National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Vegetation Classification and Map

El Malpais National Monument

Natural Resource Technical Report NPS/SCPN/NRTR—2013/803

ON THE COVER (clockwise from the upper left): 1) From Twin Craters looking across the lava flow with a small wildfire in the distance (photo: J. Coop); 2) aspen growing in lava fissure on the Hoya de Cibola flow (photo: J. Coop); 3) stunted ponderosa pines on the McCartys lava flow (photo: J. Coop); saw phacelia (*Phacelia serrata*), a sensitive species, growing on the slopes of a cinder cone (photo: J. Coop); 4) view of sandstone bluffs adjacent to the McCartys flow (photo: E. Muldavin); 5) blue grama grasslands that are common around the perimeter of the lava flows (photo: Y. Chauvin)

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

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

Natural Heritage New Mexico, in cooperation with the Earth Data Center at the University of New Mexico and NatureServe, developed a vegetation classification and high-resolution vegetation map for El Malpais National Monument, New Mexico. The project was part of the U.S. Geological Survey (USGS) Vegetation Characterization Program, a cooperative effort by the 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 follow the guidelines and requirements of the national program, and are based on data collected from 476 field plots between 2006 and 2009. Based on field sampling, we identified 50 plant associations following the guidelines of the National Vegetation Classification Standard (NVCS). Using the classification as a foundation, we constructed a vegetation map from a combination of image analysis and photo interpretation of high-resolution (0.6 m) color aerial ortho-photography combined with satellite imagery (Landsat Thematic Mapper). The map legend is hierarchically structured, with an upper Level 1 of nine vegetation map units corresponding more or less to the Group Level of the NVCS, and a Level 2 composed of 42 nested map units defined by the plant associations from the vegetation classification.

The vegetation pattern of El Malpais National Monument (ELMA) is intricately interwoven with its geology. In particular, the Zuni-Bandera volcanic lava field with its five lava flows and associated cones and craters dominates the landscape. The flows range in age from 3,200 to 54,000 years old and have differing degrees of soil development and commensurate vegetation expression.

The youngest flows, McCartys (≈ 3,200 years old), Bandera (≈ 10,000 years old), and Twin Craters (≈ 18,750 years old) are characterized at higher elevations by stunted forests of scattered Douglas-fir and ponderosa pine, with occasional aspen growing among the cracks and fissures of the lava. Large areas of exposed lava are still common (both rough "`a`a" lava and smooth "pahoehoe" forms). Lower down the elevation gradient, these open forests give way to equally open and stunted woodlands dominated by pinyon pine and scrub-like oneseed junipers, and at the lowest elevations, transition to shrublands dominated by Apache plume, skunkbush sumac, and wax currant. On these sparsely vegetated young flows, fire is infrequent and limited in extent, creating an environment where trees and shrubs can live to extended ages and sites develop unique assemblages of species.

On the older flows (Hoya de Cebola, 50,000 years old, and El Calderon, 54,000 years old), a similar elevation gradient of vegetation is apparent, but because these flows have developed a deep and more continuous soil mantle over time, the understory vegetation is more continuous and typically dominated by grasses. Trees grow taller on these more productive sites, but the more continuous grass cover can foster more frequent surface fires resulting in woodlands with a more open, savanna-like character.

The cinder cones provide a different environment of steep, unstable slopes, yet vegetation has managed to establish in patches, which we have mapped as distinct forest, woodland and scrub classes.

Vegetation adjacent to young lava flows can be quite different in character. Old basalt plains (700,000 years old) and older cinder cones, as well as hills of sedimentary limestone and sandstone are prevalent around the perimeter of, or as islands (kipukas) within, the flows. With relatively deep soils, these flows support ponderosa pine and pinyon-juniper woodlands and grasslands that are representative of typical non-volcanic landscapes of the southern Colorado Plateau.

Overall, the vegetation map was designed to facilitate ecologically-based natural resource management at a 1:24,000 scale with 0.25 ha minimum map unit size. Based on an independent sample of 1,190 plots, overall accuracy was 97% for the broad themes of forest/woodland, shrubland, grassland, and other land types; 88% for Level 1 (the Group level of the National Vegetation Classification), and 80% for Level 2, the finest units. Level 1 units will likely be sufficient and most appropriate for many natural resource plans and evaluations, while Level 2 units provide added fine-scale information within major ecological groups. To support the map as a management tool, we provide an annotated map legend along with local descriptions of each plant association, a corresponding diagnostic key, field forms, and a plant species list. The map was delivered 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 as major vegetation changes such as those caused by fire, disease, or other impacts, occur in the park.

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 Jonathan Coop, Eric Lindahl, Katie Mann, and Matthew Wilder 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. Lisa Thomas, SCPN Program Manager, provided network support for the project 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, Karl Brown, Tammy Hamer, and Chris Lea provided important guidance and review. Additional review was provided by Janet Coles, Chief of Resource Management, Guadalupe Mountains National Park.

Acronyms and Abbreviations

BCE	Before Common Era
CE	Common Era
CPCESU	Colorado Plateau Cooperative Ecosystem Studies Unit
ELMA	El Malpais National Monument
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	Thousand years ago
MMU	Minimum Mapping Unit
NDSVI	Normalized Difference Senescent 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
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

El Malpais National Monument harbors world-renowned, expansive, volcanic landscapes etched by multiple eruptions over the course of the last 100,000 years. These have given us tall volcanic cinder cones, and lava flows that stream for miles, with island kipukas of sandstone hills and bluffs from a more ancient time (see the cover of this report). This complex history of recent landscape formation has also given rise to diverse vegetation communities that now provide habitat and forage for a plethora of wildlife, as well as exceptional recreational opportunities for park visitors. In addition, the malpais is embedded in the cultural fabric of Native Americans, from the Ancient Puebloans to the current day. The National Park Service has sought to manage these biological resources, in concert with geological and cultural resources, with the same care and attention it has given to archeological resources. A key tool for effective biological management, along with comprehensive biological inventories and monitoring, 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.

The U.S. Geological Survey (USGS)-National Park Service Vegetation Mapping Program and the NPS Southern Colorado Plateau Network (SCPN), in cooperation with Natural Heritage New Mexico (NHNM)[1], NatureServe[2], and the staff at El Malpais National Monument (ELMA), set out to develop a vegetation map that meets or exceeds USGS-NPS standards[3] (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. The project was initiated in 2005 with reconnaissance field surveys of the vegetation communities of ELMA, followed by intensive field sampling from 2006 through 2009. The vegetation survey data were entered into a database and used to develop a park-wide vegetation classification following the National Vegetation Classification System (Federal Geographic Data Committee [FGDC] 2008) guidelines. A vegetation map was then generated from the vegetation classification and associated ground-control points at the 1:24,000 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 uses for fire, wildlife, and recreation management.

In this report we provide : (1) details on how the map was constructed; (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 presented 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 report 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 United States (http://www.usgs.gov/core_science_systems/csas/vip/index.html). Consistent vegetation classification, mapping, and accuracy assessment protocols and standards are applied across projects supported by this

[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/

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

program. The National Vegetation Mapping Program is administered by the USGS Center for Biological Informatics in cooperation with the NPS Inventory & Monitoring (I&M) Program and its Vegetation Mapping Inventory. As a result of the NPS Natural Resource Challenge (National Park Service 1999), significant funding became available for completing important natural resource baseline inventories in park units, including vegetation classification and mapping. This support enabled the NPS to move forward with dozens of new park unit vegetation classification and mapping projects, including the project at ELMA. 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)
- Content Standard for Digital Geospatial Metadata (FGDC 1998a)
- Spatial Data Transfer Standard (FGDC 1998b)
- United States National Map Accuracy Standards (United States Geological Survey [USGS] 1999)
- Integrated Taxonomic Information System
- 12-Step Guidance for NPS Vegetation Inventories (National Park Service Inventory and Monitoring Program 2013)

1.3 Park environment

1.3.1 Location

El Malpais National Monument is located east of the Zuni Mountains, southwest of Mount Taylor, and approximately 20 km south of the town of Grants in northwestern New Mexico (Fig. 1). The monument encompasses 46,477 ha (114,848 ac), and is bounded on the north by the Cibola National Forest, and on the east, south, and west by the El Malpais National Conservation Area (NCA),which is managed by the Bureau of Land Management (BLM). Private lands are interspersed with NCA areas on the east side of the monument (primarily belonging to Acoma Pueblo), as well as in the central Little Hole in the Wall area, and the “Ice Caves” resort in the northwest portion (Fig. 2).

Located on the southeastern edge of the Colorado Plateau, the area where ELMA is located was the site of nearly continuous volcanic activity from about 700,000 to 3,000 years ago (Laughlin and WoldeGabriel 1997). This long-term activity has resulted in a landscape of diverse volcanic substrates; the more recent lava flows are of the `a`a (rough-textured, jagged surface) and pahoehoe (smooth, twisted surface) types (Fig. 3). The older flows are eroded and covered with aeolian and water-borne deposits of sediment from surrounding areas. Cinder cones, shield volcanoes, spatter cones, and hornitos (hollow spatter cones without a roof) dot the landscape. Within the flows, pressure ridges, collapse depressions, and lava tubes add roughness to the already broken terrain. Lava caves, lava tubes, collapsed lava tubes, and lava-tube caves collect moisture and, depending on light available, provide habitats for an array of unusual plant and animal species. Kipukas, or islands of sedimentary or other non-volcanic formations, can be found isolated within the basalt flows. Throughout the monument, the varying ages and textures of lava flows and other volcanic features, with attendant differing lengths of erosional and depositional processes taking place, have created a mosaic of vegetation types ranging from coniferous forests to grasslands (Bleakly 1997).

Elevation within the monument ranges from about 2,500 m in the northwest to about 2,000 m in the northeast. While the substrates are primarily volcanic and there are large areas of relatively recent lava flows with rough and broken basalt, a surprising abundance of plant life exists here, with many species that are usually associated with

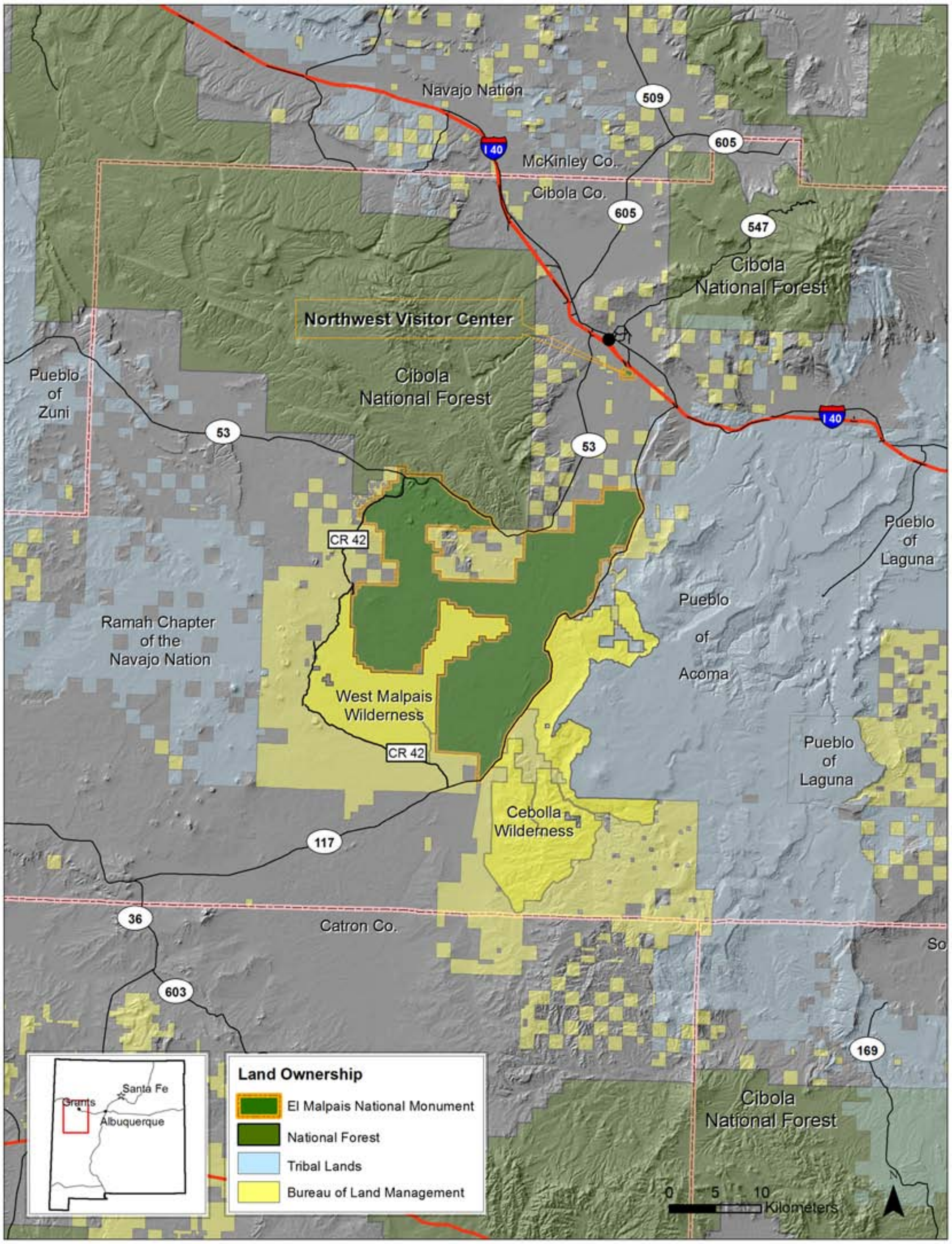

Figure 1. El Malpais NM is located in west-central New Mexico, just south of Grants. Much of the monument lies adjacent to BLM lands, including the West Malpais and Cebolla Wilderness Areas, providing a large area of relatively unfragmented landscape. In addition, the Zuni Mountains within the Cibola National Forest are found along the northwest portion. A small but important historical area of the Acoma Pueblo touches the monument on the eastern side. The inset on the lower left depicts the monument in the broader state context.

