1)

DISTRIBUTION

Common on the eastern escarpment.

ENVIRONMENTAL DESCRIPTION

This association is occurs on steep (30-50%), basalt, boulder-strewn escarpment slopes along the lower edge the Albuquerque Volcanic Field lava flow (lava flows 1 and 2). Elevations were recorded between 5,194 and 5,908 ft (1,583 and1,801 m) on predominantly northeasterly to southeasterly aspects.

VEGETATION DESCRIPTION

This grassland is dominated by *Bouteloua eriopoda*, *Muhlenbergia porteri*, and *Setaria leucopila*. *Aristida purpurea, Dasyochloa pulchella, Sporobolus cryptandrus, Sporobolus flexuosus, Hesperostipa neomexicana,* and *Pleuraphis jamesii* may also be common, but seldom exceed 5% cover collectively. *Atriplex canescens* and *Gutierrezia sarothrae* are common shrub associates. Forbs are variable; among the most consistent species are *Allionia incarnata*, *Solanum elaeagnifolium*, and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Muhlenbergia porteri*
Herb	*Setaria leucopila*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots:07AK004, 07SS024, 08YC029, 07AK036, 07AK054, 07PE064, 08SS038, 07SS022, 07SS023, 08YC002, 11EM009

Local description author(s): E. Muldavin

Bouteloua eriopoda / Lava Flow Herbaceous Vegetation

Black Grama / Lava Flow

CODE	NHNM000836
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Semi-Desert Grassland (MG087)
GROUP	Chihuahuan Semi-Desert Grassland Group (G490)

DISTRIBUTION

Common along the southeastern edge of the mesa top and the edge of the Volcanoes Escarpment to the west.

ENVIRONMENTAL DESCRIPTION

This association occurs mostly the older lava flows 1 and 2 (and occasionally lava flow 3) near the edge of the escarpments. On these sites, there is a thin veneer of gravels and sandy aeolian deposits over the lava, and extensive areas of exposed minimally weathered basalt rock (up to 30%). The elevations range from 5,310 to 5,716 ft (1,619 to 1,742 m); slopes are gentle (<10%) and aspects predominantly northeasterly to southeasterly.

VEGETATION DESCRIPTION

This grassland is dominated by *Bouteloua eriopoda*, which ranges in canopy cover from 5% to as high as 40% while other grasses are typically scattered and poorly represented (<5% cover overall). Of the 11 other grasses, the most common are *Sporobolus cryptandrus, S. flexuosus, Aristida purpurea, Pleuraphis jamesii,* and *Hesperostipa neomexicana*. Shrubs are scattered, and among the eight species reported, *Krascheninnikovia lanata* and *Ephedra torreyi* are the most prevalent along with *Gutierrezia sarothrae* and *Opuntia polyacantha*. Forbs are also scattered and variable, with 18 species recorded for the association. Among perennials, the most common and abundant are *Melampodium leucanthum* and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Bouteloua eriopoda*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 11EM205, 07PE046,11EM111, 08YC022, 11YC011, 11YC015

Local description author(s): E. Muldavin

Bouteloua eriopoda Semi-desert Herbaceous Vegetation

Black Grama Semi-desert Herbaceous Vegetation

CODE	CEGL001752
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	Chihuahuan Semi-Desert Grassland (MG087)
GROUP	Chihuahuan Semi-Desert Grassland Group (G490)

DISTRIBUTION

Common on the mesa top and in the Mesa Prieta gravel hills.

ENVIRONMENTAL DESCRIPTION

This association occurs on all lava flows except lava flow 5 (the volcanoes), and on the ancient sediments of the Ceja formation that underlies the Mesa Prieta gravel hills. The lava flows are typically overlain with a thin veneer of gravelly and sandy soil deposits. The elevations range from 5,334 to 5,807 ft (1,626 to 1,770 m); slopes are gentle (<10%) to moderate (up to 25%) and aspects variable.

VEGETATION DESCRIPTION

This grassland is dominated by *Bouteloua eriopoda*, which ranges in canopy cover from 5% to as high as 40% while other grasses are typically scattered and poorly represented (<5% cover overall). Of the 11 other grasses, the most common are *Sporobolus cryptandrus, S. flexuosus, Aristida purpurea, Pleuraphis jamesii, Achnatherum hymenoides*, and *Hesperostipa neomexicana*. Shrubs are scattered, and among the eight species reported, *Krascheninnikovia lanata, Yucca baileyi* var. *intermedia*, and *Ephedra torreyi* are the most prevalent along with *Gutierrezia sarothrae, Opuntia phaeacantha,* and *Opuntia polyacantha*. Forbs are also scattered and variable, with 27 species recorded for the association. Among perennials, the most common and abundant are *Stephanomeria pauciflora* and *Sphaeralcea incana*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Bouteloua eriopoda*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07EL019, 07EL025, 07PE021, 07PE032, 07YC003, 07AK030, 08YC028, 07AK023, 07EL010, 10YC025, 07AK031, 08SS050, 07AK010, 11EM065, 11EM040, 11EM100, 11EM041, 11EM151, 11EM133, 11EM125, 11EM169, 11EM185, 11EM187, 11EM074, 11EM083, 11EM088, 11EM056, 11EM057

Local description author(s): E. Muldavin

Celtis laevigata var. *reticulata* Canyon Woodland

Netleaf Hackberry / Canyon Woodland

CODE	NHNM000813
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	North American Warm-Desert Xero-Riparian (MG092)
GROUP	Warm Semi-Desert Shrub & Herb Wash-Arroyo Group (G541)

DISTRIBUTION

Uncommon in drainages on the northeast mesa top and Upper Boca Negra Canyon.

ENVIRONMENTAL DESCRIPTION

This association occurs along drainage ways on the mesa top in the head of a small canyon in escarpment (Boca Negra Canyon). The elevations range from 5,275 to 5,409 ft (1,608 to 1,649 m).

VEGETATION DESCRIPTION

This shrubland association is characterized by the dominance of shrub-statured *Celtis laevigata* var. *reticulata* along with scattered *Fallugia paradoxa*¸ *Rhus trilobata*, and *Juniperus monosperma*. The understory is made up of scattered grasses and forbs that collectively are less than 5% in cover. The most common species are *Bouteloua curtipendula*, *Artemisia ludoviciana*, and *Datura wrightii*.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Celtis laevigata* var. *reticulata*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 08YC007, 10YC013, 08YC032

Local description author(s): E. Muldavin

Chilopsis linearis - Artemisia filifolia Shrubland

Desert Willow - Sand Sagebrush Shrubland

CODE	NHNM000385
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Warm Semi-Desert Scrub & Grassland (3.A)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Scrub & Grassland (3.A.1)
PHYSIOGNOMIC DIVISION	North American Warm Desert Scrub & Grassland (3.A.1.a)
MACROGROUP	North American Warm-Desert Xero-Riparian (MG092)
GROUP	Warm Semi-Desert Shrub & Herb Wash-Arroyo Group (G541)

DISTRIBUTION

Common in Ladera Wash and other drainages of the Mesa Prieta gravel hills area.

ENVIRONMENTAL DESCRIPTION

This association occurs in ephemerally flooded washes along drainage ways. Sites are typically made up of recent gravel alluvium. The elevations range from 5,268 to5,550 ft (1,606 to 1,692 m); channel gradients are between 1% and 5%.

VEGETATION DESCRIPTION

This shrubland is characterized by open shrub canopies dominated by *Chilopsis linearis* and other species tolerant of periodic flooding (e.g., *Fallugia paradoxa, Ericameria nauseosa*, *Artemisia filifolia, Atriplex canescens, Lycium pallidum*, and *Brickellia californica*). The herbaceous layer is typically sparse (total canopy cover seldom exceeds 5%). The most consistent species are *Muhlenbergia porteri, Dasyochloa pulchella*, and *Baileya multiradiata* along with a mixture of annuals, depending on the year.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Chilopsis linearis*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07AK037, 07AK035, 08YC026, 08YC024, 08SS047, 10YC018, 10YC011, 10YC011, 11EM059

Local description author(s): E. Muldavin

Fallugia paradoxa Arroyo Wash Shrubland

Apache Plume Arroyo Wash Shrubland

CODE	CEGL002716
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	North American Warm-Desert Xero-Riparian (MG092)
GROUP	Warm Semi-Desert Shrub & Herb Wash-Arroyo Group (G541)

DISTRIBUTION

Occasional in drainages of the northern portion of the mesa top and in the Southern Geologic Window.

ENVIRONMENTAL DESCRIPTION

This association occurs in ephemerally flooded washes along shallow drainage ways on lava flows 2 and 3. Sites are typically made up of recent sandy alluvium. The elevations range from 5,425 to 5,590 ft (1,654 to 1,704 m); channel gradients are between 1% and 5%.

VEGETATION DESCRIPTION

This dry-wash shrubland is characterized by open shrub canopies dominated by *Fallugia paradoxa* and other species tolerant of periodic flooding (e.g., *Artemisia filifolia, Atriplex canescens*, and *Rhus trilobata*). The herbaceous layer is typically sparse (total canopy cover seldom exceeds 5%). The most consistent species are grasses from the surrounding grassland matrix that include *Hesperostipa neomexicana, Bouteloua eriopoda, Sporobolus cryptandrus,* and *Aristida purpurea*.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Fallugia paradoxa*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07EL023, 10YC020, 08YC010, 07PE048, 11EM122

Local description author(s): E. Muldavin

Bouteloua eriopoda - Pleuraphis jamesii Herbaceous Vegetation

Black Grama - James' Galleta Herbaceous Vegetation

CODE	CEGL001751
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (MG171)
GROUP	Intermountain Semi-Desert Grassland & Steppe Group (G311)

DISTRIBUTION

Common on the mesa top, Mesa Prieta gravel hills, and below the escarpment in Rinconada canyon

ENVIRONMENTAL DESCRIPTION

This association occurs on all lava flows except lava flow 5 (the volcanoes), and on the ancient sediments of the Ceja formation that underlie the Mesa Prieta gravel hills. It is also known from a sandy site below the escarpment. Sites are typically nearly flat or in slight depressions or small drainages, and exposed basalt is limited. The elevations range from 5,220 to 5,906 ft (1,591 to1,800 m); slopes are gentle (generally <5%), and aspects northerly to easterly to southeasterly.

VEGETATION DESCRIPTION

This grassland is co-dominated by *Pleuraphis jamesii* and *Bouteloua eriopoda* with S*porobolus cryptandrus* often well-represented to abundant. Total grass cover can reach as high as 70% while other grasses are typically scattered and poorly represented (<5% cover overall). Shrubs are scattered, and among the 14 species reported, *Krascheninnikovia lanata, Gutierrezia sarothrae, Opuntia phaeacantha,* and *Opuntia polyacantha* are the most prevalent. Forbs are also scattered and variable, with 28 species recorded for the association. Among perennials, the most common and abundant are *Xanthisma spinulosum* and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Pleuraphis jamesii*
Herb	*Bouteloua eriopoda*
Herb	*Sporobolus cryptandrus*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07AK026, 07EL022, 07PE034, 07EL006, 11YC005, 08YC013, 07PE045, 07EL009, 07PE049, 07EL032, 07AK040, 7AK039, 07EL030, 07EL004, 07PE008, 07PE030, 07PE038, 07AK024, 07PE025, 07PE019, 11YC010, 08YC021, 11YC003, 11EM150, 11EM157, 11EM171, 11EM113, 11EM087, 11EM129, 11EM195, 11EM142, 11EM146, 11EM106, 11EM090, 11EM147, 11EM089, 11EM211, 11YC017, 11EM030, 11EM086

Local description author(s): E. Muldavin

Hesperostipa neomexicana - Pleuraphis jamesii Herbaceous Vegetation

New Mexico Needlegrass - Galleta Grassland

CODE	NHNM000176
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (MG171)
GROUP	Intermountain Semi-Desert Grassland & Steppe Group (G311)

DISTRIBUTION

Common on the northern mesa top, and occasional in the Mesa Prieta gravel hills.

ENVIRONMENTAL DESCRIPTION

This association occurs mostly on lava flows 2 and 3 on the mesa top, and occasionally on the lower slopes of the volcanoes (lava flow 4). It also can occur on the ancient sediments of the Ceja formation that underlie the Mesa Prieta gravel hills. Sites are typically nearly flat with gravelly and sandy soils the norm, with little exposed basalt lava rock. The elevations range from 5,375 to ,5,797 ft (1,638 to 1,767 m); slopes are gentle (generally <5%), and aspects northerly to easterly to southeasterly.

VEGETATION DESCRIPTION

This grassland is co-dominated by *Pleuraphis jamesii* and *Hesperostipa neomexicana* with *Sporobolus cryptandrus* a common associate. Total grass cover can reach as high as 60% while other grasses are typically scattered and poorly represented (<5% cover overall). Shrubs are scattered, and among the five species reported, *Krascheninnikovia lanata*, *Gutierrezia sarothrae*, and *Opuntia polyacantha* are the most prevalent. Forbs are also scattered and variable, with six species recorded for the association. The most common and abundant are *Xanthisma spinulosum* and *Phacelia integrifolia*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Pleuraphis jamesii*
Herb	*Hesperostipa neomexicana*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots:07EL024, 07SS030, 07SS039, 07EL029, 11EM112, 11EM153, 11EM042

Local description author(s): E. Muldavin

Pleuraphis jamesii - Scleropogon brevifolius Herbaceous Vegetation

Galleta - Burrograss Grassland

CODE	NHNM000224
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (MG171)
GROUP	Intermountain Semi-Desert Grassland & Steppe Group (G311)

DISTRIBUTION

Occasional on the southern and western mesa top, and in the Mesa Prieta gravel hills.

ENVIRONMENTAL DESCRIPTION

This association occurs on lava flows 1 and 4 on the on the ancient sediments of the Ceja formation that underlie the Mesa Prieta gravel hills. Sites are typically nearly flat or in slight depressions or small drainages, with little exposed basalt lava rock. The elevations range from 5,799 to 5,439 ft (1,638 to 1,767 m).

VEGETATION DESCRIPTION

This grassland is co-dominated by *Pleuraphis jamesii* and *Scleropogon brevifolius* with *Sporobolus cryptandrus* a common associate. Total grass cover can reach as high as 30% while other grasses are typically scattered and poorly represented (<5% cover overall). Shrubs are scattered, with *Krascheninnikovia lanata, Gutierrezia sarothrae, Opuntia phaeacantha*, and *Opuntia polyacantha* the most prevalent. Forbs are limited, with eight species recorded for the association. Among perennials these may include *Gaura coccinea* and *Rumex hymenosepalus*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Pleuraphis jamesii*
Herb	*Scleropogon brevifolius*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots:07EL024, 07SS030, 07SS039, 07EL029, 11EM112, 11EM153, 11EM042

Local description author(s): E. Muldavin

Pleuraphis jamesii - Sporobolus cryptandrus Herbaceous Vegetation

Galleta - Sand Dropseed Grassland

CODE	NHNM000227
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (MG171)
GROUP	Intermountain Semi-Desert Grassland & Steppe Group (G311)

DISTRIBUTION

Common throughout the monument

ENVIRONMENTAL DESCRIPTION

This association occurs on all lava flows where there is a veneer of wind-deposited sandy soils. It also occurs on Mesa Prieta and the slopes of the Mesa Prieta gravel hills that are underlain by the ancient alluvial sediments of the Ceja formation. In addition, it occurs below the escarpments on sandy sites. Sites are typically nearly flat or in slight depressions or small drainages, and exposed basalt is limited. The elevations range from 5,212 to 5,920 ft (1,589 to 1,804 m). Slopes are generally low (generally <10%) but occasionally stands extend on to steeper hill or escarpment toe slopes (up to 25%). Aspects are variable.

VEGETATION DESCRIPTION

This grassland is co-dominated by *Pleuraphis jamesii* and *Sporobolus cryptandrus* (or *Sporobolus flexuosus* or *Sporobolus contractus*) with total grass canopy cover that can reach 60%. Other grasses are typically scattered and poorly represented (<5% cover overall). Shrubs are scattered, and among the 11 species reported, *Krascheninnikovia lanata*, *Gutierrezia sarothrae*, *Opuntia phaeacantha*, and *Opuntia polyacantha* are the most prevalent. Forbs are also scattered and variable, with 29 species recorded for the association. Among perennials, the most common and abundant are *Xanthisma spinulosum* and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Pleuraphis jamesii*
Herb	*Sporobolus cryptandrus*
Herb	*Sporobolus flexuosus*
Herb	*Sporobolus contractus*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 11YC002, 11YC004, 07SS031, 07AK027, 08SS034, 07EL007, 07SS012, 07SS014, 07SS007, 07EL012, 07SS005, 07PE001, 08YC019, 07SS002, 07PE002, 10YC017, 07EL008, 07AK002, 07SS008, 07SS011, 07AK018, 07EL016, 11EM213, 11EM137, 11EM164, 11EM163, 11EM149, 11EM219, 11EM208, 11EM200, 11EM061, 11EM058, 11EM055, 11EM014, 11EM054, 11EM131, 11EM062, 11EM180, 11EM080, 11EM007, 11EM047, 11EM222, 11EM173, 11EM175, 11EM050, 11EM194

Local description author(s): E. Muldavin

Pleuraphis jamesii Herbaceous Vegetation

James' Galleta Herbaceous Vegetation

CODE	CEGL001777
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (MG171)
GROUP	Intermountain Semi-Desert Grassland & Steppe Group (G311)

DISTRIBUTION

Common throughout the monument.

ENVIRONMENTAL DESCRIPTION

This association occurs on all lava flows where there is a veneer of wind-deposited sandy soils. It also occurs on Mesa Prieta and the slopes of the Mesa Prieta gravel hills that are underlain by the ancient alluvial sediments of the Ceja formation. In addition, it occurs below the escarpments on sandy sites. Sites are typically nearly flat or in slight depressions or small drainages, and exposed basalt is limited. The elevations range from 5,212 to 5,920 ft (1,589 to 1,804 m). Slopes are generally low (generally <10%) but occasionally stands extend on to steeper hill toe slopes (up to 15%). Aspects are variable.

VEGETATION DESCRIPTION

This grassland is dominated by *Pleuraphis jamesii,* with a mixture of other grasses that seldom exceed 5% cover (e.g., *Bouteloua eriopoda, Sporobolus cryptandrus, Aristida purpurea, Hesperostipa neomexicana, Bouteloua gracilis*, and *Achnatherum hymenoides*). Total grass canopy cover that can reach 50%. Shrubs are scattered, and, among the 10 species reported, *Krascheninnikovia lanata, Atriplex canescens, Artemisia filifolia, Gutierrezia sarothrae, Opuntia phaeacantha*, and *Opuntia polyacantha* are the most prevalent. Forbs are also scattered and variable, with 17 species recorded for the association. Among perennials, the most common and abundant are *Xanthisma spinulosum* and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Pleuraphis jamesii*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07SS036, 08YC004, 07AK008, 08YC011, 08SS046, 08SS033, 07SS003, 08SS049, 07AK059, 07AK058, 07EL020, 07AK057, 07SS020, 07AK022, 11EM092, 11EM136, 11EM132, 11EM021, 11EM105, 11EM210, 11EM017, 11EM130, 11EM013, 11EM143, 11EM075, 11EM070, 11EM063, 11EM027, 11EM025

Local description author(s): E. Muldavin

Artemisia bigelovii / Bouteloua eriopoda Dwarf-shrub Herbaceous Vegetation

Bigelow Sagebrush / Black Grama Dwarf-shrub Herbaceous Vegetation

CODE	CEGL001741
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin & Intermountain Dwarf Sage Shrubland & Steppe (MG170)
GROUP	Intermountain Low & Black Sagebrush Shrubland & Steppe Group (G308)

DISTRIBUTION

Occasional on the western mesa top and on the Volcanoes, and on the mesa top at Piedras Marcadas.

ENVIRONMENTAL DESCRIPTION

This association occurs on rocky sites within the lava flows on the mesa top. Stands are often associated with exposed lava pressure ridges or collapse features where there is little soil accumulation. The elevations range from 5,260 to 5,910 ft (1,603 to 1,801 m); slopes are gentle (<10%) and aspects northerly.

VEGETATION DESCRIPTION

This shrub-steppe is characterized by the prevalence of the subshrub *Artemisia bigelovii*, which can be well represented to abundant. *Bouteloua eriopoda* is the usual grass dominant, but S*porobolus cryptandrus* may be the most abundant in some stands. Grass canopy cover, while often sparse, can reach 40% on some sites. Of the eight other grasses, the most common are *Pleuraphis jamesii* and *Dasyochloa pulchella*. Shrubs are scattered, and among the eight species reported, *Krascheninnikovia lanata* and *Ephedra torreyi* are the most prevalent along with *Gutierrezia sarothrae* and *Opuntia polyacantha*. Forbs are also scattered and variable, with 22 species recorded for the association. Among perennials, the most common and abundant are *Physaria fendleri, Astragalus lentiginosus* var. *diphysus*, and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Artemisia bigelovii*
Herb	*Bouteloua eriopoda*
Herb	*Sporobolus cryptandrus*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 08YC003, 07EL011, 07AK009, 07PE063, 07PE057, 07PE013, 07PE062, 11EM148

Local description author(s): E. Muldavin

Atriplex canescens Cinder Shrubland

Fourwing Saltbush Cinder Shrubland

CODE	NHNM000841
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin Saltbrush Scrub (MG093)
GROUP	Intermountain Shadscale - Saltbush Scrub Group (G300)

DISTRIBUTION

Known from the Volcanoes on the west side of the park.

ENVIRONMENTAL DESCRIPTION

This association occurs on the northerly slopes of volcanoes (lava flows 3 and 5) and within the vents of the cones. Sites are typified by extensive exposed rocks and boulders composed of basalt cinder and scoria (10-40% of the ground cover). Elevations range from 5,775 to 6,001 ft (1,760 to 1,829 m); slopes are moderate (10-30%).

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Atriplex canescens* with *Gutierrezia sarothrae,* a common sub-shrub associate. The shrub understories and inter-shrub spaces are often sparsely vegetated, but cover can reach 10%. The most abundant grasses are *Muhlenbergia porteri, Sporobolus cryptandrus, Sporobolus contractus*, and *Bouteloua eriopoda*. Forbs are variable, but in years where rainfall is favorable, annuals may be abundant (e.g., *Kallstroemia parviflora, Cuscuta umbellata, Tidestromia lanuginosa, Trianthema portulacastrum, Amaranthus torreyi, Chamaesyce micromera, Cryptantha crassisepala, Portulaca oleracea*, *Polanisia dodecandra ssp. Trachysperma, Astragalus nuttallianus¸ Eriogonum abertianum*, *Lappula occidentalis*, and *Euphorbia exstipulata*).

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Atriplex canescens*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 10YC021, 07AK016, 07YC002, 07SS001, 10YC016, 07AK014, 11EM138, 11EM155, 11EM156

Local description author(s): E. Muldavin

Atriplex canescens Lava Flow Shrubland

Fourwing Saltbush Lava Flow Shrubland

CODE	NHNM000837
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin Saltbrush Scrub (MG093)
GROUP	Intermountain Shadscale - Saltbush Scrub Group (G300)

DISTRIBUTION

Common along the eastern edge of the mesa top near the escarpment.

ENVIRONMENTAL DESCRIPTION

This association occurs mostly on nearly flat sites on the older lava flows 1 and 2 near the edge of the escarpments. On these sites, there is a thin veneer of gravels and sandy aeolian deposits over the lava, and extensive areas of exposed minimally weathered basalt rock (up to 30%). The elevations range from 5,305 to 5,367 ft (1,617 to 1,636 m).

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of Atriplex canescens with Gutierrezia sarothrae a common sub-shrub associate. The shrub understories and inter-shrub spaces are sparsely vegetated (<5% cover). The most common grasses are Aristida purpurea and Pleuraphis jamesii. Forbs are variable and scattered. Among perennials, the most common and abundant are Astragalus lentiginosus var. diphysus, Chaetopappa ericoides, Physaria fendleri, Stephanomeria pauciflora, and Allionia incarnata.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Atriplex canescens*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07AK042, 08YC017, 11EM024

Local description author(s): E. Muldavin

Atriplex canescens Rockland Shrubland

Fourwing Saltbush Rockland Shrubland

CODE	NHNM000839
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin Saltbrush Scrub (MG093)
GROUP	Intermountain Shadscale - Saltbush Scrub Group (G300)

DISTRIBUTION

Common on the eastern escarpment and on the volcanoes escarpment.

ENVIRONMENTAL DESCRIPTION

This association occurs on steep (30-60%), basalt, boulder-strewn escarpment slopes associated with lava flows 1 and 2. Elevations range from 5,226 to 5,920 ft (1,593 to 1,804 m); aspects are generally southerly.