higher elevations (Bleakly 1997). Forests and woodlands, consisting primarily of coniferous species, as well as shrublands, occur on the more recent flows and cinder cones; grasslands occur on the older, more eroded flows that have accumulated substantial sediments transported by wind and water over time. Kipukas, with sedimentary deposits of limestone, sandstone, and shale, provide habitat for plants that cannot survive on volcanic substrates. Precipitation is captured by the rough terrain rather than running off

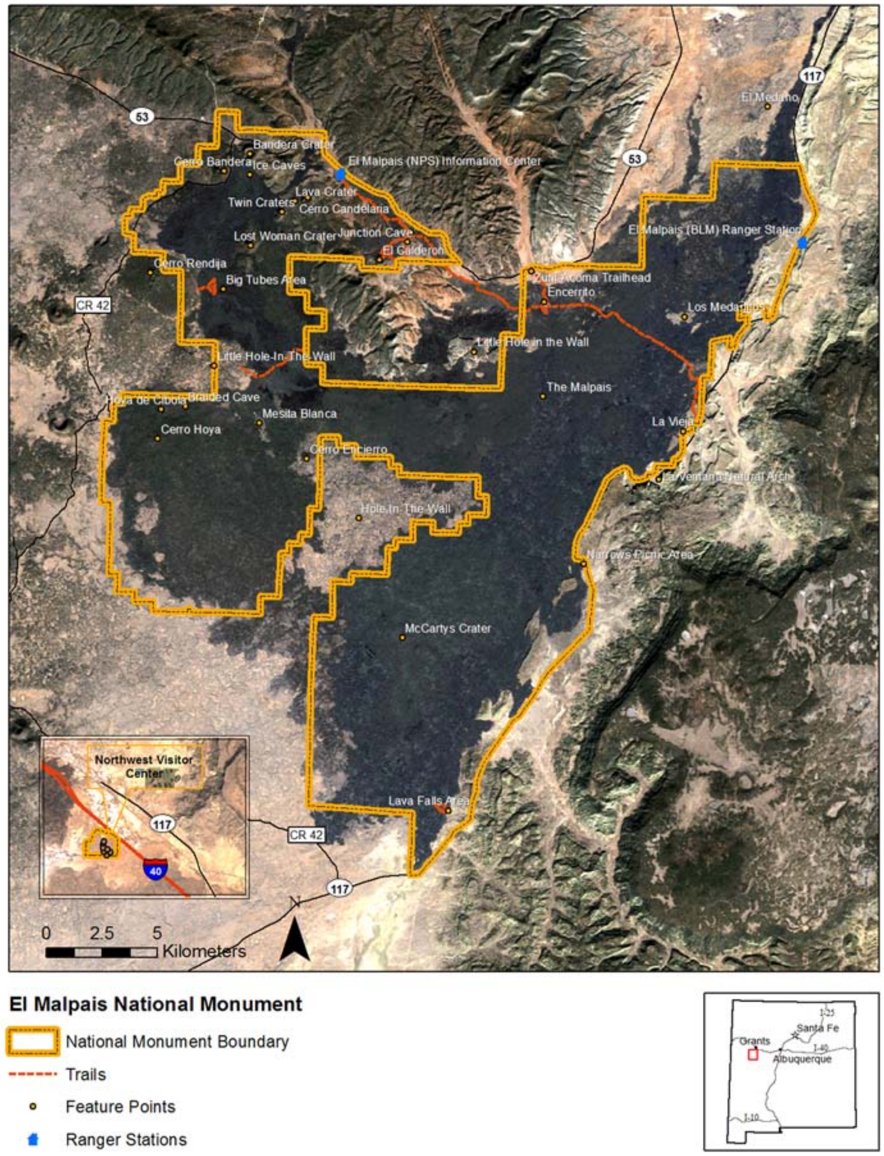

Figure 2. El Malpais NM vegetation map study area and points of interest.

Figure 3. Examples of the two types of lava that are common among El Malpais lava flows: pahoehoe lava (left) has a relatively smooth and twisted surface with large fissures and cracks (McCartys flow); a'a' lava (right) is rough, jagged and uneven (Bandera flow) (photos by Y. Chauvin).

into surface drainages or being held on the surface and evaporating. As a result, water may be held in pools and/or retained underground where plants have access to it.

The coniferous species of El Malpais have presented unique opportunities to explore the climate of the past. El Malpais is home to the oldest known living *Pseudotsuga menziesii* (Douglas-fir) trees, which are estimated by tree-ring studies to date from between 719 CE and 1062 CE (Grissino-Mayer et al. 1997). Well preserved dead wood of *Pseudotsuga menziesii* and *Pinus ponderosa* (ponderosa pine) allowed investigators to extend tree-ring chronologies back to around 150 BCE. A dead *Juniperus scopulorum* (Rocky Mountain juniper) log yielded a tree-ring chronology extending from 29 BCE to 1859 CE. It is likely that even older ancient living trees, as well as downed logs, will be found at ELMA.

1.3.2 Cultural setting and history

While the boundaries of the monument encompass an area that is difficult for people to live in, archeological evidence of early human occupation and use by Paleo-Indian and Ancestral Puebloans has been found within the monument and vicinity. Most of the archeological sites thought to be temporary or permanent habitations (indicated by fire-cracked rocks or structures) are found along the eastern side of the monument, with a few in the north and northwest. Projectile points, evidence for Paleo-Indian presence (around 8,000–5,000 BCE), were found on nearby Cebollita Mesa and Armijo Canyon to the east and southeast of El Malpais.

Hunter-gatherer sites, dating from Archaic times (5,500 BCE to 400–600 CE), have been found east and south of ELMA, including the North Plains, Armijo Canyon, and Cebollita Mesa areas, as well as within the boundaries of the monument (Mangum 1997; Powers and Orcutt 2005). These sites consist of projectile points, ground stone, and lithic debris, as well as occasional fire-cracked rocks and hearths (Orcutt et al. 2005; Powers and Orcutt 2005).

Early, more-or-less permanent settlements dating from Basketmaker III period (400/500 to 700/720 CE), representing the near completion of the transition from hunter-gatherer to more agricultural based subsistence, are not common, but occur in or near potential agricultural areas (Orcutt et al. 2005). Pueblo I (700/720 to 1125/1175 CE) sites have been found on Cebollita Mesa east of the monument and in the El Malpais National Conservation Area east of the monument (Orcutt et al. 2005). Pueblo II sites (probably occupied around 1100 CE) include structures that are larger, with contiguous above-ground masonry rooms, and below-ground ceremonial changers or kivas. Some of the Pueblo II sites are similar to Chacoan outliers; in general, there seemed to have been a population increase and coalescing of the population during this period. Las Ventanas, on the east side of the monument, is an example of a large site with some Chacoan characteristics (Orcutt et al. 2005).

During Pueblo III (1125/1175 to 1320/1325 CE) times, there was an apparent decline in numbers of sites, although those remaining increased in size. Sites from this period are known from Cerritos de Jaspe, Cebolla Canyon, and Armijo Canyon. Pueblo IV (1320/1325 to 1540 CE) sites, large pueblos that continued to be occupied or became occupied just prior to the entrance of Europeans into the country were found in the Zuni area and at Acoma, along with now-abandoned sites on Cebollita Mesa. Some of the sites (like Acoma) are located on mesa tops. Human habitation within the current monument boundary apparently ceased after 1150 CE; most of the sites occupied after this time are in Cebolla and Armijo canyons. However, evidence of farming, plant gathering, hunting, and religious activities after 1150 CE have been found within the boundaries of ELMA (Powers and Orcutt 2005).

While much of the monument is covered by rough, broken lava flows that provide little opportunity for agriculture, it and the surrounding areas provided other resources for prehistoric humans, such as wildlife for hunting, water, shelter, plants, and lithic materials. Most of the materials used for producing stone tools had their sources in and around the monument (Schachner and Kilby 2005). San Andres chert, Cretaceous chert and chalcedony, Grants Ridge obsidian, as well as non-vesicular basalt, are all found nearby. Material from distant locations (including from the Jemez, Chuska, Pedernal, and Ladron mountains) have been found among the stone artifacts at ELMA and indicate possible trade relationships. Ceramic analysis of pot sherds from puebloan sites provides evidence that there was trade among the various groups, primarily to the south and east (Mogollon Brown Ware, Socorro Black-on-white, White Mountain Red Ware).

Europeans arrived in New Mexico in 1540, when Coronado's expedition traveled east from Hawikuh (a Zuni pueblo) to the Rio Grande valley and beyond (Mangum 1997). The next expedition, led by Rodriguez and Chamuscado in 1581, went to Acoma and Zuni. This was closely followed by the Espejo expedition into New Mexico (1582-1583). Diego Pérez de Luxán, one of the men with the expedition, kept a journal, recording the events and descriptions of the countryside as they traveled. Pérez de Luxán describes "…many irrigated maize fields with canals and dams as if Spaniards had built them" at Acoma. As they traveled westward toward the Zuni region they "…camped at some badlands without water" and passed through a pine forest (through Guadalupe or Zuni Canyon in the Zuni Mountains). They stopped at a "…waterhole at the foot of a rock…" which they called "El Estanque del Peñol"; this must have been the pool at the base of the sandstone bluff at modern-day El Morro National Monument. When they arrived at the village of Hawikuh in the Zuni Province, they found a "…large marsh with many waterholes so that they irrigate some fields of maize with this water." (Pérez de Luxán [translated by Hammond and Rey] 1929).

These descriptions provide the reader with hints of the landscape that the original residents of the El Malpais area lived in, as well as how they sustained life using both domesticated crops and wild resources. Pérez de Luxán recounts that their little group was greeted by the people of Acoma with "… blankets, tanned deerskins, turkeys, and much maize."

In 1605, Oñate, on a colonizing and exploring expedition to New Mexico, Arizona, and California, inscribed his name in the sandstone bluff above the waterhole at El Morro (Mangum 1997). As the Spanish returned to New Mexico over the years to colonize the area, and on their travels further west, contacts were made with Acoma Pueblo to the east and probably with the Navajo people in the Mount Taylor region. De Vargas, returning to New Mexico after the Pueblo Rebellion in 1680, left his name and the date in the sandstone bluff at El Morro. The members of the Dominguez-Escalante expedition camped east of ELMA, at what is now San Rafael, in 1776. However, permanent Spanish settlements in the area remained few. By the 1830s, settlements had been built at Cubero (to the east) and San Mateo (to the north), and the route between Acoma and Zuni and points west was well-traveled (Mangum 1997).

The transition from Spanish government to Mexican government in 1821 brought little change to the region; however, the war between the United States and Mexico that began in 1846 was transformative (Mangum 1997). After visiting Chaco Canyon and Canyon de Chelly, the expedition led by Lt. J. H. Simpson went to Zuni Pueblo. Traveling east from there, he stopped at El Morro and added his inscription to the sandstone bluff. Taking up the journey again to the east, he passed through El Malpais and camped at San Rafael. He described "…unseemly piles of blackened scoriaceous volcanic rocks" and a little further on, "…acres of volcanic rock…exhibiting the undulations of the wave in its oscillatory motion." (probably pahoehoe-type lava) (Mangum 1997; Simpson 1852).

With the American annexation of the Southwest began a period of expeditions and surveys for roads and possible railway routes, and the building of forts (including the first Fort Wingate, at the present site of San Rafael). In 1868, after the Civil War and the resettlement of the Navajo people back in their homeland, Fort Wingate was dismantled and moved to its current location near Gallup, New Mexico. The settlement of San Rafael about this time marked an expansion in the area, including new settlements of Hispanic and Anglo people. The railroad arrived in 1881 and sheep and cattle ranching began on thousands of acres around the monument. Commercial logging began in the 1880s (Mangum 1997). Hispanic settlers had been occupying small ranchos in the area since the 1700s (Huntley 2005) and the Homestead Act of 1916 brought new settlers. While many of them eventually abandoned their homesteads, cattle and sheep ranching continue today. Logging was a viable commercial operation until the 1960s. Fluorspar and pumice were mined during World War II from near Bandera Crater Ice Caves (Huntley 2005), and uranium created a boom economy for the town of Grants and vicinity from about 1950 through the 1970s (Mangum 1997).

Native American groups (Zuni, Acoma, Laguna, and Ramah Navajo) continued to use the monument and adjacent lands for hunting, seasonal farming, herding and ranching, and maintaining religious shrines throughout the historic period (Huntley 2005). Acoma and Laguna people used kipukas for cattle and sheep grazing. The Zuni used the areas around Bandera Ice Caves and hunted in the nearby mountains and the North Plains. The Navajo hunted and gathered, grazed sheep and cattle, and had religious shrines in the malpais (Huntley 2005).

The archeological evidence for many of these activities can be found in and around the land around ELMA. Archeological surveys of surrounding areas and recent surveys in the monument reveal patterns in land use (Huntley 2005), which seemed to be concentrated in three areas: (1) ranching, herding, and agricultural features were more common on the east side than other areas; (2) ice and water collection and logging occurred mainly on the west side, in the vicinity of Big Tubes; and (3) mining was concentrated in the area of El Calderon. Using dated evidence such as cans, bottles, hardware, and other items with manufacturing dates, archeologists estimate the highest intensity of use of the monument was between 1920 and 1950 (Huntley 2005).

1.3.3 Climate

The ELMA climate is characterized by cool-to-cold, relatively dry winters, and warm, wet (monsoonal) summers. At the Grants airport (National Weather Service station 293682), about 20 km north of the park, daily temperature ranges between -36.1 °C and 28.9 °C (-32.9 °F and 84.0 °F) in winter, and -2.2 °C and 41.1 °C (28.0 °F and 106.0 °F) in summer.The large differentials between the average monthly minimum and maximum temperatures over the course of a year reflect an essentially continental climate (Fig. 4).

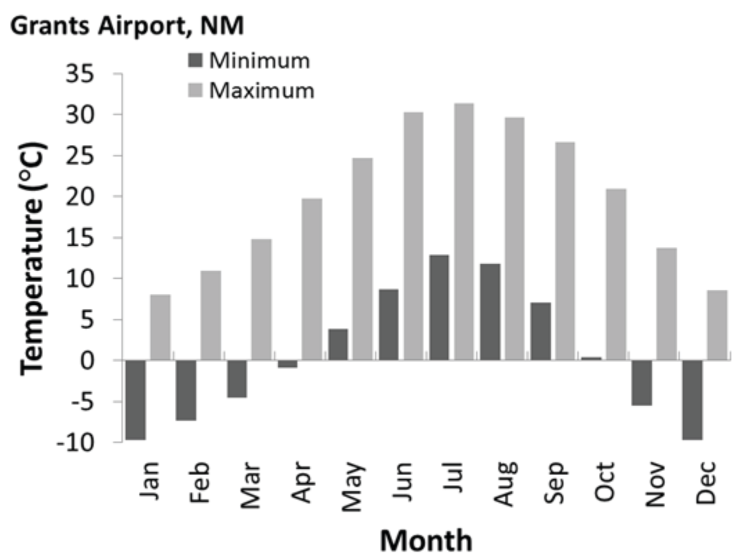

Figure 4. Average monthly temperature patterns between 1953 and 2008 at the Grants Airport, 20 km north of El Malpais NM. Average annual maximum temperature was 19.95 °C; minimum was 0.57 °C.

The average annual precipitation is 264 mm, of which 37% (96 mm) falls in winter (October through March) and is delivered principally by low-pressure systems that sweep from west to east across the Southwest, and coalesce with moisture from the Pacific Ocean or the Gulf of Mexico (Fig. 5).

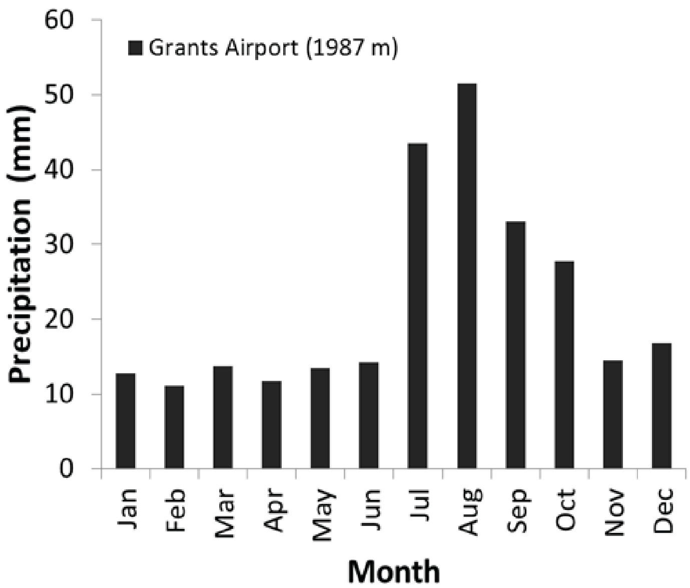

Figure 5. Average monthly precipitation patterns between 1953 and 2008 at the Grants Airport (station 293682), 20 km north of El Malpais NM. Average annual precipitation was 263.9 mm.

Winter precipitation is generally followed by a seasonal dry period from April through June. This dry period is defined as much by the increased potential evapotranspiration that accompanies increased day length, solar radiation, and temperatures, as by decreased precipitation. The spring dry period is usually relieved by the onset of the Mexican/Arizona monsoon, which lasts from July through September, and is associated mostly with short-duration, high-intensity thunderstorms. The thunderstorms can be localized, leading to high year-to-year variability

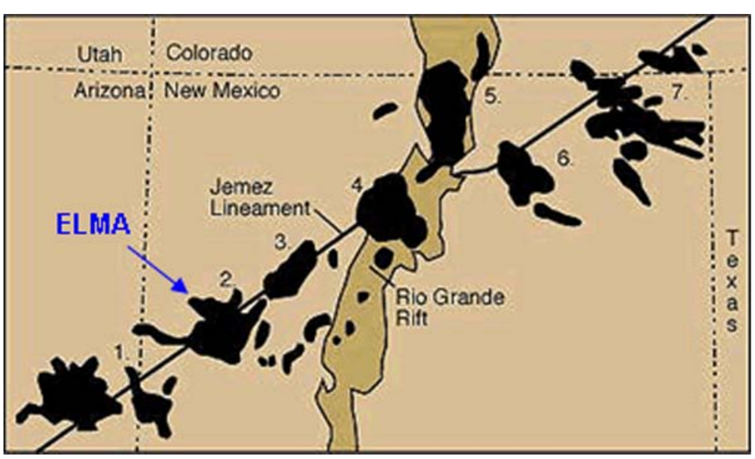

Figure 6. Geologically, ELMA is located in the Zuni-Bandera volcanic field, part of the Miocene to Holocene volcanic fields that form the Jemez Lineament: 1. Springerville; 2. Zuni-Bandera; 3. Mount Taylor; 4. Jemez Mountains; 5. Taos; 6. Ocate; and 7. Raton-Clayton (from Ander et al. 1981).

of precipitation over small areas across the park. During the project period sampling (2006–2009), precipitation was near normal (average 258 mm), but dipped to 210 mm in 2008, a result of lower summer precipitation (110 mm versus an average of 167 mm).

1.3.4 Geology and soils

The central geologic feature of ELMA is the Zuni-Bandera volcanic field (Maxwell 1986; Laughlin and WoldeGabriel 1997). This field is part of an extensive fracture zone known as the Jemez Lineament—a chain of volcanic centers extending from northern Arizona to northeast New Mexico and southeastern Colorado (Mayo 1958) (Fig. 6). Maxwell (1986) mapped the lava field and surrounding areas at 1:62,500 scale (he referred to it as the El Malpais Lava Field). Figure 7 provides a digital approximation of this information for the monument; see Table 1 for descriptions of the rock units.

Inside the monument, the lava field is dominated by five lava flows and associated craters that range in age from the late Pleistocene to the late Holocene (Table 2). A generalized map of the lava flows and surrounding relevant terrains with respect to vegetation mapping and classification is provided in Figure 8. These young flows, McCartys (M), Bandera (B), Twin Craters (T), Hoya de Cibola (H), and El Calderon (C) lie on top of older early-to-mid-Pleistocene basalt flows that have weathered significantly and accumulated sediments to form nearly flat, grass-covered plains in the surrounding landscape (Qb in Fig. 7 and part of the "Other" class in Fig. 8). In addition, embedded among the lava flows are islands or "kipukas" of Permian-, Jurassic-, and Cretaceous-age sedimentary limestone and sandstone rock outcrops and hills (the Sedimentary class in Fig. 8).

All five of the younger flows have their origin in vents within the park. These vents typically comprised one or more pyroclastic cinder cones along with basalt lava flow eruptions, the latter extending eastward up to 50 km. Because of their relatively young age, the cinder cones tend to have steep, unstable slopes,

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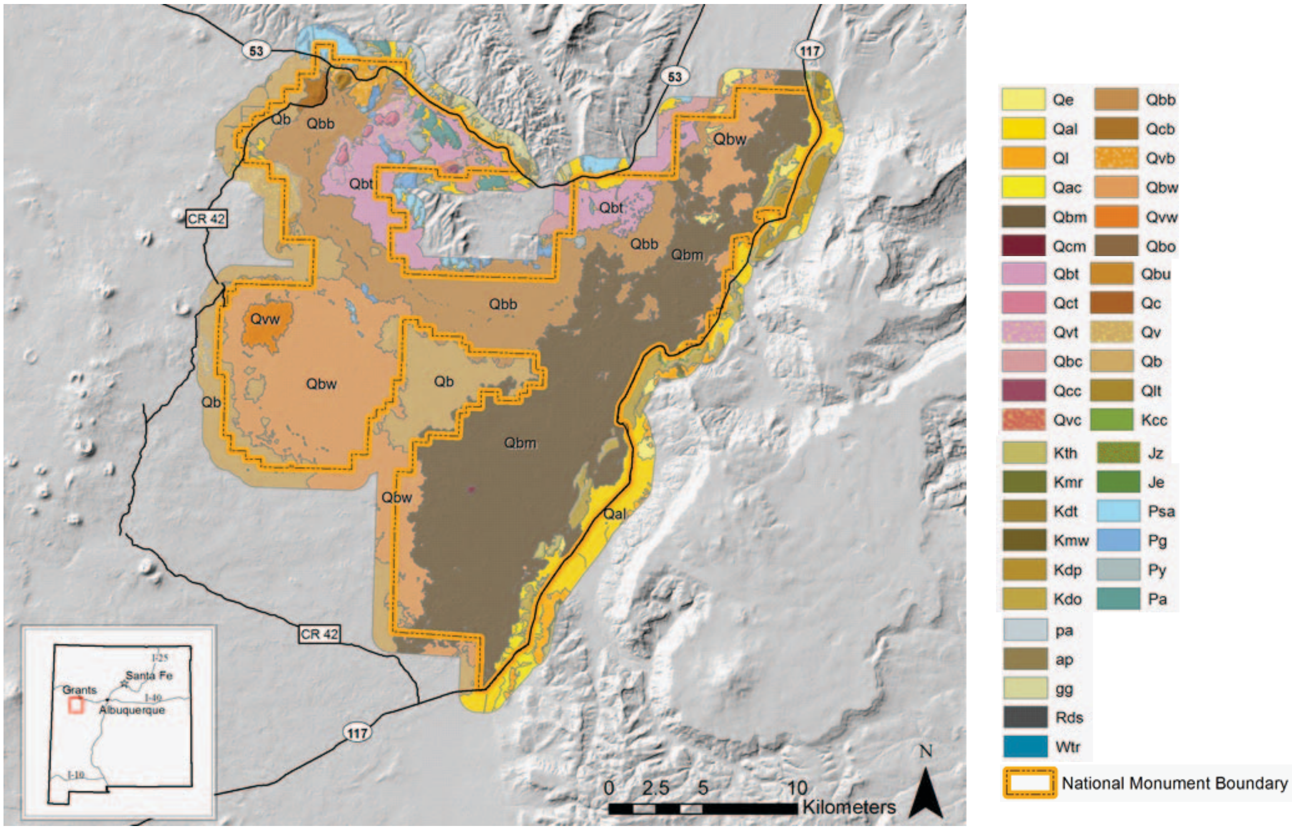

Qe	Eolian Deposits (Holocene)	Qvt	Mixed Pyroclastics and Flows (Holocene and Pleistocene Volcanics)	Kdp	Paguate Tongue of Dakota Sandstone (Cretaceous)
Qal	Alluvium (Pleistocene)	Qbc	El Calderon Flows (Holocene and Pleistocene Volcanics)	Kdo	Clay Mesa Tongue of Mancos Shale and Lower Part of Dakota Sandstone (Cretaceous)
Ql	Landslide Deposits (Pleistocene)	Qcc	El Calderon Crater (Holocene and Pleistocene Volcanics)	Jz	Zuni Sandstone and Wanakah Formation (Jurassic)
Qac	Alluvium, Colluvium, and Soil (Holocene and Pleistocene)	Qvc	El Caleron Cinder Field (Holocene and Pleistocene Volcanics)	Je	Entrada Sandstone (Jurassic)
Qbm	McCartys Flows (Holocene and Pleistocene Volcanics)	Qbu	Basalt Flows (Holocene and Pleistocene Volcanics)	Psa	San Andres Limestone (Permian)
Qcm	McCartys Crater (Holocene and Pleistocene Volcanics)	Qc	Cinder Cones (Holocene and Pleistocene Volcanics)	Pg	Glorieta Sandstone (Permian)
Qbb	Bandera Flows (Holocene and Pleistocene Volcanics)	Qv	Volcanic Debris (Holocene and Pleistocene Volcanics)	Py	Yeso Formation (Permian)
Qcb	Bandera Crater (Holocene and Pleistocene Volcanics)	Qb	Old Basalt Flows (Holocene and Pleistocene Volcanics)	Pa	Abo Formation (Permian)
Qvb	Bandera Cinder Field (Holocene and Pleistocene Volcanics)	Qlt	Lava Tube (Quaternary Lava Tube)	pa	Porphyritic Aplite (Permian)
Qbw	Hoya de Cibola Flows (Holocene and Pleistocene Volcanics)	Kcc	Crevasse Canyon Formation (Cretaceous)	ap	Gneissic Aplite (Precambrian)
Qvw	Hoya de Cibola Shield Volcano (Holocene and Pleistocene Volcanics)	Kth	Tres Hermanos Sandstone (Cretaceous)	gg	Gneissic Granite (Precambrian)
Qbo	Oso Ridge Flows (Holocene and Pleistocene Volcanics)	Kmr	Rio Salado Tongue (Cretaceous)	Rds	Roads
Qbt	Twin Craters Flows (Holocene and Pleistocene Volcanics)	Kdt	Twowells Tongue of Dakota Sandstone (Cretaceous)	Wtr	Water
Qct	Twin Craters Cinder Cones (Holocene and Pleistocene Volcanics)	Kmw	Whitewater Arroyo Tongue (Cretaceous)		

Figure 7. The geology of ELMA as mapped by Maxwell (1986). This is an approximation based on screen digitizing of a scanned version of the original map.