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Atriplex canescens* with a sparse to grassy understory dominated by *Bouteloua eriopoda*, *Muhlenbergia porteri*, and *Setaria leucopila*. *Gutierrezia sarothrae* is a common sub-shrub associate. Forbs are variable; the most consistent species are *Physaria fendleri* and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Atriplex canescens*
Herb	*Bouteloua eriopoda*
Herb	*Muhlenbergia porteri*
Herb	*Setaria leucopila*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07EL001, 08YC018, 07PE033, 08YC012, 07AK051, 07SS025, 07PE061, 07PE060, 11EM189, 11EM038, 11EM035

Local description author(s): E. Muldavin

Atriplex canescens / Pleuraphis jamesii Shrubland

Fourwing Saltbush / James' Galleta Shrubland

CODE	CEGL001288
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin Saltbrush Scrub (MG093)
GROUP	Intermountain Shadscale - Saltbush Scrub Group (G300)

DISTRIBUTION

Known from the eastern escarpment, particularly in the "Gooseneck" from Boca Negra to Homestead Circle.

ENVIRONMENTAL DESCRIPTION

This association occurs mostly on nearly flat sites on the older lava flows 1, 2 and 3 near the edge of the escarpment. On these sites, there is a thin veneer of gravels and sandy aeolian deposits over the lava. The elevations range from 5,247 to 5,518 ft (1,599 to 1,682 m).

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Atriplex canescens* with grassy inter-shrub spaces dominated by *Pleuraphis jamesii*. *Gutierrezia sarothrae* is a common sub-shrub associate. *Artemisia filifolia* can be present but is clearly subordinate. Other common grasses include *Sporobolus cryptandrus, Sporobolus contractus, Aristida purpurea, Bouteloua eriopoda*, and *Hesperostipa neomexicana*. Forbs are variable and scattered. Among perennials, the most common and abundant are S*olanum elaeagnifolium* and *Sphaeralcea hastulata*.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Atriplex canescens*
Herb	*Pleuraphis jamesii*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 08YC006, 08SS044, 08YC016, 08SS045, 11EM183, 11EM184

Local description author(s): E. Muldavin

Atriplex canescens / Sparse Shrubland

Fourwing Saltbush / Sparse Undergrowth Shrubland

CODE	NHNM000354
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin Saltbrush Scrub (MG093)
GROUP	Intermountain Shadscale - Saltbush Scrub Group (G300)

DISTRIBUTION

Common on the mesa top and east of the volcanoes, and below the escarpment.

ENVIRONMENTAL DESCRIPTION

This association occurs on lava sites with a thin veneer of wind-deposited sands with extensive exposed basalt. It is also associated with sand dune areas below the escarpment, drainage way dry washes, and human-disturbed areas. The elevation is about 5,525 ft (1,680 m); slopes are generally gentle (<5%) and aspects variable.

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Atriplex canescens* with *Psorothamnus scoparius* and *Artemisia filifolia* as common shrub associates. The shrub understories and inter-shrub spaces are sparsely vegetated, i.e., perennial cover seldom exceeds 1%.

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Artemisia filifolia*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 10YC022

Local description author(s): E. Muldavin

Atriplex canescens / Sporobolus flexuosus (S. cryptandrus, S. contractus) Shrubland

Fourwing Saltbush / Mesa (Sand, Spike) Dropseed Shrubland

CODE	NHNM000356
PHYSIOGNOMIC CLASS	Semi-Desert (Xeromorphic Scrub & Herb Vegetation) (3)
PHYSIOGNOMIC SUBCLASS	Cool Semi-Desert Scrub & Grassland (3.B)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.a)
MACROGROUP	Great Basin Saltbrush Scrub (MG093)
GROUP	Intermountain Shadscale - Saltbush Scrub Group (G300)

DISTRIBUTION

Common below the eastern escarpment of the mesa.

ENVIRONMENTAL DESCRIPTION

This association occurs along drainage ways and sandy areas below the escarpment. The elevations range from 5,139 to 5,310 ft (1,566 to 1,618 m); slopes range from gentle (3-10%) up to 20%, and aspects are southerly.

VEGETATION DESCRIPTION

This shrubland is characterized by an open canopy of *Atriplex canescens* with sparsely vegetated shrub understories and inter-shrub spaces. *Psorothamnus scoparius* and *Atriplex canescens* may be present but clearly subordinate. Among grasses, *Sporobolus cryptandrus, Sporobolus flexuosus*, and *Setaria leucopila* are the most common. Forbs are variable and low in cover. That is, perennial cover seldom exceeds 1% , but annuals, on years where rainfall is favorable, may be abundant (e.g., *Croton texensis, Dimorphocarpa wislizeni, Dieteria canescens* var. *glabra, Plantago patagonica, Mollugo cerviana, Cryptantha crassisepala, Palafoxia sphacelata, Amaranthus acanthochiton, Phacelia integrifolia, Nama hispidum, Linum aristatum, Euphorbia exstipulata, Iva ambrosiifolia, Proboscidea louisianica*, and *Tribulus terrestris*).

MOST ABUNDANT SPECIES

Stratum	Species
Shrub/sapling (tall & short)	*Atriplex canescens*
Herb	*Sporobolus cryptandrus*
Herb	*Sporobolus flexuosus*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07SS027, 08SS042, 07AK034, 10YC019, 10YC012, 07SS021, 08SS043, 11EM190, 11EM012, 11EM015

Local description author(s): E. Muldavin

IV. Nonvascular & Sparse Vascular Rock Vegetation (Lithomorphic Vegetation)

Sparse Vegetation / Boulder Rockland

Sparse Vegetation / Boulder Rockland

CODE	NPS_NM013
PHYSIOGNOMIC CLASS	Nonvascular & Sparse Vascular Rock Vegetation (Lithomorphic Vegetation) (6)
PHYSIOGNOMIC SUBCLASS	Semi-Desert Nonvascular & Sparse Vascular Vegetation (6.C)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Cliff, Scree & Rock Vegetation (6.C.1)
PHYSIOGNOMIC DIVISION	Warm Semi-Desert Cliff, Scree & Rock Vegetation (6.C.1.a)
MACROGROUP	North American Warm Semi-Desert Cliff, Scree & Rock Vegetation (MG117)
GROUP	North American Warm Semi-Desert Cliff, Scree & Pavement Sparse Vegetation Group (G569)

DISTRIBUTION

Common on the eastern escarpment and Volcanoes Escarpment

ENVIRONMENTAL DESCRIPTION

This sparsely vegetated land cover type is characterized by large boulder scree derived from the basalt lava of lava flows 1, 2 and 3.

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 07AK053, 07AK050

Local description author(s): E. Muldavin

Sparse Vegetation / Lava Flow

Sparse Vegetation / Lava Flow

CODE	NPS_NM067
PHYSIOGNOMIC CLASS	Nonvascular & Sparse Vascular Rock Vegetation (Lithomorphic Vegetation) (6)
PHYSIOGNOMIC SUBCLASS	Semi-Desert Nonvascular & Sparse Vascular Vegetation (6.C)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Cliff, Scree & Rock Vegetation (6.C.1)
PHYSIOGNOMIC DIVISION	Warm Semi-Desert Cliff, Scree & Rock Vegetation (6.C.1.a)
MACROGROUP	North American Warm Semi-Desert Cliff, Scree & Rock Vegetation (MG117)
GROUP	North American Warm Semi-Desert Cliff, Scree & Pavement Sparse Vegetation Group (G569)

DISTRIBUTION

Common on the mesa top.

ENVIRONMENTAL DESCRIPTION

This sparsely vegetated land cover type is characterized by extensive areas of exposed basalt lava that have been little weathered or have a thin veneer of wind-deposited sands on lava flows 1, 2 and 3.

VEGETATION DESCRIPTION

Sparsely vegetated.

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 08SS040

Local description author(s): E. Muldavin

Sparse Vegetation / Sand

Sparse Vegetation / Sand

CODE	NHNM000851
PHYSIOGNOMIC CLASS	Nonvascular & Sparse Vascular Rock Vegetation (Lithomorphic Vegetation) (6)
PHYSIOGNOMIC SUBCLASS	Semi-Desert Nonvascular & Sparse Vascular Vegetation (6.C)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Cliff, Scree & Rock Vegetation (6.C.1)
PHYSIOGNOMIC DIVISION	Warm Semi-Desert Cliff, Scree & Rock Vegetation (6.C.1.a)
MACROGROUP	North American Warm Semi-Desert Cliff, Scree & Rock Vegetation (MG117)
GROUP	North American Warm Semi-Desert Cliff, Scree & Pavement Sparse Vegetation Group (G569)

DISTRIBUTION

Common below the escarpment.

ENVIRONMENTAL DESCRIPTION

This sparsely vegetated land cover type is characterized by extensive areas of exposed sands forming sand sheets and dunelands, and the bottoms of dry washes.

VEGETATION DESCRIPTION

Sparsely vegetated.

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: NA

Local description author(s): E. Muldavin

Sparse Vegetation / Bare Ground

Sparse Vegetation / Bare Ground

CODE	NPS_NM073
PHYSIOGNOMIC CLASS	Nonvascular & Sparse Vascular Rock Vegetation (Lithomorphic Vegetation) (6)
PHYSIOGNOMIC SUBCLASS	Semi-Desert Nonvascular & Sparse Vascular Vegetation (6.C)
PHYSIOGNOMIC FORMATION	Warm Semi-Desert Cliff, Scree & Rock Vegetation (6.C.1)
PHYSIOGNOMIC DIVISION	Warm Semi-Desert Cliff, Scree & Rock Vegetation (6.C.1.a)
MACROGROUP	North American Warm Semi-Desert Cliff, Scree & Rock Vegetation (MG117)
GROUP	North American Warm Semi-Desert Cliff, Scree & Pavement Sparse Vegetation Group (G569)

DISTRIBUTION

Occasional throughout the park.

ENVIRONMENTAL DESCRIPTION

This sparsely vegetated land cover type is characterized by extensive areas of exposed soils that are typically the result of recent disturbance, natural and human.

VEGETATION DESCRIPTION

Sparsely vegetated.

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 11EM205, 07PE046,11EM111, 08YC022, 11YC011, 11YC015

Local description author(s): E. Muldavin

Ruderal Disturbance Vegetation

Weedy Disturbance Vegetation

CODE	NPS_NM027
PHYSIOGNOMIC CLASS	Miscellaneous Vegetation (0)
PHYSIOGNOMIC SUBCLASS	Miscellaneous Vegetation (0.0)
PHYSIOGNOMIC FORMATION	Miscellaneous Vegetation (0.0.0)
PHYSIOGNOMIC DIVISION	Miscellaneous Vegetation (0.0.0.0)
MACROGROUP	Miscellaneous Vegetation (MGSWU)
GROUP	Miscellaneous Vegetation Group (GSWU)

DISTRIBUTION

Common throughout the park.

ENVIRONMENTAL DESCRIPTION

Recently disturbed sites, natural and human.

VEGETATION DESCRIPTION

This is a mixed association typically dominated herbaceous species tolerant of human disturbance and may include both natives and exotics (e.g., Solanum elaeagnifolium, Cirsium undulatum, Salsola tragus, and Elymus elymoides)

MOST ABUNDANT SPECIES

Stratum	Species
Herb	*Solanum elaeagnifolium*
Herb	*Cirsium undulatum*
Herb	*Salsola tragus*
Herb	*Elymus elymoides*

ELEMENT SOURCES

Data: Petroglyph National Monument PLOTS.MDB database available at: http://biology.usgs.gov/npsveg/products/parkname.html

NHNM Plots: 11EM205, 07PE046,11EM111, 08YC022, 11YC011, 11YC015

Local description author(s): E. Muldavin

Appendix E: Level 2 Map Unit Summaries

Appendix E contains the map unit summaries for the vegetation map of Petroglyph National Monument, based on Table 5 of the main report. For each Level 2 map unit, we provide a description with the following:

- The name of the level 1 map unit (the top-most line) that each level 2 map unit falls under
- A list of primary and secondary plant association components, related and contrasting inclusions, if applicable (see main report for definitions)
- Elevation range derived from the GIS
- A summary of the distribution, environment, and floristic composition of the unit
- A representative ground photograph
- A distribution map of the unit where polygons are filled in with black against a backdrop of shaded relief and elevation
- An image map showing the delineation of a representative polygon(s) in the 2004 color aerial photography
- The total hectares and acres of the unit and number of polygons as derived from the GIS

1 Southern Rocky Mountain Juniper Woodland and Savanna

A Oneseed Juniper Savanna Woodland Draw

Area	21.8 ha, 53.9 ac
Polygons	18
Primary component associations	*Juniperus monosperma* / *Bouteloua eriopoda* Woodland
Secondary component associations	*Fallugia paradoxa* Arroyo Wash Shrubland
Related inclusions	*Artemisia filifolia* / Sparse Undergrowth Shrubland
Elevation	5347–5790 ft (1630–1764 m)
Summary	Open woodland characterized by scattered oneseed junipers with an often grassy ground cover dominated by black grama. It occurs along drainage ways and draws across the mesa top volcanic field. Often intermixed with shrubs such as Apache plume and sand sagebrush.