Table 1. Rock units for geology maps associated with El Malpais National Monument as adapted from Maxwell (1986).

Symbol	Name	Description
Qal	Alluvium (Holocene and Pleistocene)	Composed largely of silt and fine-grained sand; a few local lenses contain coarse sand and pebbles. As much as 50 ft (15 m) exposed in recent gullies. Include some eolian and colluvial deposits.
Qac	Alluvium, Colluvium, and Soil (Holocene and Pleistocene)	Soil and alluvium uplifted by recent faulting in southern part of the map area. Locally covered by recent alluvial and eolian deposits.
	Pyroclastic Debris and Basalt Flows (Holocene and Pleistocene)	Basalt flows are divided into two informal groups, the younger Malpais and an older group. Older group is deeply weathered, largely covered by more or less well developed soil. Oldest flows (Qb) locally overlain by slightly younger flows (Qbu) and by pyroclastic debris (Qv) and cinder cones (Qc); some mightbe as young as the Malpais. The Malpais basalt field is dived into five units, each having basalt flows and associated volcanic debris and cinder cones. Cinder cones composed of basaltic ash, cinders, bombs, large angular blocks of scoria, and minor flows of glassy lava. Range in height from a few feet to more than 560 ft (170 m), and many are three-quarters of a mile (1 km) or more in diameter. A few cones are symmetrical with a central depression as much as 270 ft (70 m) deep over the vent, but most have been breached on one side by lava flows and have a cresent shape. Pyroclastic debris composed largely of basalt flows mixed with and covered by cinders, bombs, scoria blocks, and flow breccia. Deposits around Bandera Crater are mostly cinder covering sedimentary rocks.
Qc	Cinder cones	Cones in the western part of map area appear older than those associated with the Malpais flows; however, some could be contemporary, but without recent lava flows.
Qct	Cinder cones (Twin Craters)	Extend in northeast trending line with Twin Craters in about the center of the line, Lost Woman center to southwest, and La Tetra center to northeast.
Qbt	Twin Craters Flows	Originated from complex of cinder cones (Qct). Composed of several overlapping flow units emerging from different vents; difficult or impractical to separate. Includes most flows under or adjacent to State Highway 53.
Qbw	Hoya de Cibola Flows	Western flows originated from Hoya de Cibola crater and shield volcano (Qvw) in western part of the Malpais. Lava flowed south, east, and probably northeast; covered by the Bandera and McCartys flows. Flows, exposed in NE part of the map, tentatively correlated with western lows on the basis of similarity of composition, flow characteristics, weathering, and vegetation. Rock is similar to the McCartys flows but slightly higher Al_2O_3 and alkalis, and lower in MgO.
Qlt	Lava tubes	Lava tubes
Qcb	Bandera Crater	Ideal example of breached cinder cone. Cone is steep sided, symmetrical, almost three-quarters mile (a km) in diameter and 500 ft (150 m) high; has a central depression 600 ft (180 m) below rim and 260 ft (80 m) below breach on southwest side. Large lava tube begins at breach, totally collapsed to half mile (800 m), may extend to south and east for 12 mi (20 km) or more. Ice Cave, and its deposit of perpetual ice, developed in lava tube near crater; other ice caves occur at other localities in tube.
Qbb	Bandera Flows	Originated at Bandera Crater (Qcb) adjacent to State Highway 53. Rock is similar to the McCartys flow. Ultramafic inclusions in final tephra eruptions contain spinel-bearing dunitic and pyroxene-rich rock.
Qvb	Bandera Cinder Field	Fine cinders surround north, east, and west sides of crater, and cover sedimentary rocks and older basalt flows.
Qvw	Hoya de Cibola shield volcano	Shield volcano
Qvt	Mixed pyroclastics and flows	Surround cinder cones (Qct) and partially obscure sedimentary rocks in the area.

Table 1. Rock units for geology maps associated with El Malpais National Monument as adapted from Maxwell (1986), *continued*

Symbol	Name	Description
Qbm	McCartys Flow	Originated at a small cinder cone (Qcm) in southern part of Malpais; some flows to the south and more to the north, along the eastern margin of the Malpais, extending northward to the Rio San Jose and eastward along Interstate Highway 40. Not accurately dated; age inferred to be about 1000 years old on basis of Acoma Indian legends and presence of archeological materials in nearby valley fill that was correlated with the alluvium underlying the McCartys flow on the Rio San Jose valley. Flows could be as young as 400 years old. Generally unweathered, uneroded, and relatively barren of vegetation; in good exposures, flows exhibit grooved lava, squeeze ups, pahoehoe, \`a\`a, ropes, collapse depressions, pressure ridges, spatter cones, and a few lava tubes. Basalt is hpocrystalline, porphyritic; contains subhedral to euhedral phenocrysts of plagioclase and olivine in groundmass of subhedral plagioclase, anhedral olivine, pyroxene, and tachylyte heavily dusted woth opaque minerals; plagioclase phenocrysts predominant in remainder of the flows.
Qb	Old Basalt Flows	Deeply weathered, cover much of western half of map area. Largely covered with soil and alluvium; produce open grasslands having only small outcrops of basalt. Dated 0.788 MY near Cerro Bandera, and 1.38 MY old several miles west of map area.
Qv	Volcanic Debris	Volcanic debris in western part of the map area associated with cinder cones and with a few older flows; composed largely of weathered lava covered with coarse lava blocks and scoria.
Qbc	El Calderon Flows	Originated from El Calderon crater (Qcc) below and northeast of Cerritos de Jaspe. Oldest of the Malpais flows, largely covered by alluvium or younger flows near source. Flows in northeast part of map area have similar morphology and weathering and are correlated with the Calderon flows; probably the same as the Laguna flows of Nichols. Rock is coarse grained, porous, diktytaxitic; groundmass of plagioclase, subophitic augite, and brownish glass. Some rocks included with old basalt flows (Qb), notably Cerro Bandera and Cerro Rendija, are similiar and may correlate with this unit.
Qcc	El Calderon Crater	El Calderon crater.
Kth	Tres Hermanos Sandstone (Upper Cretaceous)	Composed of three units, a sandstone top, a highly variable middle unit, and a light-yellowish-gray sandstone at base. Middle unit around Mesa Negra is similar to the D-Cross or Rio Salado Tongues but grades southward to interbedded carbonaceous shale and sandstone containing lenticular coal beds; locally grades into predominately thin-bedded shaley sandstone and siltstone. In southern part grades into dray-gray, fossiliferous shale and light-gray and brown, thin-bedded, calcareois sandstone.
Kdp	Paguate Tongue of Dakota Sandstone (Upper Cretaceous)	Light-brown and tan, fine to very fine grained sandstone; local lenses medium to coarse grained sandstone, thin- to medium-bedded. Forms prominent cliffs along northeast side of the Malpais. Thickness 30–100 ft (1030 m).
Kdo	Clay Mesa Tongue of Mancos Shale and Lower Part of Dakota Sandstone (Upper Cretaceous)	Map unit includes, from top to bottom, the Clay Mesa Tongue of Mancos Shale, Cubero Tongue of Dakota Sandstone, the Oak Canon Member, and a basal sandstone and conglomerate unit of Dakota Sandstone; 90–120 ft (30–70 m) thick. The Clay Mesa is dark-gray, fissile shale containing greenish-gray bentonite beds and numerous, brown- weathering limestone concretions; unit is about 30 ft (10 m) thick. The Cubero Tongue pinches out in northeastern corner of area; lithology similiar to the Twowells and Paguate. The Oak Canyon Member is light-gray and grayish-tan, locally calcareous or carbonaceous sandstone and siltstone, very fine grained and thin-bedded sandstone; generally shaly siltstone with abundant, finely comminuted, carbonaceous material; numerous thin-bedded, light-gray, brown-weathering fossiliferous limestone lenses and concretions, and limestone or aragonite cone-in-cone concretions; 60–90ft (20–30m) thick. The basal sandstone conglomerate unit of the Dakota is light gray to white, medium to coarse grained, poorly sorted, crossbedded, and has siliceous cement. Lenses of conglomerate, especially near the base, have prominent scour and fill structures. In northeastern part of map area, thin-bedded, fine-grained sandstone, locally disturbed by trails and burros, pinches out southward; locally absent; shales rest directly in the Zuni Sandstone. Thickness 0–65 ft (0–20 m).

Table 1. Rock units for geology maps associated with El Malpais National Monument as adapted from Maxwell (1986), *continued*

Symbol	Name	Description
Jz	Zuni Sandstone and Wanakah Formation (Middle Jurassic)	Variable color, generally yellowish-gray or tan, locally chalk white, fine- to medium-grained sandstone; well rounded grains largely of quartz; very well sorted, large-scale eolian crossbeds. Conspicuous bleached zone at tip of unit. The Wanakah Formation in the northeastern corner of map area is white to pale-brown, thin- to medium-bedded, very fine-grained, silty sandstone interbedded with thin, dark-brown mudstone and claystone. Grades southward into thin-bedded, fluviatile sandstone at base of Zuni. The Wanakah is underlain by the Todilto Member and Entrada Sandstone in northeastern part of map area; the Todilto pinches out in northern part of area and its position is then occupied by a pebble conglomerate above the next exposure of Entrada to the south. The Zuni and Wanakah are 360–600 ft (110–180 m) thick in area.
Psa	San Andres Limestone (Lower Permian)	Mostly gray to yellow, thick-bedded, fossiliferous dolomitic limestone with thin, calcareous, shale partings and thin, sandy limestone lenses; a yellowish-gray sandstone bed about 20 ft (6 m) thick locally present in lower part. Thickness 115–145 ft (35–44 m). Forms cliff or persistent dip slope.
Pg	Glorieta Sandstone (Lower Permian)	White to buff, very pure, well-sorted, medium grained, crossbedded quartz sandstone; weathers yellow to light brown, well cemented with silica or calcite, generally about 150–165 ft (45–50 m) thick; forms cliff, ridge, or dip slopes.
Py	Yeso Formation (Lower Permian)	Pale-reddish-brown, medium-to fine-grained, thick- to thin-bedded, locally crossbedded sandstone and siltstone; grades upward into pink, white, and yellow alternating layers of friable sandstone. Three dense, fine-grained, light- to medium-gray limestone beds 10–13 ft (3–4 m) thick are present in upperpart of formation; locally overlain by 13–16 ft (4–5 m) of white to light-gray, poorly exposed gypsum beds. Formation about 1,300 ft (400 m).
Pa	Abo Formation (Lower Permian)	Moderate-brick-red to dusky-red, medium- to fine-grained sandstone and siltstone, locally cross bedded; forms cliffs and steep slopes. At base is 3–10 ft (1–3 m) of arkosic conglomerate containing white quartz pebbles, overlain by about 30 ft (10 m) of dusky-red arkose containing thin, medium-gray, limestone beds. Formation was deposited on an undulating surface of Precambrian rocks. Thickness about 1,300 ft (400 m).

Table 2. Relative ages of Zuni-Bandera lava flows within El Malpais National Monument. Based on Maxwell (1986) as modified by Laughlin et al. (1993) and Laughlin and WoldeGabriel (1997). Flows are ordered from youngest to oldest along with epoch designations.