Figure E-1. Ground photo of map unit 1A.

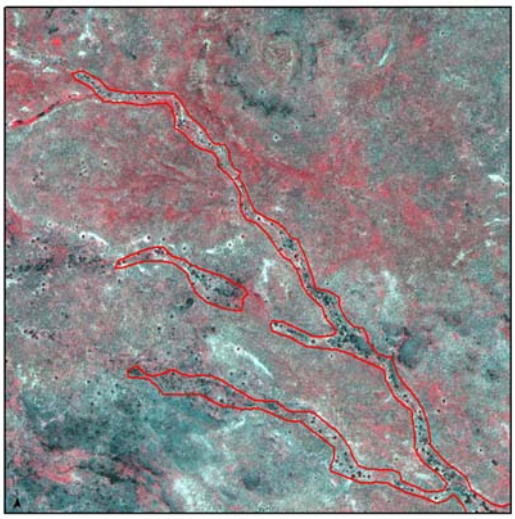

Figure E-2. Distribution of the polygons (in black) of map unit 1A.

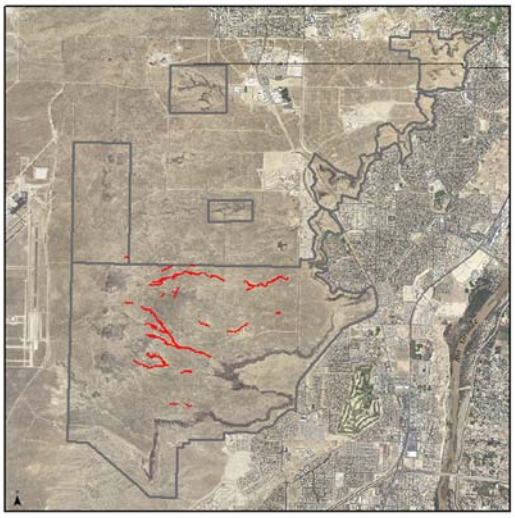

Figure E-3. Aerial photo of a representative polygon of map unit 1A.

2 Great Plains Sand Shrubland

A Sand Sagebrush Mesa Shrubland

Area	60.5 ha, 149.5 ac
Polygons	59
Primary component associations	*Artemisia filifolia* / *Bouteloua eriopoda* Shrubland
Secondary component associations	*Artemisia filifolia* / *Hesperostipa neomexicana Shrubland, Artemisia filifolia* / Sparse Undergrowth Shrubland
Related inclusions	*Artemisia filifolia* / *Sporobolus cryptandrus* Shrubland, *Artemisia filifolia* / *Pleuraphis jamesii* Shrubland, *Psorothamnus scoparius* / *Sporobolus flexuosus* Shrubland, Sparse Vegetation / Sand
Elevation	5204–5833 ft (1586–1778 m)
Summary	Sand sagebrush-dominated shrublands that typically have grassy understories with a mix of species such as black grama, New Mexico feathergrass, sand dropseed, or galleta. Found as scattered stands across the mesa top in all park units and on the slopes of the Mesa Prieta gravel hills to the south.

Figure E-4. Ground photo of map unit 2A.

Figure E-5. Distribution of the polygons (in black) of map unit 2A.

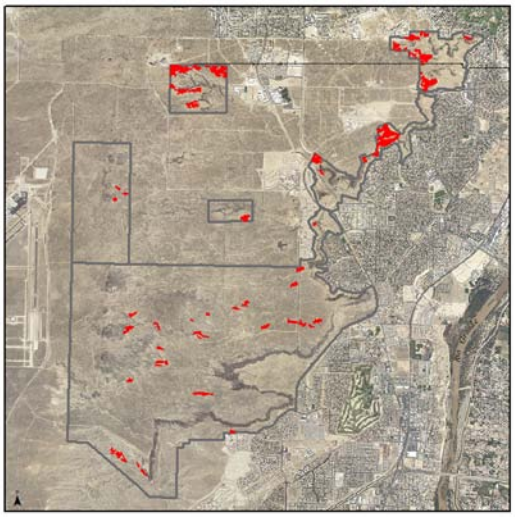

Figure E-6. Aerial photo of a representative polygon of map unit 2A.

3 Intermountain Shadscale-Saltbush Scrub

A Fourwing Saltbush Mesa Shrubland

Area	26.5 ha, 65.4 ac
Polygons	19
Primary component associations	*Atriplex canescens* / *Pleuraphis jamesii* Shrubland
Secondary component associations	*Atriplex canescens* / *Sporobolus flexuosus (S. cryptandrus, S. contractus)* Shrubland
Related inclusions	*Atriplex canescens* Lava Flow Shrubland, *Atriplex canescens* / Sparse Shrubland, Sparse Vegetation / Sand
Elevation	5161–5812 ft (1573–1771 m)
Summary	Fourwing saltbush-dominated shrublands with ground surface ranging from barren lava to moderate grass cover with such species as galleta and sand dropseed. Occurs as scattered stands across the mesa top and particularly on shallow lava soils near the eastern mesa edge.

Figure E-7. Ground photo of map unit 3A.

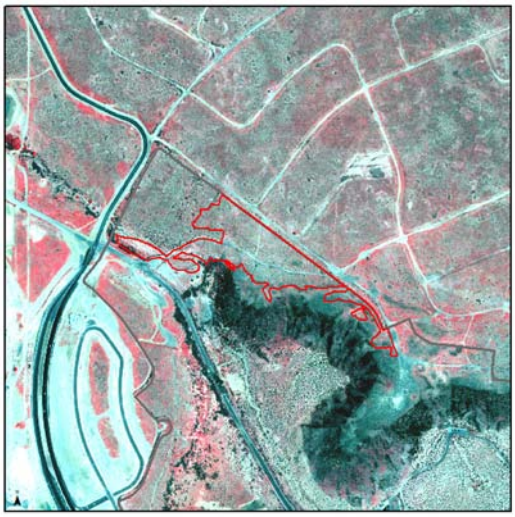

Figure E-8. Distribution of the polygons (in black) of map unit 3A.

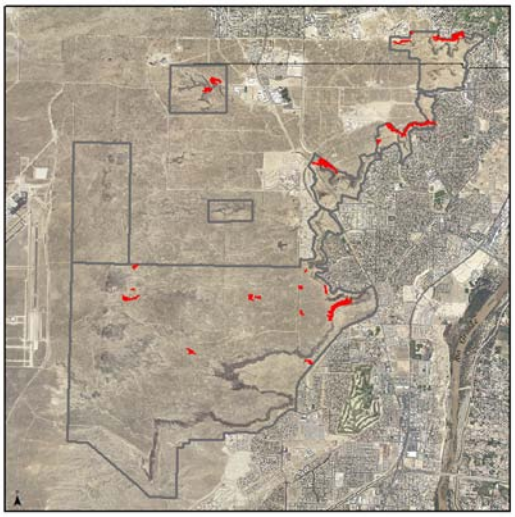

Figure E-9. Aerial photo of a representative polygon of map unit 3A.

3 Intermountain Shadscale-Saltbush Scrub

B Fourwing Saltbush Foothilll-Volcano Shrubland

Area	14.4 ha, 35.6 ac
Polygons	10
Primary component associations	*Atriplex canescens* Rockland Shrubland,
Secondary component associations	*Atriplex canescens* Cinder Shrubland, *Bouteloua eriopoda - Muhlenbergia porteri - Setaria leucopila* Mixed Herbaceous Rockland Vegetation
Elevation	5696–6031 ft (1736–1838 m)
Summary	Fourwing saltbush-dominated shrublands found on the slopes of the volcanic vents along the western side. Sites are often steep and rocky with scattered grasses such as bush muhly and black grama along with weedy forbs. Some sites have been significantly impacted by historical mining and are essentially barren of cover.

Figure E-10. Ground photo of map unit 3B.

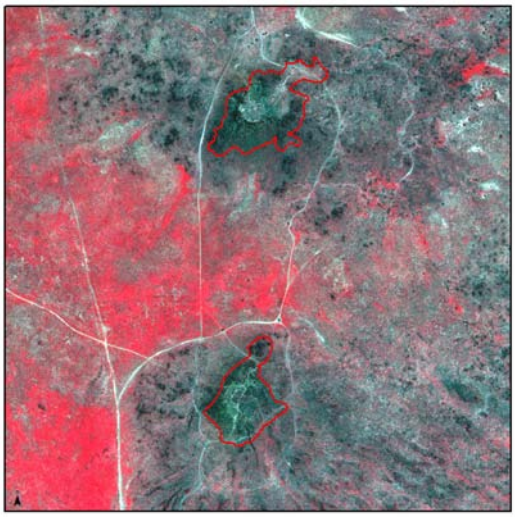

Figure E-11. Distribution of the polygons (in black) of map unit 3B.

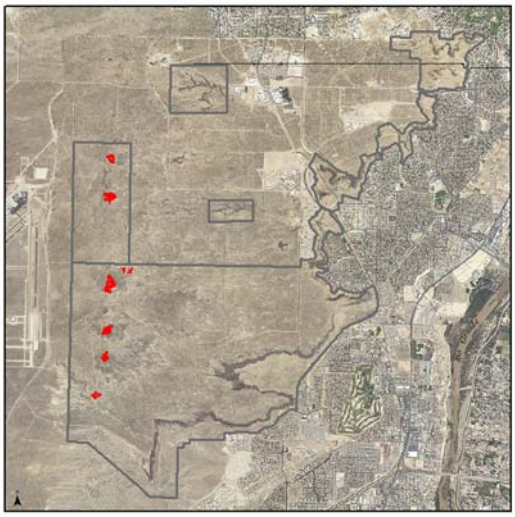

Figure E-12. Aerial photo of a representative polygon of map unit 3B.

4 Mixed Semi-Desert Shrubland

A Fourwing Saltbush-Sand Sagebrush-Lava Cliff Shrubland

Area	111.3 ha, 275.1 ac
Polygons	65
Primary component associations	*Atriplex canescens* Rockland Shrubland, *Artemisia filifolia* Rockland Shrubland
Secondary component associations	*Aloysia wrightii* / *Muhlenbergia porteri* Rockland Shrubland
Related inclusions	Sparse Vegetation / Boulder Rockland
Elevation	5147–5754 ft (1568–1754 m)
Summary	Mixed shrublands found on the steep boulder-strewn slopes of lava flow escarpments. These are open shrublands dominated or codominated by fourwing saltbush, sand sagebrush and Wright's beebrush, and occasionally by Apache plume and skunkbush sumac. Understories are variable but often grassy with such species as bush muhly and streambed bristlegrass.

Figure E-13. Ground photo of map unit 4A.

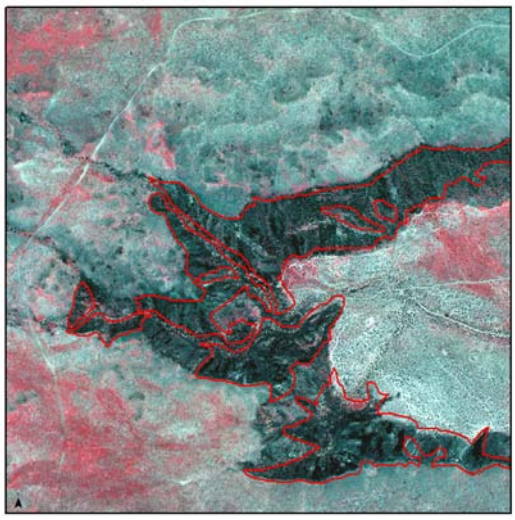

Figure E-14. Distribution of the polygons (in black) of map unit 4A.

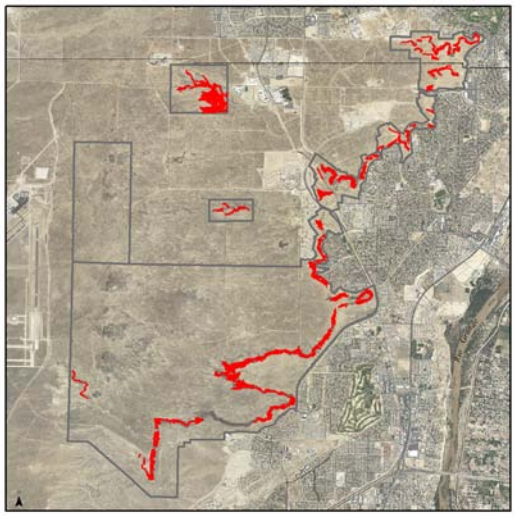

Figure E-15. Aerial photo of a representative polygon of map unit 4A.