Symbol	Lava Flow	Absolute age (KA)	Epoch
Qbm	McCartys	3.6-3.2	Holocene
Qbb	Bandera	10.05-10.7	Holocene
Qbt	Twin Craters	18.4-19.1	Late Pleistocene
Qbw	Hoya de Cibola	50 (18?)	Late Pleistocene
Qbc	El Calderon	54	Late Pleistocene
Qb	Old Basalt Flows	~700	Early Pleistocene

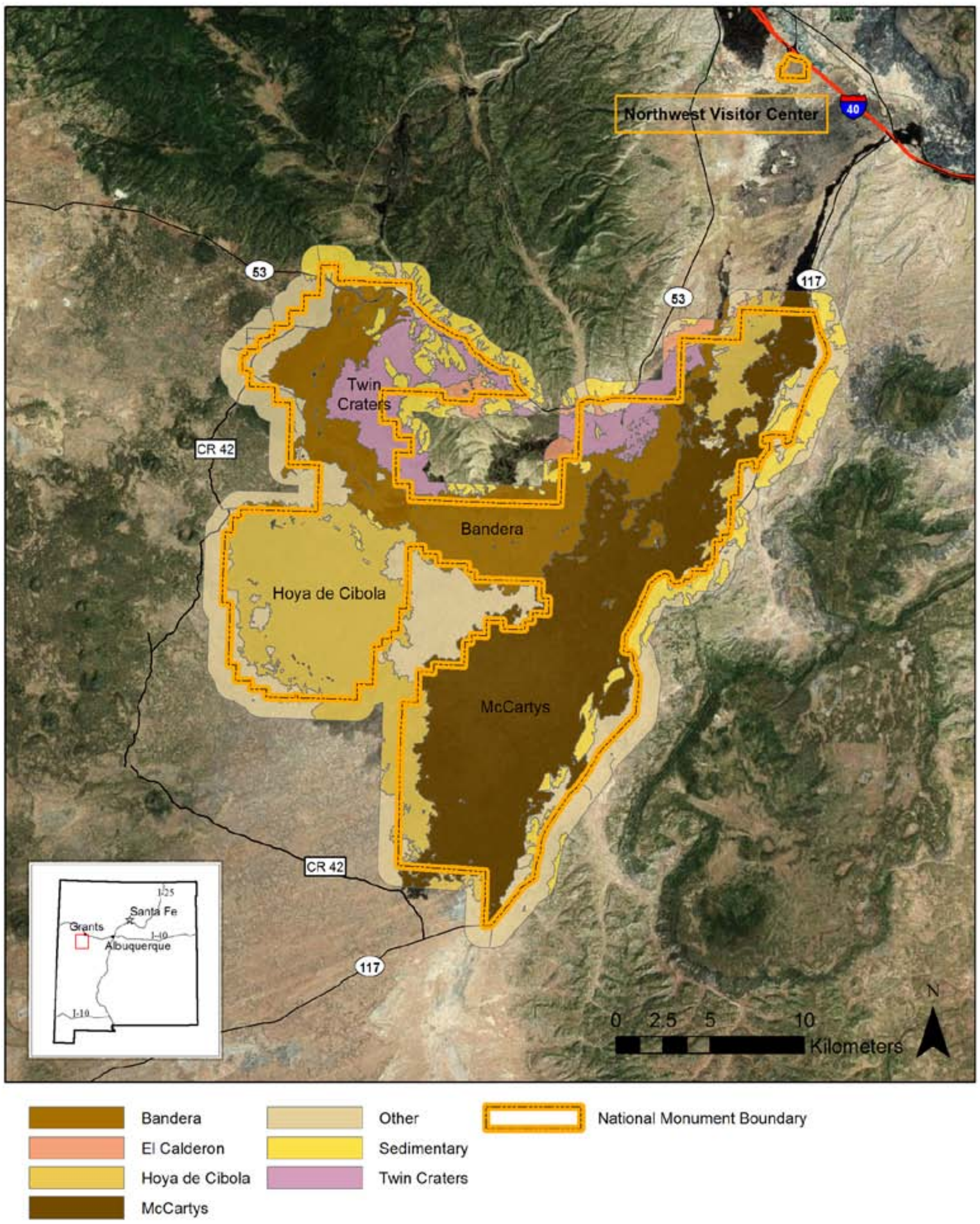

Figure 8. A summary geology and landform map where the original units of Maxwell (1986) have been merged into seven units to reflect the major lava flows, sedimentary rock formations, and other land types (alluvial plains, aeolian deposits, and old basalt plains). These units were used to stratify the mapping process and inform the vegetation classification.

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but they do support patches of vegetation, both outside and inside the craters. Similarly, the younger lava flows can have extensive, nearly barren expanses of exposed rough `a`a or ropy pahoehoe basalt lava. Yet, significant vegetation cover occurs on most of the surfaces, particularly on the smoother pahoehoe lavas, albeit sparse and stunted at times. Networks of lava tubes are prominent features of the lava flows, many of which have collapsed, forming depressions across the landscape which support vegetation that can be quite different from the surrounding lava flows. Where they are intact, the tubes have sometimes formed “ice caves”, where ancient ice has been preserved to this day. The mouths of these caves often provide a unique mesic, cool environment that can support ferns, mosses and lichens, along with other mesic vascular plants (Bleakly 1997; Northup and Welbourn 1997).

As the lava flows age, they accumulate wind-deposited sediments and develop a soil mantle (little soil is directly derived from weathering of the underlying basalt lava). Each lava flow has developed its own character through time, which has direct implications for the patterns of vegetation found on them. The McCartys flow (Fig. 7; Qbm) is the youngest, and last erupted perhaps 3,200 years ago. It is the largest lava flow and dominates the eastern portion of the park where it initiates from McCartys Crater in the southeast corner. While the soil mantle is limited, extensive areas of stunted woodlands and shrublands are intermixed among barren lava flows (mostly pahoehoe type).

The next oldest (10–11 Ka) lava flow is Bandera (Qbb) which originated around the Bandera Cone (Qvb and Qvc) at the far northwestern area of the park. The Bandera flow also extended well eastward but was later overlain by the McCartys Flow over much of its extent on the eastern side of the park. It is a mix of `a`a and pahoehoe, but the `a`a lavas predominate, creating large, barren or weakly vegetated areas throughout. The older, Late Pleistocene (18–19 Ka) Twin Craters flows (Qbt) also have their origins among cones (Qvt) in the northwestern sector of the park. They lie adjacent to and north of the Bandera flow and presumably are overlain by Bandera as well as McCartys in portions of the distribution. Cascadden et al. (1997) differentiated four separate flow events within this original unit of Maxwell (1986) that emanate from the Cerro Candelaria, Twin Craters, Lost Woman, and Lava cones (in order from oldest to youngest). They indicate that the differences in geomorphology are subtle, and for our purpose here the flows are considered together under the original Maxwell (1986) Twin Craters name and delineation. Twin Craters also has a mix of `a`a and pahoehoe lavas that affect vegetation pattern as well (i.e., `a`a flow exposures tend to have lower vegetation cover). As with McCartys, the soil mantle is relatively thin on the Bandera and Twin Craters flows, and in some areas absent.

The Hoya de Cibola (Qbw) and El Calderon (Qbc) flows are significantly older at 50 and 54 Ka, respectively. According to Laughlin and WoldeGabriel (1997), reports conflict as to the age of the Hoya flow, and some portions may be younger. Both flows have better developed soil mantles than the younger flows above, but Hoya has a greater degree of lava exposure than El Calderon, suggesting that it is the younger of the two. The Hoya flow dominates the southwestern portion of the park, and also extends well north and east, but was overlain by the younger flows. As a result, Hoya kipukas are scattered within the McCartys flow and on large disjunct exposures at the northeastern boundary of park. The El Calderon flow has also been extensively overlain by the other Pleistocene flows, and is exposed within the park only near its origins at the El Calderon Crater (Qcc).

1.3.5 Previous botanical and vegetation studies

The earliest description of the vegetation of the El Malpais area was provided by Lindsey (1951). He described and broadly mapped three vegetation belts on the lava flows, dominated respectively by (1) P*seudotsuga menziesii*, (2) *Pinus ponderosa*, and (3) *Fallu-*

gia paradoxa (Apache plume), with *Pinus edulis* (pinyon pine) and *Juniperus monosperma* (oneseed juniper) trees as part of the Apache plume belt. In addition, Lindsey described the vegetation associated with specific geologic substrates, which included lava cones, cinder cones, cinder benches, granite hills, yellow sandstones, high Tertiary plains, and the ice caves.

Bleakly (1994, 1997) mapped four broad vegetation zones: (1) Mixed Conifer, which was inclusive of Lindsey's Douglas-fir and ponderosa pine belts; (2) Bare to Sparse Grass/Shrub, more or less equivalent to Lindsey's Apache plume belt; (3) a Grass or Grass/Shrub zone that corresponds to Lindsey's high Tertiary plains associated with the early Pleistocene volcanic surfaces; and (4) a Shrub/Conifer zone associated with sedimentary rock substrates and alluvial plains that supported pinyon and juniper woodlands and grasslands. He also provided a comprehensive vascular plant species list for the monument.

Carroll (1989) produced a Biophysical Land Units (BLU) map at approximately 1:50,000 scale, which covered the monument and the adjacent BLM lands of El Malpais National Conservation Area (also part of the general management plan for the NCA by BLM [1990]). This map was developed using 30-meter LANDSAT Thematic Mapper (TM) imagery from 1984 and has 11 BLU map units. BLUs use a combination of terrain, soil, and vegetation classes in the mapping process. Carroll (1989) identified eight vegetative classes which are similar in thematic content to Lindsey (1951) and Bleakly (1994): (1) Lava/lichen/pygmy scrub; (2) Sparse/bare; (3) Grass/shrub; (4) Shrub/conifer; (5) Mixed conifer; (6) Pinyon-juniper woodland; (7) Deciduous; and (8) Ponderosa parklands.

2 Vegetation classification

A consistent, ecologically based vegetation classification is the foundation for the development of an information–rich vegetation map. Vegetation classifications are ground-based descriptions of vegetation patterns that take into account floristic composition and abundance, site characteristics, and ecological dynamics. Accordingly, for ELMA, 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 our methods for developing the classification and provide an overview and discussion of the ELMA classification.

2.1 Classification methods

2.1.1 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 3). 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 in 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, such as the one described in this report, continually add to the documentation and listing of NVC types.

2.1.2 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

Table 3. National Vegetation Classification hierarchy for terrestrial vegetation following the FGDC (2008) standard.

Level	Level name	Criteria	Example
Upper levels			
L1	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)
L2	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)
L3	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			
L4	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)
L5	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)
L6	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			
L7	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)
L8	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)

15 when botanical expression is at its best). The four- to six-week sampling campaigns were planned to optimize field crew efficiency while still capturing as wide a range of vegetation types as possible on any given day. Accordingly, we used a cluster-sampling approach for which we designed a series of daily routes for the sampling crews in a GIS using the digital ortho-photography and preliminary vegetation maps. The selection of eight to ten sampling points per route was driven by differences in vegetation, soils, and geologic pattern, plus logistics, i.e., what a field crew could accomplish in one day's travel time by vehicle and foot (sampling days were ten hours long to further increase daily efficiency). Routes were distributed as widely as possible throughout the study area, but the lack of trails and difficulty of traversing lava flow terrain in ELMA limited field accessibility. Routes in the GIS were chosen in consideration of these logistical issues. We estimated that crews would not be able to push further than two miles from a road into any given rough lava terrain without trail markers (on-the-ground crews often have to follow long meandering courses to avoid extensive collapse features and crevasses to reach a point). Accordingly, sampling was often constrained to the outer portions of the lava flows. Sampling deeper into the flows would have required helicopter support, which was unavailable. In addition, certain roads were also off-limits to our use, particularly the road to the Little Hole in Wall area within the BLM wilderness (despite repeated requests for access). Regardless, based on our interpretation of the imagery, we felt we covered the range of variability of vegetation patch types to the greatest degree possible. 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, habitat, and logistics.

Field crews were composed of two to three people, which included a senior technician crew chief, who was responsible for botany and vegetation sampling, and one or two 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, a list of all vascular plant species, stratified by life form (tree, shrub, subshrub, grass and forb layers) and height was compiled, and cover estimated for each species using a modified Domin-Krajina Scale (Table 4) (Mueller-Dombois and Ellenberg 1974). Total non-overlapping cover was also recorded by stratum. Site attributes for plots, including slope percent, aspect, slope shape, surface rock type, and ground cover (percent rock, gravel, bare soil and litter) were noted, along with a description of species composition and site conditions. Plot locations were recorded with a Garmin GPS Model 12 with +/- 10 m accuracy. For each plot, at least four photos were taken in the four cardinal directions from plot center, with each photo containing a placard noting

Table 4. 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 (m^2) within the 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

the project, sampling date, and plot number. The compass direction and focal length of each shot was logged for future reference. See Appendix A for the NHNM field survey handbook, detailed descriptions of sampling procedures, and examples of sampling forms.

We primarily used standard plots to support vegetation classification development, and could establish three to five in a day. To maximize ground control for the mapping process, we employed stripped-down mapping plots (quick plots) for which only the cover of the dominant species in each strata was recorded, along with a reduced set of site parameters. Anywhere from 6 to 12 of these quick plots could be established in a day, depending on logistics (all accuracy assessment plots were of this style). We collected 476 plots for the classification and mapping portion of the project (Fig. 9). Of these, 253 were standard plots and 223 were quick plots.

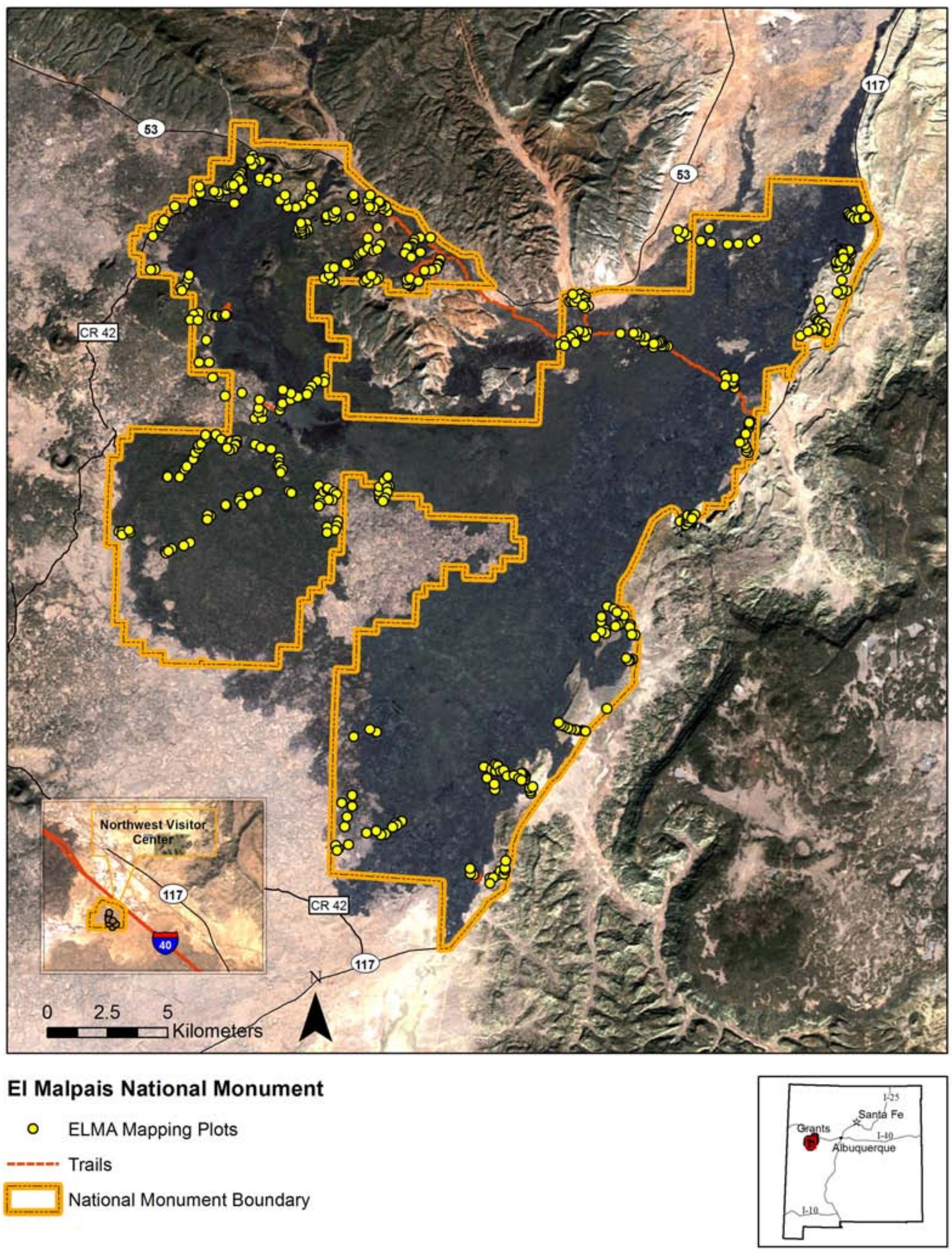

Figure 9. Distribution of 476 vegetation plots used for the classification and mapping of ELMA.

We collected plant voucher specimens to confirm field identifications when necessary. These are housed at the University of New Mexico (UNM) 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 (US Department of Agriculture, Natural Resources Conservation Service 2009) and the Integrated Taxonomic Information System (ITIS). Qualifying specimens were accessioned with both UNM accession numbers and NPS record numbers tied 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 and quality controlled through error-checking computer routines and manual read-backs. Each record contains the comprehensive documentation of the plot location, 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_ELMA.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.

2.1.3 Vegetation analysis

To develop the vegetation classification, the plot data were analyzed 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 used to supplement the analysis. In general, each plot was classified into a particular plant association (PA) based on codominance and/or other groups of differential species. Phases of associations were assigned as necessary to further define the character of the plant community. For 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. 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 were the basis for plant association descriptions and dichotomous keys.

2.2 Classification results

The vegetation of El Malpais National Monument (ELMA) is diverse and reflects both the complex volcanic history of the past 50,000 years and the subtle elevation gradient across the monument. We identified 50 plant associations (PAs) that range from the semi-desert grasslands/shrublands of the older lowland basaltic plains to mixed conifer forests on the slopes of cinder cones. In addition, there are four sparsely vegetated land-cover elements in the classification: Sparse Vegetation / Alluvial Flat, Sparse Vegetation / Cinder Cone, Sparse Vegetation / Lava Flow, and Sparse Vegetation / Boulder Rockland. In Table 5, we present the PAs ordered by the NVCS hierarchy, along with their classification status, number of ELMA plots, and NatureServe database code. Thirty-seven of the PAs were considered established (E) types according to the NVC (i.e., they are well documented either in the park or in the region) and have been entered into the NVC database and assigned a NatureServe database code as Standard Associations. Another 18 have limited documentation within and outside the park and are considered “Park Specials” (P) that need further documentation before being included officially in the NVC. For the established associations and Park Specials,

Table 5. A hierarchical vegetation classification for the El Malpais National Monument following the National Vegetation Classification System of seven levels: Class, Subclass, Formation, Division, MacroGroup, Group, and Plant Association (see Table 3 for hierarchical level definitions). At the plant association level, the status of a plant association is indicated as either established (E) in the national classification, a provisional park special (P) association pending review, or (I) for an incidental provisional association that was observed but not sampled. The number of quantitative plots gathered for the association on ELMA excludes semi-quantitative observation points. "Code" refers to the NatureServe plant association database code (CEGL codes are NatureServe database codes for nationally/globally recognized associations; CEPS codes are provisional "Park Special" associations). "Map unit" refers to the vegetation map units in which the plant association is considered to be either a primary component, secondary component, or related inclusion (see Table 8).

Group	Association	Status	# of plots	Code	Map unit
Class: 1. Forest to Open Woodland					
Subclass: 1.B Temperate & Boreal Forest					
Formation: 1.B.1 Warm Temperate Forest					
Division: 1.B.1.Nd Madrean & Southwest Great Plains Warm Temperate Woodland & Scrub					
Macrogroup: M010. Madrean Lowland Evergreen Woodland					
G200. Madrean Pinyon - Juniper Woodland	*Pinus edulis - Juniperus deppeana - Quercus grisea* Woodland	P	3	CEPS009509	4H
G487. Madrean Juniper Savanna & Woodland	*Juniperus monosperma / Muhlenbergia pauciflora* Woodland	E	1	CEGL005387	4H
Class: 1. Forest to Open Woodland					
Subclass: 1.B Temperate & Boreal Forest					
Formation: 1.B.2. Cool Temperate Forest					
Division: 1.B.2.Nb Rocky Mountain Cool Temperate Forest					
Macrogroup: M020. Rocky Mountain Subalpine & High Montane Conifer Forest					
G222. Rocky Mountain Subalpine & Montane Aspen Forest & Woodland	*Populus tremuloides* / Mixed Shrubs / Cinder Woodland	E	3	CEGL005034	1A, 3A
	Populus tremuloides / Ribes cereum Woodland	P	5	CEPS009504	1B, 2D, 2G, 4E, 6C
Macrogroup: M022. Southern Rocky Mountain Lower Montane Forest					
G228. Southern Rocky Mountain Ponderosa Pine Forest & Woodland	*Pinus ponderosa / Artemisia filifolia* Woodland	P	1	CEPS009503	3D
	Pinus ponderosa / Carex inops ssp. *heliophila* Woodland	E	11	CEGL000849	2A, 2E, 2F, 2G

Table 5. A hierarchical plant association classification for El Malpais National Monument (ELMA) *continued*

Group	Association	Status	# of plots	Code	Map unit
	Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland	E	10	CEGL005032	2B, 2E, 2D, 2G
	Pinus ponderosa / Fallugia paradoxa Woodland	E	13	CEGL002999	2C
	Pinus ponderosa / Poa fendleriana Woodland	E	5	CEGL005507	2B, 3A
	Pinus ponderosa / Quercus gambelii Woodland	E	5	CEGL000870	1C, 2A, 2H, 2I
	Pinus ponderosa / Quercus X *pauciloba* Woodland	E	5	CEGL000874	2H
G229 Southern Rocky Mountain Ponderosa Pine Savanna	*Pinus ponderosa / Bouteloua gracilis* Woodland	E	26	CEGL000848	2E, 2G, 3A, 3B, 3C
	Pinus ponderosa / Festuca arizonica Woodland	E	1	CEGL000856	3A
	Pinus ponderosa / Muhlenbergia montana Woodland	E	73	CEGL000862	2A, 2E, 2F, 2G, 2I, 3A, 3B, 3C
	Pinus ponderosa / Schizachyrium scoparium Woodland	E	5	CEGL000201	2E, 2G, 3B
	Pinus ponderosa / Sporobolus cryptandrus Woodland	P	1	CEPS009510	3D
G226. Southern Rocky Mountain White Fir - Douglas-fir Dry Forest	*Pseudotsuga menziesii / Holodiscus dumosus* Lavaflow Woodland	P	1	CEPS009505	1B
	Pseudotsuga menziesii / Muhlenbergia montana Forest	E	4	CEGL000443	1A, 2G
	Pseudotsuga menziesii / Quercus gambelii Forest	E	2	CEGL000452	1C
	Pseudotsuga menziesii / Ribes (leptanthum, cereum) Woodland	P	1	CEPS009506	1A

Class: 1. Forest to Open Woodland

Subclass: 1.B Temperate & Boreal Forest

Formation: 1.B.2. Cool Temperate Forest

Division: 1.B.2.Nc Western North American Cool Temperate Woodland & Scrub

Macrogroup: M027. Rocky Mountain Two-needle Pinyon - Juniper Woodland

Table 5. A hierarchical plant association classification for El Malpais National Monument (ELMA) *continued*

Group	Association	Status	# of plots	Code	Map unit
G252. Southern Rocky Mountain Juniper Woodland & Savanna	*Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus* Woodland	P	13	CEPS009507	4G, 5F
	Juniperus monosperma / Bouteloua gracilis Woodland	E	29	CEGL000710	5C, 5D, 5E, 5F, 5G
	Juniperus monosperma / Fallugia paradoxa Woodland	E	3	CEGL000716	5A
	Juniperus monosperma / Fraxinus cuspidata Woodland	P	6	CEPS009508	5B, 5C
	Juniperus monosperma / Quercus × pauciloba Woodland	E	4	CEGL000721	4C, 5B, 5G
G253. Southern Rocky Mountain Pinyon - Juniper Woodland	*Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Woodland	E	46	CEGL002151	4B, 4F, 4G, 4H, 5E
	Pinus edulis - (Juniperus spp.) / Cinder Woodland	P	8	CEPS009512	4A, 4B
	Pinus edulis - Juniperus monosperma / Quercus × pauciloba Woodland	E	3	CEGL000793	4C, 4H
	Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland	E	8	CEGL002802	1A, 1B, 2B, 2D, 4E
	Pinus edulis - Juniperus spp. / *Fallugia paradoxa* Woodland	E	20	CEGL002188	2D, 4A, 4D, 4E
	Pinus edulis / Achnatherum scribneri Woodland	E	8	CEGL000798	4H
Class: 2. Shrubland & Grassland					
Subclass: 2.B Temperate & Boreal Grassland & Shrubland					
Formation: 2.B.2. Temperate Grassland, Meadow & Shrubland					
Division: 2.B.2.Na Western North American Grassland & Shrubland					
Macrogroup: M049. Southern Rocky Mountain Montane Shrubland					
G276. Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland	*Fallugia paradoxa* / Rockland Shrubland	E	9	CEGL002330	1C, 6A, 6B
	Fallugia paradoxa - Rhus trilobata Shrubland	E	13	CEGL002222	6B, 6C
	Rhus trilobata - Ribes cereum Shrubland	E	5	CEGL002333	6C

Table 5. A hierarchical plant association classification for El Malpais National Monument (ELMA) *continued*