4 Mixed Semi-Desert Shrubland

B Sand Sagebush-Broom Dalea-Fourwing Saltbush Sand Shrubland

Area	257.1 ha, 635.4 ac
Polygons	82
Primary component associations	*Artemisia filifolia* / Sparse Undergrowth Shrubland, *Artemisia filifolia* / *Sporobolus cryptandrus* Shrubland, *Psorothamnus scoparius* / *Sporobolus flexuosus* Shrubland
Secondary component associations	*Atriplex canescens* / *Sporobolus flexuosus (S. cryptandrus, S. contractus)* Shrubland
Related inclusions	*Artemisia filifolia* / *Bouteloua eriopoda* Shrubland, *Atriplex canescens* / Sparse Shrubland, Sparse Vegetation / Sand
Elevation	5104–5663 ft (1556–1726 m)
Summary	Mixed shrublands found on sandy plains and dunelands along the base of the mesa escarpment on the eastern side. These sparse to moderate-canopied shrublands are dominated or co-dominated by sand sagebrush, broom dalea, and fourwing saltbush. The understories are typically sparse with only scattered grasses and forbs, although in favorable rainfall years, annuals can be abundant.

Figure E-16. Ground photo of map unit 4B.

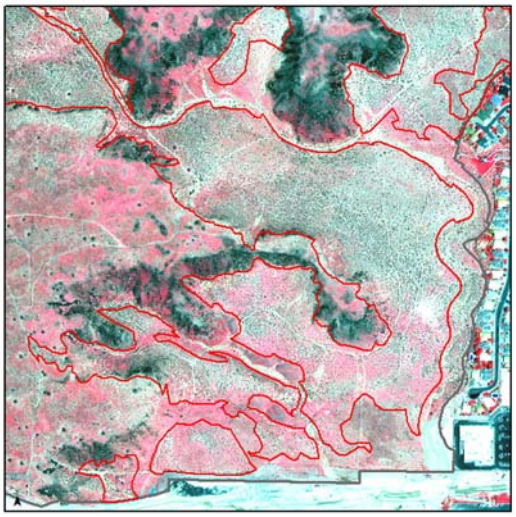

Figure E-17. Distribution of the polygons (in black) of map unit 4B.

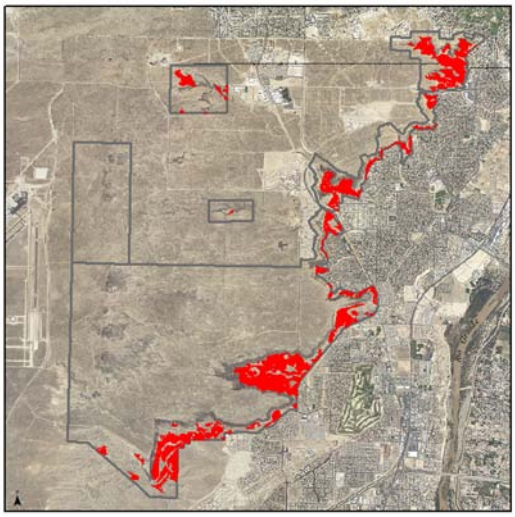

Figure E-18. Aerial photo of a representative polygon of map unit 4B.

5 Warm Semi-Desert Shrub & Herb Wash-Arroyo

A Apache Plume-Sand Sagebrush Dry Wash Shrubland

Area	61.2 ha, 151.2 ac
Polygons	46
Primary component associations	*Fallugia paradoxa* Arroyo Wash Shrubland
Secondary component associations	*Artemisia filifolia* / Sparse Undergrowth Shrubland, *Artemisia filifolia* / *Sporobolus cryptandrus* Shrubland
Related inclusions	*Atriplex canescens* / Sparse Shrubland, *Celtis laevigata* var. *reticulata* Canyon Woodland, Sparse Vegetation / Bare Ground, Sparse Vegetation / Sand
Elevation	5135 –5835 ft (1565–1778 m)
Summary	Open shrublands of ephemeral drainages (dry washes or arroyos) on the mesa, among the Ceja hills, and through the sandy lands below the escarpment. Apache plume, sand sagebrush, or occasionally fourwing saltbush dominate the shrubs while the understories range from sparse gravel beds to grass-covered alluvial terraces. Netleaf hackberry is also occasionally found in the canyon drainages of the escarpment itself.

Figure E-19. Ground photo of map unit 5A.

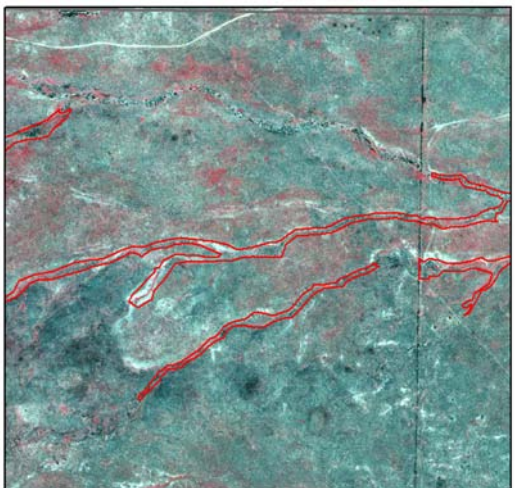

Figure E-20. Distribution of the polygons (in black) of map unit 5A.

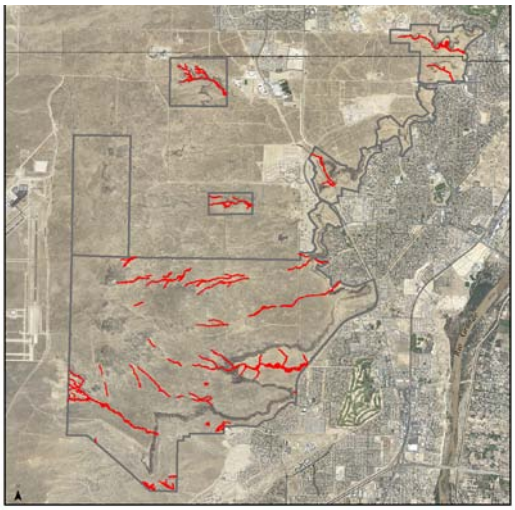

Figure E-21. Aerial photo of a representative polygon of map unit 5A.

5 Warm Semi-Desert Shrub & Herb Wash-Arroyo

B Desert Willow-Sand Sagebrush Dry Wash Shrubland

Area	50.3 ha, 124.2 ac
Polygons	4
Primary component associations	*Chilopsis linearis* - *Artemisia filifolia* Shrubland
Secondary component associations	*Artemisia filifolia* / Sparse Undergrowth Shrubland, *Artemisia filifolia* / *Sporobolus cryptandrus* Shrubland
Related inclusions	*Atriplex canescens* / Sparse Shrubland, Sparse Vegetation / Bare Ground, Sparse Vegetation / Sand
Elevation	5258–5731 ft (1602–1747 m)
Summary	Open shrublands found along the larger epheremal dranages (dry washes or arroyos) draining the Mesa Prieta gravel hills along the southern boundary. Here the drainages are dominated by desert willow and sand sagebrush, and occasionally fourwing saltbush interspersed with barren gravel and sand bars along the braided channels of the wash.

Figure E-22. Ground photo of map unit 5B.

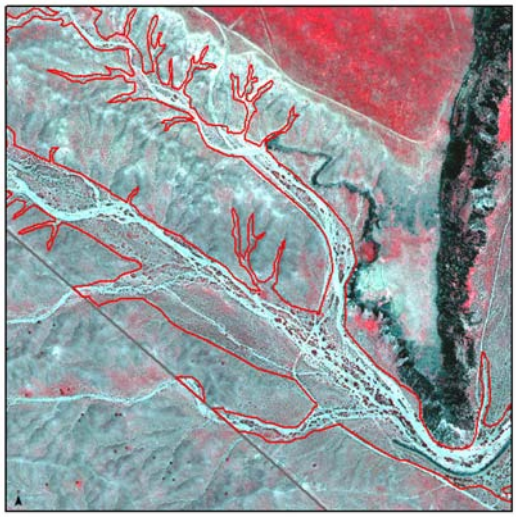

Figure E-23. Distribution of the polygons (in black) of map unit 5B.

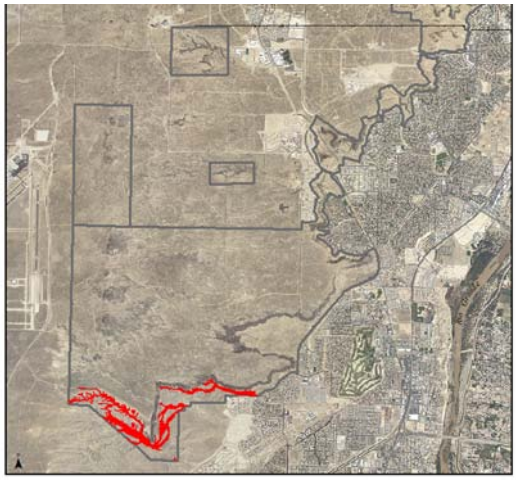

Figure E-24. Aerial photo of a representative polygon of map unit 5B.

6 Great Plains Shortgrass Prairie

A New Mexico Feathergrass-Black Grama Gravelly Grassland

Area	13.1 ha, 32.4 ac
Polygons	12
Primary component associations	*Bouteloua eriopoda - Hesperostipa neomexicana* Herbaceous Vegetation
Secondary component associations	*Hesperostipa neomexicana* Mixed Prairie Herbaceous Vegetation
Related inclusions	*Hesperostipa neomexicana - Pleuraphis jamesii* Herbaceous Vegetation
Elevation	5569 –5748 ft (1697–1752 m)
Summary	New Mexico feathergrass and black grama grasslands of the upper slopes and summits of the Mesa Prieta gravel hills along the southern boundary. May also include galleta grass as a codominant.

Figure E-25. Ground photo of map unit 6A.

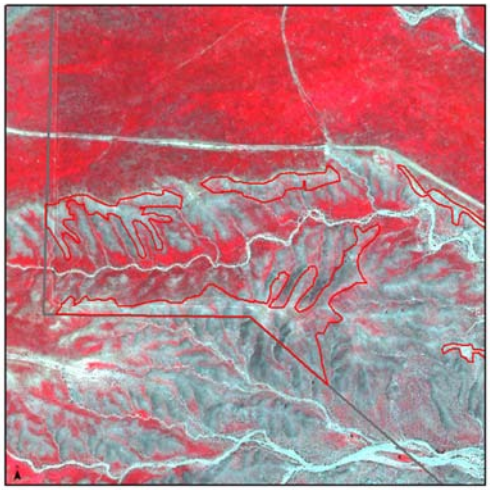

Figure E-26. Distribution of the polygons (in black) of map unit 6A.

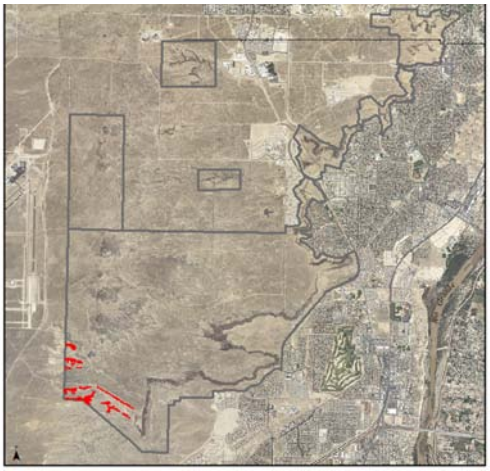

Figure E-27. Aerial photo of a representative polygon of map unit 6A

6 Great Plains Shortgrass Prairie

B New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland

Area	503.8 ha, 1244.9 ac
Polygons	41
Primary component associations	*Bouteloua eriopoda - Hesperostipa neomexicana* Herbaceous Vegetation
Secondary component associations	*Hesperostipa neomexicana* Mixed Prairie Herbaceous Vegetation
Related inclusions	*Hesperostipa neomexicana - Sporobolus cryptandrus* Herbaceous Vegetation, *Bouteloua eriopoda* Semi-desert Herbaceous Vegetation
Elevation	5320–5954 ft (1621–1810 m)
Summary	New Mexico feathergrass and black grama grasslands found mostly on the eastern slopes of the volcanoes extending eastward and downslope to mid-mesa. Mostly grasslands of lava flows 3, 4, and 5. Feathergrass is usually the dominant or codominant with black grama but other grasses such as galleta and sand dropseed may be common.

Figure E-28. Ground photo of map unit 6B.

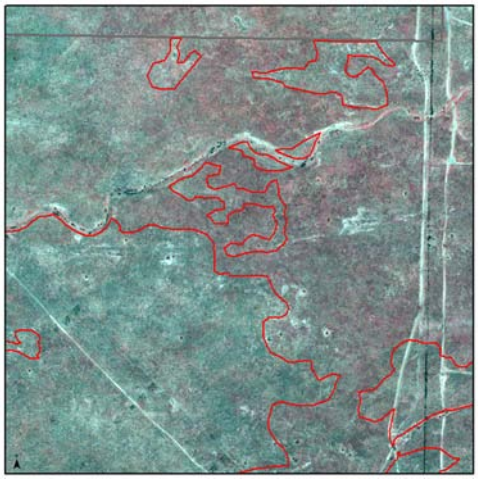

Figure E-29. Distribution of the polygons (in black) of map unit 6B.

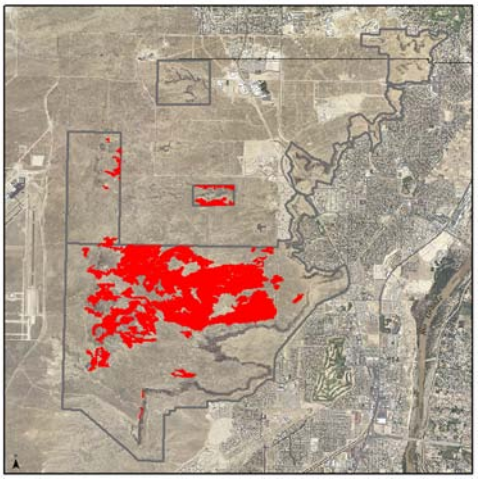

Figure E-30. Aerial photo of a representative polygon of map unit 6B.

6 Great Plains Shortgrass Prairie

C New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland with Juniper

Area	33.8 ha, 83.6 ac
Polygons	7
Primary component associations	*Bouteloua eriopoda - Hesperostipa neomexicana* Herbaceous Vegetation
Secondary component associations	*Juniperus monosperma / Bouteloua eriopoda* Woodland
Related inclusions	*Hesperostipa neomexicana* Mixed Prairie Herbaceous Vegetation
Elevation	5271–5882 ft (1606 –1792 m)
Summary	New Mexico feathergrass and black grama grasslands with scattered oneseed junipers found mostly on the eastern slopes of the volcanoes extending eastward and downslope to mid-mesa. Mostly grasslands of lava flows 3, 4, and 5. Feathergrass is usually the dominant or codominant with black grama but other grasses such as galleta and sand dropseed may be common. This a variant of 6B that is found on somewhat rockier sites such as lava pressure ridges.

Figure E-31. Ground photo of map unit 6C.

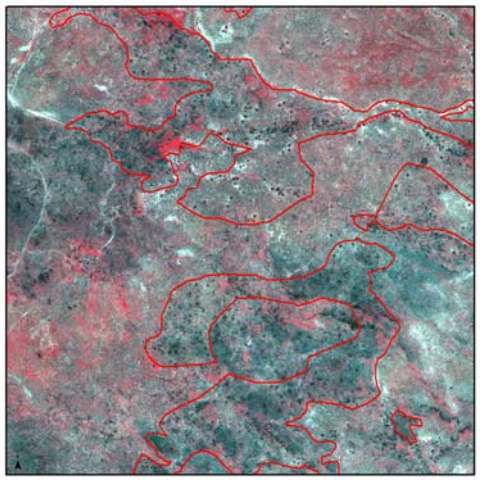

Figure E-32. Distribution of the polygons (in black) of map unit 6C.

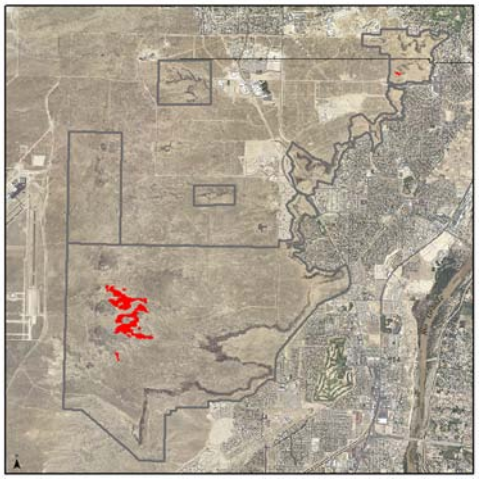

Figure E-33. Aerial photo of a representative polygon of map unit 6C.

7 Intermountain Semi-Desert Grassland

A Galleta-Black Grama-New Mexico Feathergrass Mesa Grassland

Area	612.2 ha, 1512.8 ac
Polygons	97
Primary component associations	*Pleuraphis jamesii - Sporobolus cryptandrus* Herbaceous Vegetation, *Pleuraphis jamesii* Herbaceous Vegetation
Secondary component associations	*Bouteloua eriopoda Pleuraphis jamesii* Herbaceous Vegetation, *Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus)* Herbaceous Vegetation, *Bouteloua eriopoda* Semi-desert Herbaceous Vegetation
Related inclusions	*Hesperostipa neomexicana - Pleuraphis jamesii* Herbaceous Vegetation, *Bouteloua eriopoda - Hesperostipa neomexicana* Herbaceous Vegetation
Elevation	5209 to 5878 ft (1587–1791 m)
Summary	Galleta-dominated grasslands with black grama and/or New Mexico feathergrass as codominants. This grassland is associated with gently sloping terrains of lava flows 2, 3, and 4 along the western front of the volcanoes, lava surfaces overlain with alluvium and coluvium in the southern mesa area, and along the low rim of the mesa to the north.

Figure E-34. Ground photo of map unit 7A.

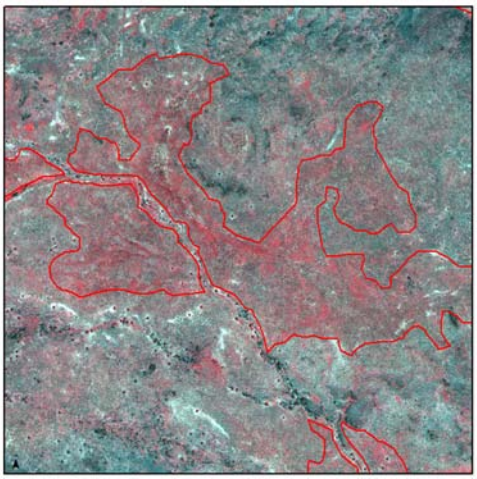

Figure E-35. Distribution of the polygons (in black) of map unit 7A.

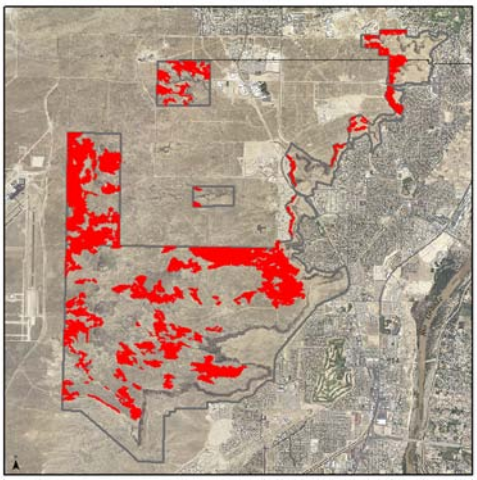

Figure E-36. Aerial photo of a representative polygon of map unit 7A.

7 Intermountain Semi-Desert Grassland

B Galleta-Sand Dropseed Mesa Grassland

Area	267.0 ha, 659.9 ac
Polygons	35
Primary component associations	*Pleuraphis jamesii - Sporobolus cryptandrus* Herbaceous Vegetation, *Sporobolus flexuosus - Sporobolus contractus* Herbaceous Vegetation
Secodary component associations	*Pleuraphis jamesii* Herbaceous Vegetation
Related inclusions	*Bouteloua eriopoda - Pleuraphis jamesii* Herbaceous Vegetation, *Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus)* Herbaceous Vegetation
Elevation	5145–5955 ft (1568–1815 m)
Summary	Galleta-dominated grasslands with sand dropseeds (and related dropseeds) as codominants (black grama may occasionally be codominant). Stands occur primarily on gentle slopes and flats on the western side of the volcanoes and to the south on Mesa Prieta.

Figure E-37. Ground photo of map unit 7B.

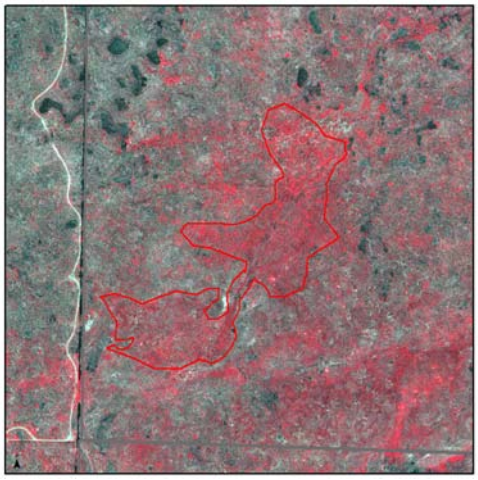

Figure E-38. Distribution of the polygons (in black) of map unit 7B.

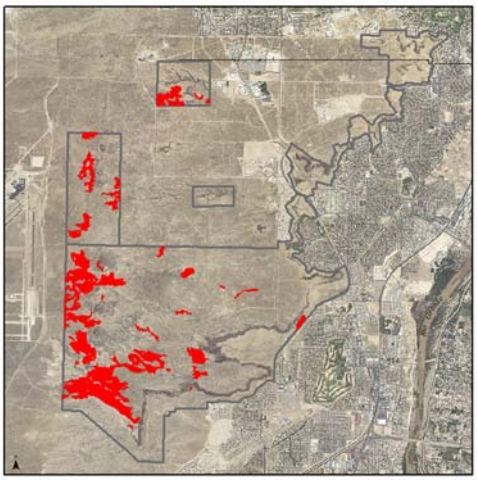

Figure E-39. Aerial photo of a representative polygon of map unit 7B.

7 Intermountain Semi-Desert Grassland

C Galleta-Burrograss Mesa Swale Grassland

Area	31.8 ha, 78.5 ac
Polygons	18
Primary component associations	*Pleuraphis jamesii* Herbaceous Vegetation
Secondary component associations	*Pleuraphis jamesii - Scleropogon brevifolius* Herbaceous Vegetation
Elevation	5318–5822 ft (1620–1774 m)
Summary	Galleta-dominated grasslands of low-lying flats and swales on the western side of the volcanoes (Lava Flow 3) and on the lower southeastern portions of Lava Flow 2. Burrow grass is a common codominant.

Figure E-40. Ground photo of map unit 7C.

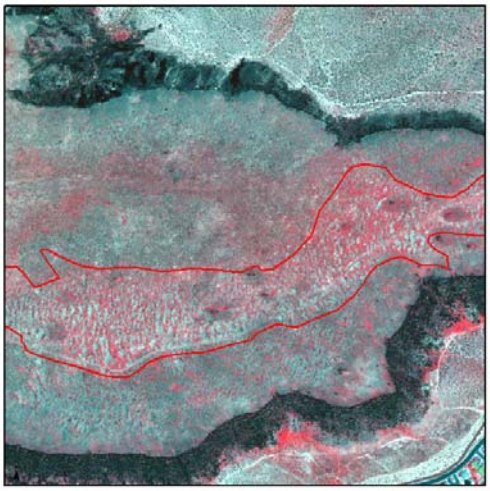

Figure E-41. Distribution of the polygons (in black) of map unit 7C.

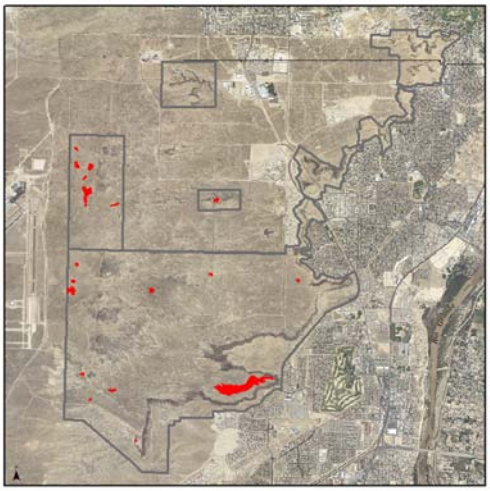

Figure E-42. Aerial photo of a representative polygon of map unit 7C.