Group	Association	Status	# of plots	Code	Map unit
Macrogroup: M168. Rocky Mountain-Vancouverian Subalpine & High Montane Mesic Grass & Forb Meadow					
G268. Southern Rocky Mountain Montane-Subalpine Grassland	*Bouteloua gracilis - Muhlenbergia montana* Herbaceous Vegetation	P	5	CEPS009500	9B
Class: 2. Shrubland & Grassland Subclass: 2.B Temperate & Boreal Grassland & Shrubland Formation: 2.B.2. Temperate Grassland, Meadow & Shrubland Division: 2.B.2.Nb Great Plains Grassland & Shrubland					
Macrogroup: M052. Great Plains Sand Grassland & Shrubland					
G069. Great Plains Sand Shrubland	*Artemisia filifolia / Bouteloua (curtipendula, gracilis)* Shrubland	E	5	CEGL002176	5F, 8A
Macrogroup: M053. Great Plains Shortgrass Prairie & Shrubland					
G144. Great Plains Shortgrass Prairie	*Artemisia frigida / Bouteloua gracilis* Dwarf-shrubland	E	15	CEGL002782	9C
	Bouteloua gracilis - Sporobolus cryptandrus Herbaceous Vegetation	E	12	CEGL001761	9D
	Bouteloua gracilis Herbaceous Vegetation	E	22	CEGL001760	9A, 9B, 9C, 9F
	Bouteloua gracilis Ruderal Herbaceous Vegetation	P	4	CEPS009501	9E
	Pascopyrum smithii - Bouteloua gracilis Herbaceous Swale Vegetation	P	2	NHNM000857	9F
	Pascopyrum smithii / Grindelia squarrosa Herbaceous Vegetation	P	5	CEPS009502	9F
Class: 3. Desert and Semi-Desert Subclass: 3.B Cool Semi-Desert Scurb & Grassland Formation: 3.B.1 Cool Semi-Desert Scrub & Grassland Division: 3.B.1.Ne Western North American Cool Semi-Desert Scrub & Grassland					
Macrogroup: M171. Great Basin & Intermountain Dry Shrubland & Grassland					
G311. Intermountain Semi-Desert Grassland	*Bouteloua gracilis - Pleuraphis jamesii* Herbaceous Vegetation	E	7	CEGL001759	9B

Table 5. A hierarchical plant association classification for El Malpais National Monument (ELMA) *continued*

Group	Association	Status	# of plots	Code	Map unit
	Sporobolus airoides Monotype Herbaceous Vegetation	E	2	CEGL001688	9F
G310. Intermountain Semi-Desert Shrubland & Steppe	*Ericameria nauseosa / Bouteloua gracilis* Shrub Herbaceous Vegetation	E	19	CEGL003495	9A
	Krascheninnikovia lanata / Bouteloua gracilis Dwarf-shrub Herbaceous Vegetation	E	1	CEGL001321	9A
	Sarcobatus vermiculatus / Sporobolus airoides Shrubland	E	1	CEGL001368	9F
Macrogroup: M093. Great Basin Saltbrush Scrub					
G300. Intermountain Shadscale - Saltbush Scrub	*Atriplex canescens / Bouteloua gracilis* Shrubland	E	6	CEGL001283	7A
	Atriplex canescens / Panicum obtusum Shrubland	P	5	CEPS009511	7A
	Atriplex canescens / Sporobolus airoides Shrubland	E	5	CEGL001291	7A
Class: 6. Rock Vegetation					
Subclass: 6.C Desert & Semi-Desert Rock Vegetation					
Formation: 6.C.1 Warm Desert & Semi-Desert Cliff, Scree & Other Rock Vegetation					
Division: 6.C.1.Na North American Warm Semi-Desert Cliff, Scree & Rock Vegetation					
Macrogroup: M117. North American Warm Semi-Desert Cliff, Scree & Rock Vegetation					
G569. North American Warm Semi-Desert Cliff, Scree & Pavement Sparse Vegetation	Sparse Vegetation / Alluvial Flat	P	1	NPS_NM049	7A, 9E, 9F, 10C
	Sparse Vegetation / Cinder Cone	P	1	NPS_NM066	1A, 2A, 4A, 6A, 10B, 2B
	Sparse Vegetation / Lava Flow	P	7	NPS_NM067	1B, 2C, 2D, 2E, 2F, 2G, 2H, 3B, 4C, 4D, 4E, 4F, 5A, 5B, 5C, 5D, 6B, 6C, 10A
	Sparse Vegetation / Boulder Rockland	i	-	NPS_NM013	10D

we have provided diagnostic keys and detailed descriptions of floristic composition site characteristics in Appendices C and D, respectively. Lastly, we have cross-walked each PA to the map units in which they are either a primary or secondary component, or a related inclusion (see Chapter 3 for a description of map unit structure and Table 8).

2.2.1 Classification overview

Below we summarize the information on composition, structure, and environments of vegetation communities within the monument in the context of the NVCS hierarchy. We focus on the middle tiers of the hierarchy (Division, Macrogroup, and Group, see Table 5) with brief summaries of plant association composition and distribution. For detailed descriptions of each association see Appendix D. Plant associations that are Park Specials, with limited documentation both within and outside the park, are listed at the end of Appendix D.

1 Forest to Open Woodland

1.B Temperate & Boreal Forest

1.B.1 Warm Temperate Forest

1.B.1. Nd Madrean & Southwest Great Plains Warm Temperate Woodland & Scrub

M010 Madrean Lowland Evergreen Woodland

This macrogroup is dominated by species that have their center of distribution south in the highlands of Mexico and Central America (i.e., in the Sierra Madre Occidentale and Sierra Madre Orientale), and has been variously referred to as Madrean pine-oak woodland or encinal (oak) woodland (Brown et al. 1998; Dick-Peddie 1993; Thompson et al. 1996). In ELMA, the macrogroup is represented by the Madrean Juniper Savanna & Woodland Group (G487), and the Madrean Pinyon - Juniper Woodland Group (G200), the latter being represented by the *Pinus edulis - Juniperus deppeana - Quercus grisea* Woodland PA. While *P. edulis* is widely distributed further north and in the southern Rocky Mountains, both *J. deppeana* (alligator juniper) and the evergreen oak *Q. grisea* have the center of their distributions in southern New Mexico and Arizona and adjacent northern Mexico. *P. edulis* and *J. deppeana* form moderately open to closed canopies with *Q. grisea* as an understory and inter-tree shrub, along with a scattering of grasses and forbs (Fig. 10).

Figure 10. This stand of the *Pinus edulis - Juniperus deppeana - Quercus grisea* PA is an example of the Madrean Lowland Evergreen Woodland Group growing on limestone of a sedimentary rock hill kapuka (island) surrounded by lava flows (photo by Y. Chauvin).

The Madrean Juniper Savanna & Woodland Group is represented by the *Juniperus monosperma / Muhlenbergia pauciflora* Woodland PA. As with *P. edulis, J. monosperma* is more common to the north, but the dominance of *M. pauciflora* is indicative of the Madrean affiliation. In ELMA, these groups are known to occur only on soils derived from limestone or sandstone (Sedimentary unit in Fig. 8). That is, they typically occur on the ancient Permian/Jurassic/Cretaceous-aged sedimentary hills that form islands (or "kipukas") within lava flows or are adjacent to the flows.

1.B.2 Cool Temperate Forest

1.B.2.Nb Rocky Mountain Cool Temperate Forest

M020 Rocky Mountain Subalpine & High Montane Conifer Forest

On ELMA, this macrogroup is represented by a single group, the Rocky Mountain Subalpine & Montane Aspen Forest

Figure 11. This stand of *Populus tremuloides* / Mixed Shrubs / Cinder Woodland is an example of the Rocky Mountain Subalpine & Montane Aspen Forest & Woodland Group growing on the steep slopes within the Bandera volcanic cone (photo by A. Kennedy).

& Woodland Group (G222), which is dominated by the broadleaf and cold-deciduous *Populus tremuloides* (quaking aspen), with conifers, while they may be present, making up less than 25% of the relative canopy cover of the stand. We identified two associations from this minor group, both of which are currently known only from ELMA.

Figure 12. On the younger lava flows such as the Twin Craters, a stand of *Populus tremuloides / Ribes cereum* Woodland can take on a scrub-like physiognomy (photo by J. Coop).

The *Populus tremuloides* / Mixed Shrubs / Cinder Woodland PA is associated with the cinder cones of the Bandera and Twin Craters flows, either on the steep side slopes or within the craters themselves (Fig. 11). Stands typically have a shrubby understory with a mix of mesic species, such as *Ribes leptanthum* (trumpet gooseberry), *Holodiscus dumosus* (rock spirea), *Symphoricarpos oreophilus* (whortleleaf snowberry), and *Rhus trilobata* (skunkbush sumac).

The *Populus tremuloides* / *Ribes cereum* Woodland PA occurs as scattered patches on the middle-aged lava flows, particularly on the Bandera and Twin Craters flows. Stands tend to be shrubby or stunted and growing in the fissures of the lava flows. The understories are typically sparse with scattered mesic shrubs that include *Ribes cereum* (wax currant), *Forestiera pubescens (*New Mexico olive), *Holodiscus dumosus*, and *Rhus trilobata*, with few grasses or forbs (Fig. 12).

Aspen is a clonal species that most commonly reproduces by root sprouting. Following fires (and other disturbances, such as logging), aspens can vigorously resprout and come to dominate a site for decades, even centuries (Bradley et al. 1992). Aspen regeneration is particularly strong on severely burned sites, but may be controlled to some degree by preferential elk and deer browsing in those areas (Allen 1989; Bailey and Whitham 2002). Although some aspen forests are known to be self-perpetuating, conifers will typically regain a site in the absence of fire and with adequate conifer seed sources (DeVelice et al. 1986). This is what may be occurring on the cinder cones, but out on the lava flows aspen are likely getting established in moist micro-sites where they are acting more as facultative wetland species like their congeneric cottonwood, such as *P. angustifolia* (narrowleaf cottonwood) or *P. deltoides* (plains cottonwood).

M022 Southern Rocky Mountain Lower Montane Forest

This major macrogroup on ELMA represents cool-temperate forest communities that generally occur at elevations between 2,040 and 2,500 m (6, 700 and 8, 200 ft), becoming most prevalent above 2,100 m (7,000 ft). These forests are co-dominated by relatively tall conifers, *Pseudotsuga menziesii* (Douglas-fir) and *Pinus ponderosa* (ponderosa pine), with sub-canopies of lesser-stature conifers such as *Juniperus scopulorum, J. monosperma* , or *Pinus edulis*. The macrogroup contains three groups and is synonymous with Rocky Mountain Montane Conifer Forest as described by Brown et al. (1979, 1998).

The Southern Rocky Mountain White Fir - Douglas-fir Dry Forest (G226) group is dominated by *P. menziesii*, occurs at the upper end of this elevation gradient (above 2,325 m; 7,600 ft), and is represented by four associations. This group represents the Douglas-fir Belt first described for ELMA by Lindsey (1951). Dick-Peddie (1993) includes this group for New Mexico under his Upper Montane Coniferous (Mixed Conifer) Forest type, and Brown et al. (1979, 1998) refers to it as the Douglas-Fir-White Fir (=Mixed Conifer) Series. The *Pseudotsuga menziesii / Holodiscus dumosus* Lavaflow Woodland PA, known from cool microsites on the early Holocene Bandera flow, and the *Pseudotsuga menziesii / Ribes* (*leptanthum, cereum*) Woodland PA, which occurs on northerly aspects of cinder cones on the late Pleistocene Twin Craters flow (Fig. 13), both have shrubby understories dominated by relatively mesic species, such as *Ribes leptanthum*, *Holodiscus dumosus, Forestiera pubescens, Ribes cereum*, and *Salix scouleriana* (Scouler's willow).

The *Pseudotsuga menziesii / Muhlenbergia montana* Forest PA occurs primarily on drier sites of cinder cones of the Twin Craters flow and is characterized by a grassy understory dominated by *Muhlenbergia montana* (mountain muhly) and *Poa fendleriana* (muttongrass) (Fig. 14). In contrast, *Pseudotsuga menziesii / Quercus gambelii* Forest has a shrubby understory and only occurs on soils derived from limestone or sandstone of the kipuka sedimentary hills (Fig. 15).

Figure 13. This forest stand on Twin Craters is representative of the *Pseudotsuga menziesii / Ribes (leptanthum, cereum)* Woodland PA of the Southern Rocky Mountain White Fir-Douglas-fir Dry Forest Group. It occurs on both the interior and exterior slopes of cinder cones (photo by A. Kennedy).

Figure 14. An example of the *Pseudotsuga menziesii / Muhlenbergia montana* Forest PA growing on the outer slopes of Twin Craters (photo by A. Kennedy).

Figure 15. This stand of *Pseudotsuga menziesii / Quercus gambelii* Forest was found on limestone hills east of the El Calderon lava flow (photo by E. Lindahl).

Figure 16. Extensive stands of stunted *Pinus ponderosa* typify the *Pinus ponderosa / Fallugia paradoxa* Woodland PA on the McCartys lava flow. This association is part of the Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (photo by J. Coop).