8 Chihuahuan Semi-Desert Grassland

A Black Grama-Bigelow Sage Foothill-Volcano Grassland

Area	196.7, 486.1 ac
Polygons	25
Primary component associations	*Bouteloua eriopoda* Cinder Herbaceous Vegetation, *Artemisia bigelovii / Bouteloua eriopoda* Dwarf-shrub Herbaceous Vegetation
Secondary component associations	*Bouteloua eriopoda - Hesperostipa neomexicana* Herbaceous Vegetation
Related inclusions	*Bouteloua eriopoda - Pleuraphis jamesii* Herbaceous Vegetation
Elevation	5458–5961 ft (1663–1817 m)
Summary	Grasslands dominated by black grama found on the western and southern slopes of volcanoes and on lava outcrops (pressure ridges and collapse features) within the surrounding grassland matrix dominated by galleta and New Mexico feathergrass. The dwarf shrub, Bigelow sage, is often common on the rockier sites.

Figure E-43. Ground photo of map unit 8A.

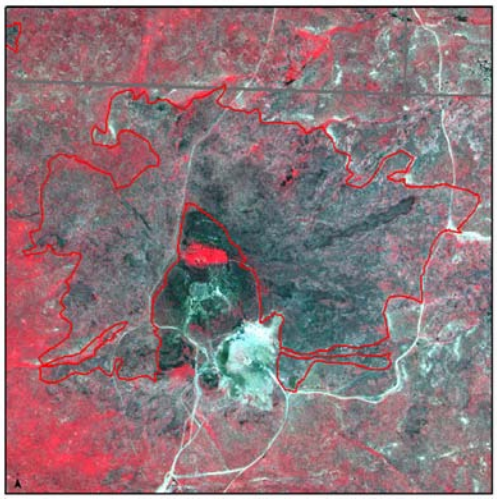

Figure E-44. Distribution of the polygons (in black) of map unit 8A.

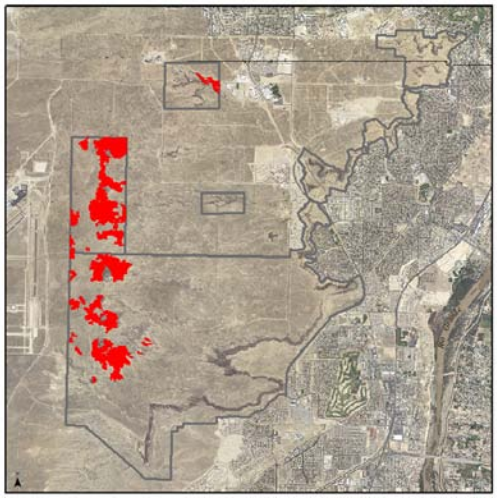

Figure E-45. Aerial photo of a representative polygon of map unit 8A.

8 Chihuahuan Semi-Desert Grassland

B Sand Dropseed-Mixed Grass Sand Grassland

Area	64.6 ha, 159.7 ac
Polygons	58
Primary component associations	*Sporobolus flexuosus* - *Sporobolus contractus* Herbaceous Vegetation
Secondary component associations	*Pleuraphis jamesii* - *Sporobolus cryptandrus* Herbaceous Vegetation, Sparse Vegetation / Sand
Related inclusions	*Pleuraphis jamesii* Herbaceous Vegetation, *Bouteloua eriopoda* - *Pleuraphis jamesii* Herbaceous Vegetation, *Bouteloua eriopoda* - *Hesperostipa neomexicana* Herbaceous Vegetation
Elevation	5106–5704 ft (1556–1738 m)
Summary	Sparse grasslands dominated by sand dropseed similar sand-tolerant dropseeds; other grasses such as galleta or black grama may be codominant. Stands occur on sandy soils overlying basalt lavas (particularly on Lava Flow 3) of the southern portion of the mesa; occasionally on the slopes of the Mesas Preieta gravel hills along the southern boundary, and in the dune lands below the escarpment.

Figure E-46. Ground photo of map unit 8B.

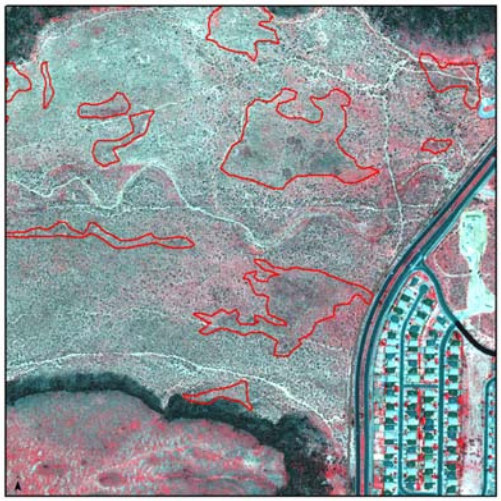

Figure E-47. Distribution of the polygons (in black) of map unit 8B.

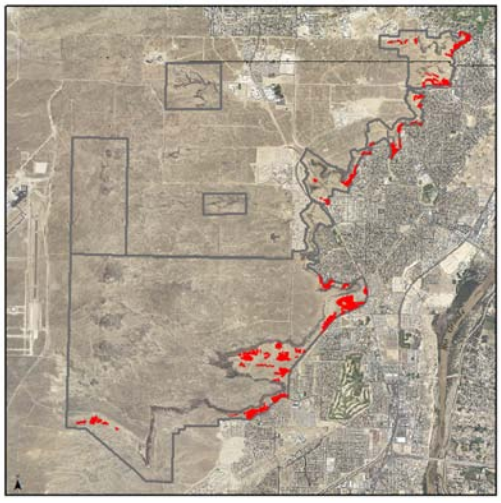

Figure E-48. Aerial photo of a representative polygon of map unit 8B.

8 Chihuahuan Semi-Desert Grassland

C Black Grama-Sand Dropseed Mesa Grassland

Area	121.9 ha, 301.1 ac
Polygons	17
Primary component associations	*Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus)* Herbaceous Vegetation
Secondary component associations	*Bouteloua eriopoda* Semi-desert Herbaceous Vegetation
Elevation	5328–5749 ft (1624–1752 m)
Summary	Grasslands dominated by black grama with sand dropseed as a codominant (galleta and New Mexico feathergrass are uncommon). They occur primarily as large stands to the south and midway down the mesa to on lava flows 2 and 3.

Figure E-49. Ground photo of map unit 8C.

Figure E-50. Distribution of the polygons (in black) of map unit 8C.

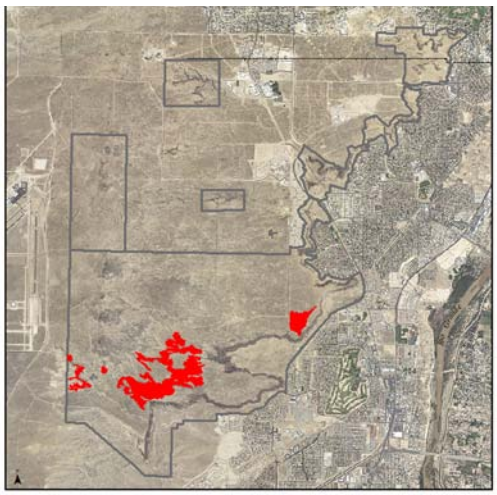

Figure E-51. Aerial photo of a representative polygon of map unit 8C.

8 Chihuahuan Semi-Desert Grassland

D Black Grama/Sparse Vegetation Mesa Grassland

Area	204.7 ha, 505.8 ac
Polygons	52
Primary component associations	*Bouteloua eriopoda* / Lava Flow Herbaceous Vegetation
Secondary component associations	*Artemisia bigelovii* / *Bouteloua eriopoda* Dwarf-shrub Herbaceous Vegetation
Related inclusions	*Bouteloua eriopoda* Cinder Herbaceous Vegetation, Sparse Vegetation / Lava Flow, Sparse Vegetation / Bare Ground, Ruderal Disturbance Vegetation, *Atriplex canescens* Lava Flow Shrubland
Elevation	5184–5880 ft (1580–1792 m)
Summary	Grasslands dominated by black grama that are found primarily on shallow soils of lava flow 1 near the eastern escarpment edge of the mesa top. Sites typically have significant exposure of lava and basalt gravels, and some sites are nearly barren. Shrubs and subshrubs such as fourwing saltbush and Bigelow sage can be common, along with weedy grasses and forbs.

Figure E-52. Ground photo of map unit 8D.

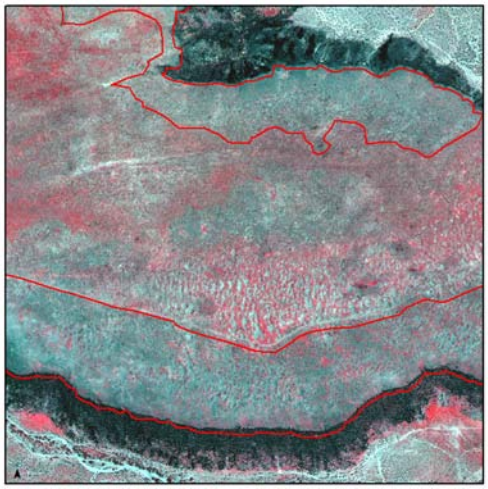

Figure E-53. Distribution of the polygons (in black) of map unit 8D.

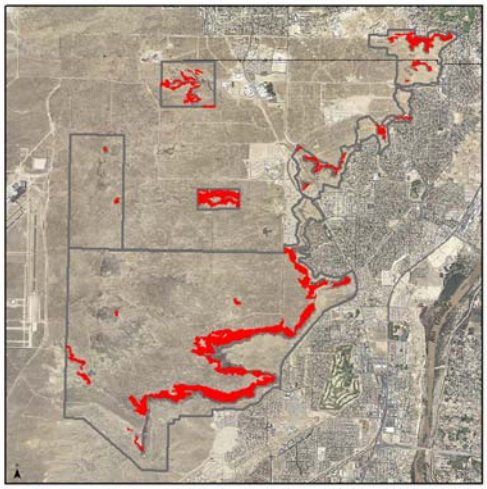

Figure E-54. Aerial photo of a representative polygon of map unit 8D.

8 Chihuahuan Semi-Desert Grassland

E Black Grama-Bush Muhly-Streambed Bristlegrass Lava Cliff Grassland

Area	71.9 ha, 177.6 ac
Polygons	89
Primary component associations	*Bouteloua eriopoda - Muhlenbergia porteri - Setaria leucopila* Mixed Herbaceous Rockland Vegetation
Secondary component associations	*Pleuraphis jamesii* Herbaceous Vegetation
Related inclusions	Sparse Vegetation / Boulder Rockland
Elevation	5139–5584 ft (1566–1702 m)
Summary	Mixed grasslands found on the steep boulder-strewn slopes and lava cliffs of the eastern edge. These are sparse to moderate cover grasslands dominated or codominated by black grama, bush muhly and streambed bristlegrass, and occasionally other semi-desert grasses.

Figure E-55. Ground photos of map unit 8E.

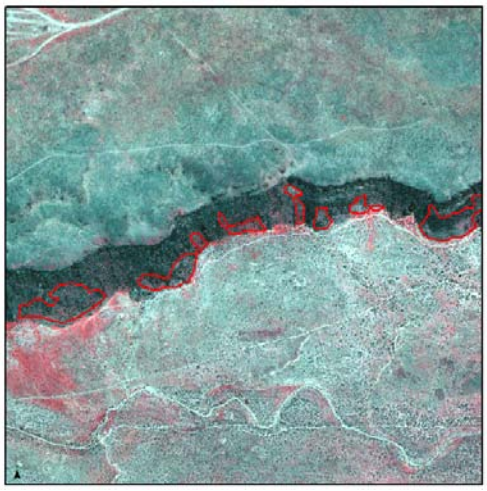

Figure E-56. Distribution of the polygons (in black) of map unit 8E.

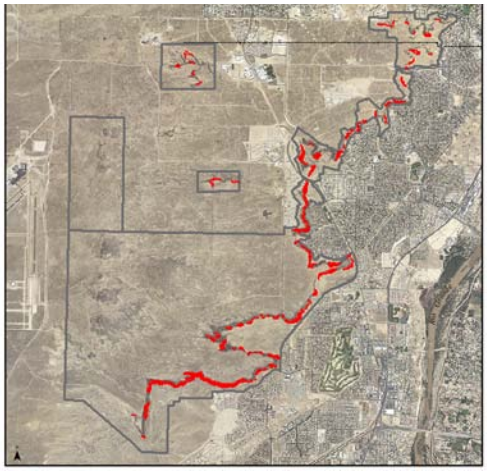

Figure E-57. Aerial photo of a representative polygon of map unit 8E.

8 Chihuahuan Semi-Desert Grassland

F Black Grama-Sparse Vegetation Gravelly Foothill Grassland

Area	99.7 ha, 246.5 ac
Polygons	44
Primary component associations	*Bouteloua eriopoda* Semi-desert Herbaceous Vegetation
Secondary component associations	*Bouteloua eriopoda - Sporobolus flexuosus (S. cryptandrus, S. contractus)* Herbaceous Vegetation, *Bouteloua eriopoda - Pleuraphis jamesii* Herbaceous Vegetation
Related inclusions	*Pleuraphis jamesii* Herbaceous Vegetation
Elevation	5311–5748 ft (1618–1752 m)
Summary	Black grama grasslands of the lower slopes and valleys of the Mesa Prieta hills along the southern boundary. May also include galleta grass as a codominant.

Figure E-58. Ground photo of map unit 8F.

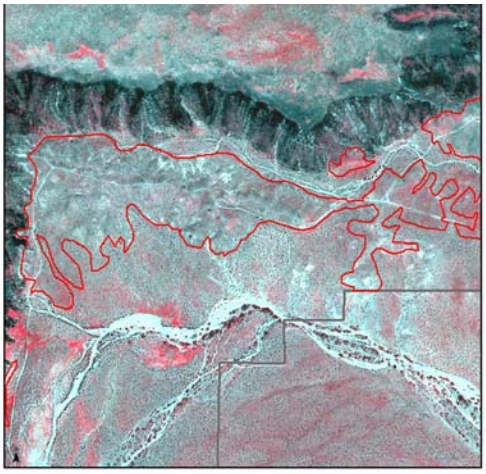

Figure E-59. Distribution of the polygons (in black) of map unit 8F.

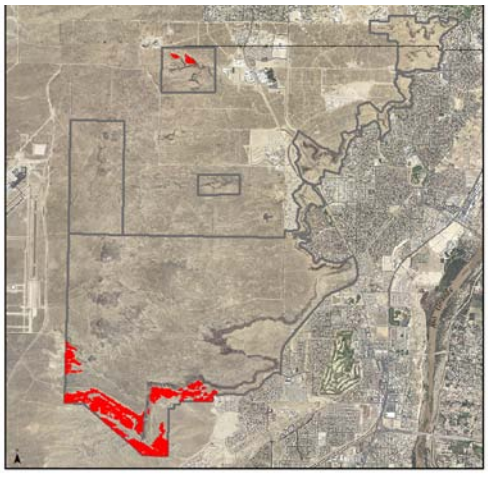

Figure E-60. Aerial photo of a representative polygon of map unit 8F.

9 Non-natural Vegetation and Other Landcover

A Ruderal Disturbance Vegetation

Area	64.1 ha, 158.5 ac
Polygons	32
Primary component associations	Ruderal Disturbance Vegetation
Secondary component associations	*Atriplex canescens* Cinder Shrubland, A*triplex canescens* / Sparse Shrubland, *Atriplex canescens* / *Sporobolus flexuosus (S. cryptandrus, S. contractus)* Shrubland
Related inclusions	*Atriplex canescens* Lava Flow Shrubland, Sparse Vegetation / Boulder Rockland, Sparse Vegetation / Lava Flow, Sparse Vegetation / Sand
Elevation	5106–5946 ft (1556–1812 m)
Summary	Variable vegetation composed of weedy grasses and forbs along with shrubs such as fourwing saltbush, which are often prevalent on disturbed ground. Sites are usually associated with human disturbance such as buildings, roads, and quarries but may occur under relatively natural conditions following fire or animal disturbance (e.g., prairie dog towns or kangaroo rat mounds).

Figure E-61. Ground photos of map unit 9A.

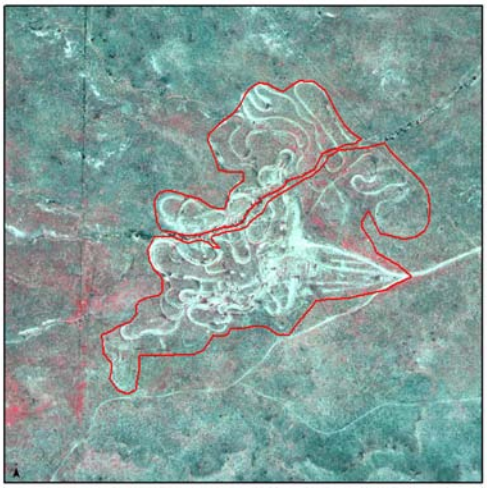

Figure E-62. Distribution of the polygons (in black) of map unit 9A.

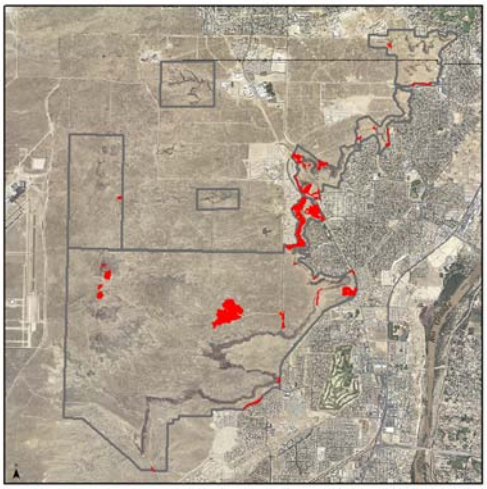

Figure E-63. Aerial photo of a representative polygon of map unit 9A.

9 Southern Rocky Mountain Pinyon-Oneseed Juniper Woodland

B Residential/Built-Up Land

Area	4.8 ha, 11.9 ac
Polygons	7
Elevation	5115–6036 ft (1559–1840 m)
Summary	Residential areas and associated yards along the eastern boundary with the city

9 Southern Rocky Mountain Pinyon-Oneseed Juniper Woodland

C Road

Area	6.4 ha, 15.8 ac
Polygons	7
Elevation	5107–5795 ft (1556–1766 m)
Summary	Paved or gravel roads

9 Southern Rocky Mountain Pinyon-Oneseed Juniper Woodland

D Recreation Site

Area	0.4 ha, 1.1 ac
Polygons	4
Elevation	5167–5838 ft (1575–1778 m)
Summary	Recreation site parking lots and associated facilities

9 Southern Rocky Mountain Pinyon-Oneseed Juniper Woodland

E Public Building

Area	0.1 ha, 0.2 ac
Polygons	5
Elevation	5121–5151 ft (1560–1570 m)
Summary	Public buildings administered by NPS

Appendix F: Petroglyph National Monument NVC Association Lookup Table

Plant associations are grouped into separate tables by NVCS macrogroup. The corresponding groups are also noted. The (G*) designation refers to a proposed NVCS group. Each plant association is designated as either a primary component (1), secondary component (2), related inclusion (Ri), or contrastingi nclusion (Ci). See section *3.2.2 Vegetation map units and legend development* on page 31 in the report for an explanation of map unit components.

Table F-1

Rocky Mountain Two-needle Pinyon - Juniper Woodland (MG027) • Southern Rocky Mountain Juniper Woodland & Savanna Group (G252)			
	Map unit name	Oneseed Juniper Savanna Woodland Draw	New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland with Juniper
NVCS Association	**Map unit**	1A	6C
Juniperus monosperma / Bouteloua eriopoda Woodland		1	2

Table F-2

Great Plains Mixedgrass Prairie & Shrubland (MG051) • Northern Great Plains Mixedgrass Dry Prairie Group (G331)				
	Map unit name	New Mexico Feathergrass-Black Grama Gravelly Grassland	New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland	New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland with Juniper
NVCS Association	**Map unit**	6A	6B	6C
Hesperostipa neomexicana Mixed Prairie Herbaceous Vegetation		2	2	Ri

Table F-3

Great Plains Sand Grassland & Shrubland (MG052) • Great Plains Sand Shrubland Group (G069)					
	Map unit name	Sand Sagebrush Mesa Shrubland	Sand Sagebush-Broom Dalea-Four-wing Saltbush Sand Shrubland	Apache Plume-Sand Sagebrush Dry Wash Shrubland	Desert Willow-Sand Sagebrush Dry Wash Shrubland
NVCS Association	**Map unit**	2A	4B	5A	5B
Artemisia filifolia / Sporobolus cryptandrus Shrubland		Ri	1	2	2

Table F-4

Warm Desert Freshwater Shrubland, Meadow & Marsh (MG076) • North American Warm Desert Riparian Low Bosque & Shrubland Group (G533)			
	Map unit name	Oneseed Juniper Savanna Woodland Draw	Apache Plume-Sand Sage-brush Dry Wash Shrubland
NVCS Association	**Map Unit**	1A	5A
Fallugia paradoxa Arroyo Wash Shrubland		2	1

Table F-5

Chihuahuan Desert Scrub (MG086) • Chihuahuan Stabilized Coppice Dune & Sand Flat Scrub Group (G287)			
	Map unit name	Sand Sagebrush Mesa Shrubland	Sand Sagebush-Broom Dalea-Four-wing Saltbush Sand Shrubland
NVCS Association	**Map unit**	2A	4B
Psorothamnus scoparius / Sporobolus flexuosus Shrubland		Ri	1

Table F-6

Apacherian-Chihuahuan Semi-Desert Grassland & Steppe (MG087) • Apacherian-Chihuahuan Semi-Desert Grassland & Steppe Group (G490) • Chihuahuan Sandy Plains Semi-Desert Grassland & Steppe Group (G491)	**Map unit name**	Sand Sagebrush Mesa Shrubland	Sand Sagebush-Broom Dalea-Fourwing Saltbush Sand Shrubland	New Mexico Feathergrass-Black Grama Gravelly Grassland	New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland	New Mexico Feathergrass-Black Grama Foothill-Mesa Grassland with Juniper	Galleta-Black Grama-New Mexico Feathergrass Mesa Grassland	Galleta-Sand Dropseed Mesa Grassland	Black Grama-Bigelow Sage Foothill-Volcano Grassland	Sand Dropseed-Mixed Grass Sand Grassland	Black Grama-Sand Dropseed Mesa Grassland	Black Grama/Sparse Vegetation Mesa Grassland	Black Grama-Sparse Vegetation Gravelly Foothill Grassland
NVCS Association	**Map unit**	2A	4B	6A	6B	6C	7A	7B	8A	8B	8C	8D	8F
Artemisia bigelovii / Bouteloua eriopoda Dwarf-shrub Herbaceous Vegetation								1			2		
Artemisia filifolia / Bouteloua eriopoda Shrubland		1	Ri										
Bouteloua eriopoda - Hesperostipa neomexicana Herbaceous Vegetation			1	1	1	Ri		2	Ri				
Bouteloua eriopoda Semi-desert Herbaceous Vegetation				Ri		2				2		1	
Sporobolus flexuosus - Sporobolus contractus Herbaceous Vegetation							1		1				

Table F-7

Great Basin Saltbrush Scrub (MG093) • Intermountain Shadscale - Saltbush Scrub Group (G300)		
	Map unit name	Fourwing Saltbush Mesa Shrubland
NVCS Association	**Map unit**	3A
Atriplex canescens / Pleuraphis jamesii Shrubland		1

Table F-8

Great Basin & Intermountain Dry Shrubland & Grassland (MG171) • Intermountain Semi-Desert Grassland Group (G311)								
	Map unit name	Galleta-Black Grama-New Mexico Feathergrass Mesa Grassland	Galleta-Sand Dropseed Mesa Grassland	Galleta-Burrograss Mesa Swale Grassland	Black Grama-Bigelow Sage Foothill-Volcano Grassland	Sand Dropseed-Mixed Grass Sand Grassland	Black Grama-Bush Muhly-Streambed Bristlegrass Lava Cliff Grassland	Black Grama-Sparse Vegetation Gravelly Foothill Grassland
NVCS Association	**Map unit**	7A	7B	7C	8A	8B	8E	8F
Bouteloua eriopoda - Pleuraphis jamesii Herbaceous Vegetation		2	Ri		Ri	Ri		2
Pleuraphis jamesii Herbaceous Vegetation		1	2	1		Ri	2	Ri

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