Among these mixed conifer associations, which tree species will dominate on a site is a function of site conditions and disturbance history (particularly fire). *Pseudotsuga* is more shade tolerant, but has less drought tolerance and fire resistance than P. *ponderosa*. Typically, *P. ponderosa* is most prevalent in early successional stages following fire in the mixed conifer forests. Later, as the pines mature, *Pseudotsuga* will replace them in the canopy. Sometimes, however, they become established at the same time and co-dominate the regenerating forest. *Populus tremuloides* is also a common component in these forests, particularly on sites that have been burned or logged.

At lower elevations and/or on warmer sites, the mixed conifer forest groups give way to the Southern Rocky Mountain Ponderosa Pine Forest & Woodland (G228) and Southern Rocky Mountain Ponderosa Pine Savanna (G229) groups. Here, *P. ponderosa* is the clear dominant and *Pseudotsuga* is uncommon or absent, but low-statured conifers, such as *Pinus edulis*, *Juniperus monosperma*, *J. scopulorum* or *J. deppeana*, may be common in the understory, along with oaks such as *Quercus gambelii* (Gambel oak) and *Q.* × *pauciloba* (wavy-leaf oak). Together the two groups would correspond to Lindsey's (1951) Ponderosa Pine Belt. They would fall within Dick-Peddie's (1993) Lower Montane Coniferous Forest type or the Brown et al. (1979, 1998) Pine Series. These are the most common forests on ELMA and are known to occur in various forms on all the flows as well as on sedimentary and alluvial soil parent materials.

The Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (G228) is represented by seven associations with moderately open to closed canopies (25 to 75% cover). Of these associations, six are characteristically shrubby with sparse herbaceous layers. For example, the *Pinus ponderosa / Fallugia paradoxa* Woodland and *Pinus ponderosa / Fallugia paradoxa - Ribes cereum* Woodland PAs are young lava flow woodlands (predominantly McCartys and Bandera, respectively) where trees and shrubs have established within the cracks and fissures of the flow, while herbaceous vegetation is limited to microsites where wind-deposited sediments have accumulated and soils have just begun to develop (Fig. 16). *Pinus ponderosa / Fallugia paradoxa - Ribes cereum* Woodland, while common on ELMA, has not been described elsewhere and tends to occur at higher elevations than the *Pinus ponderosa / Fallugia paradoxa* Woodland (2,200–2,300 m [7,200–7600 ft] versus 2,100– 2,000 m [7,000–7,200 ft]). *Pinus ponderosa / Fallugia paradoxa* Woodland PA has been previously described at Sunset Crater National Monument, Arizona (Hansen et al. 2004).

The *Pinus ponderosa / Quercus gambelii* Woodland PA, one of the more common ponderosa pine types in the Southwest, occurs on both sedimentary-derived soils and younger volcanic substrates (both lava) (McCartys flow) and cinder cones (Twin Craters and Bandera). It is characterized by an understory dominated by the deciduous oak, *Q. gambelii* (as either a shrub or small tree). In contrast, the *Pinus ponderosa / Quercus* × *pauciloba* PA is dominated by semi-deciduous and strictly shrubby *Q.* × *pauciloba* (the putative hybrid between *Q. gambelii* and *Q. grisea*, or possibly *Q. turbinella*) and is generally found at elevations below 2,130 m (7,000 ft) on the youngest lava flows (Bandera and McCartys). The *Pinus ponderosa / Carex inops* ssp. *heliophila* Woodland PA and *Pinus ponderosa / Poa fendleriana* Woodland PAs occur where oaks and other shrubs are poorly represented and the herbaceous understory is still sparse or with scattered grasses. These associations are most prevalent on the Twin Craters flow, but are also found on the older Hoya flow, as well as on the slopes of cinder cones.

Pinus ponderosa / Artemisia filifolia Woodland PA is a Park Special association that occurs among the sand deposits adjacent to lava flows along the eastern border of the monument. While *A. filifolia*-dominated shrublands (without trees) also occur in the park (see shrublands below), these sites probably have slightly enhanced soil/water relationships that support tree growth. However, that remains to be tested. Although this is the only record for this association, we suspect that it occurs elsewhere in the Southwest on sand deposits of equivalent moisture and temperature regimes.

Figure 17. The *Pinus ponderosa / Muhlenbergia montana* Woodland is part of the Southern Rocky Mountain Ponderosa Pine Savanna Group. These open, park-like stands are common on the Hoya de Cibola flow (photo by J. Coop).

The Southern Rocky Mountain Ponderosa Pine Savanna Group (G229) of associations is characterized by very open to open canopied woodlands (10 to 30% cover) and understories dominated by bunch grasses, with covers commonly between 5 and 30% and as high as 60%; shrubs are scattered or absent (Fig. 17). The *Pinus ponderosa / Muhlenbergia montana* Woodland and *Pinus ponderosa / Bouteloua gracilis* Woodland PAs are the most common woodland savanna types on ELMA and dominate the landscape of the ancient Old Basalt Flows (Qb; or Other in Fig. 8) and the older Hoya flow (Qbw; or Hoya in Fig. 8). Scattered stands also occur on the younger flows and cinder cones (albeit usually with lower grass cover). These two associations lie along an elevation gradient, with *Pinus ponderosa / Muhlenbergia montana* Woodland occurring between 2,200 m and 2,450 m (7,200 and 8,100 ft), while the *Pinus ponderosa / Bouteloua gracilis* Woodland is usually found below 2,200 m (7,200 ft) down to 2,050 m (6,700 ft), where stands are often inter-fingered with Southern Rocky Mountain Pinyon-Juniper Woodland (G253). In the middle of the gradient, transitional stands occur where *M. montana* and *B. gracilis* can co-dominate. The *Pinus ponderosa / Muhlenbergia montana* Woodland tends to have a complement of more mesic, montane grasses such as *Koeleria macrantha* (prairie Junegrass), *Poa fendleriana*, *Elymus elymoides* (bottlebrush squirreltail), *Festuca arizonica* (Arizona fescue), and *Blepharoneuron tricholepis* (pine dropseed). The *Pinus ponderosa / Bouteloua gracilis* PA, in contrast, has stronger affinity with Great Plains grassland elements, particularly among the forbs (e.g., *Sphaeralcea coccinea* [scarlet globemallow], *Hymenoxys richardsonii* [pingue Hymenoxys], *Lotus wrightii* [Wright's deervetch], and *Heterotheca villosa* [hairy goldenaster] and *Psoralidium tenuiflorum* [slimflower scurfpea]). Both of these associations are common associations in the Southwest and southern Rocky Mountains.

Less common, stands of the *Pinus ponderosa / Schizachyrium scoparium* Woodland PA occur intermixed among the *Pinus ponderosa / Muhlenbergia montana* woodlands. This association has been reported further east at Bandelier National Monument (Muldavin et al. 2011), Pecos National Historic Park (Muldavin et al. 2012), and likely occurs out into the Great Plains. In addition, a stand of *Pinus ponderosa / Festuca arizonica* Woodland was sampled on an older cinder cone slope.

While limited on ELMA, this association is a common association further to the west on the southern Colorado Plateau, as well as in the southern Rocky Mountains (see Appendix D). Lastly, the *Pinus ponderosa / Sporobolus cryptandrus* Woodland PA occurs on alluvial soils with a sandy overlying deposit on the eastern side of monument. This association is similar to the *Pinus ponderosa / Artemisia filifolia* Woodland PA, but lacks a significant shrub component.

In addition to soils and substrate, terrain, climatic factors, and fire have played an important role in shaping the structure and composition of ponderosa pine forest and woodland associations on ELMA (Grissino-Mayer and Swetnam 1997). Because *P. ponderosa* is highly fire tolerant (Bradley et al. 1992) and drought tolerant, it often occupies sites that are drier and that have higher natural fire frequencies than those of the mixed conifer zone (DeVelice et al. 1986; Allen and Peet 1990; Touchan et al. 1996). In the past, low-intensity fires would burn through ponderosa pine stands every 8 to 15 years, removing competing understory vegetation and woody debris (Weaver 1951; Cooper 1960; Mehl 1992; Swetnam and Baisan 1996; Touchan et al. 1996; Grissino-Mayer and Swetnam 1997).

On ELMA, savanna woodlands on the older flows and cinder cones tend to have the highest grass cover and hence the highest historical surface fire frequency—every three years (Grissino-Mayer and Swetnam 1997). On the sedimentary kipuka sites, frequencies were a bit lower, at five to seven years, and on the younger Hoya de Cibola flow, where grass cover is more patchy, fire frequency drops to once every 11 years. Hence, ELMA falls within the historical norm for ponderosa pine savannas in the Southwest; and, as with other forests of the region, fire frequency drops off dramatically beginning in the late 19th century as a result of heavy livestock grazing which removed fine fuels. By 1940 fire is more or less eliminated because of fire-suppression policies.

When fire is eliminated from forests, tree seedlings become established in open areas, usually in pulses correlated to favorable precipitation years (Mast et al. 1997; Mast el al. 1998; Savage et al. 1996). This can lead to higher densities of trees and increased likelihood of stand-replacing crown fires in fire-prone years. At the other end of the spectrum, *P. ponderosa* has been known to invade adjacent grasslands where fires have been suppressed (Allen 1984, 1989). Hence, some stands of the various savanna associations may be considered invasive depending on edaphic conditions and disturbance history.

Lastly, on the youngest flows, such as Bandera and McCartys, fire has been rare to non-existent because surface fuels are minimal and tree densities are not high enough to support crown fires. This has created a unique setting in which ponderosa pine and Douglas-fir trees reach exceptional ages in what amounts to an enormous safe site. Grissino-Mayer and Swetnam (1997) sampled a 1,274-year-old Douglas-fir on the Bandera flow, the oldest living Rocky Mountain Douglas-fir yet recorded.

1.B.2.Nc Western North American Cool Temperate Woodland & Scrub

M027 Rocky Mountain Two-needle Pinyon - Juniper Woodland

Pinyon-juniper woodlands occur across all substrates on ELMA and are represented by two groups: Southern Rocky Mountain Pinyon-Juniper Woodland (G253) and Southern Rocky Mountain Juniper Woodland & Savanna (G252).

The Southern Rocky Mountain Pinyon-Juniper Woodland Group is represented by six associations which are dominated by *Pinus edulis*, usually with one or more *Juniperus* spp. as co-dominant. The pattern of distribution among various lava flows parallels that of the ponderosa pine woodlands. The *Pinus edulis - Juniperus* spp. / *Fallugia paradoxa* Woodland and *Pinus edulis - Juniperus scopulorum / Holodiscus dumosus* Woodland PAs are shrub-dominated associations which occur primarily on the younger McCartys and Bandera flows, respectively. The *Pinus edulis -*

Juniperus spp. / *Fallugia paradoxa* Woodland is found at lower elevations (typically below 2,200 m [7,200 ft]) where it grades into the extensive *Fallugia paradoxa* shrublands of the northern McCartys flow (Fig. 18). It is usually found at elevations above 2,200 m and is more mesic in character, due to the presence of *Holodiscus dumosus*, along with *Ribes cereum* and cool-season grasses, such as *Poa fendleriana*.

The *Pinus edulis - Juniperus monosperma* / *Quercus × pauciloba* Woodland PA is also shrub dominated, but scrub oaks are predominant over *Fallugia paradoxa* and *Holodiscus dumosus*. This plant association is also known to occur adjacent to lava flows and on the sandstones that make up the bluffs and cliffs on the eastern boundary of the park. We have also identified a specific *Pinus edulis* - (*Juniperus* spp.) / Cinder Woodland as a Park Special that occurs on the steep, often unstable slopes of cinder cones of the Twin Craters and El Calderon. In this association, both shrub and herbaceous cover is typically low, with annual forbs, such as *Phacelia serrata* (cinder phacelia), *Bahia dissecta* (ragleaf bahia), and *Ipomopsis aggregata* (skyrocket gilia) often the most abundant species.

Among the grass-dominated associations, the *Pinus edulis* / *Achnatherum scribneri* Woodland PA is restricted to Permian sedimentary limestone and sandstone hills of the kipukas. These are often nearly closed-canopy, relatively tall-statured woodlands with grassy understories made up of mesic bunch grasses. They mostly occur above 2,250 m (7,400 ft) and are somewhat uncommon in the Southwest. *Pinus edulis* - (*Juniperus monosperma*, *Juniperus deppeana*) / *Bouteloua gracilis* Woodland also occurs on the kipuka hills, but is widespread regionally and can be found on lava flows and older cinder cones. It has more of a savanna character with an open tree canopy and grassy interspaces dominated by grama grasses, although we have also identified a cool-season grass phase co-dominated by *Poa fendleriana*.

In the Southwest, the pinyon-juniper woodlands of this group would fall within the Pinyon Series described by Layser and Schubert (1979) and Larson and Moir (1987). They are more or less equivalent to the Pinyon-Juniper Series within the Great Basin Conifer Woodland biotic community of Brown et al. (1979). For New Mexico, Dick-Peddie (1993) differentiated Colorado Pinyon—Oneseed Juniper, Colorado Pinyon—Mixed Juniper, Colorado Pinyon—Alligator Juniper, Colorado Pinyon—Rocky Mountain Juniper series that associations of this group would be a part of.

Figure 18. The *Pinus edulis - Juniperus* spp. / *Fallugia paradoxa* Woodland PA is a major association on the McCartys lava flow and is a member of the Southern Rocky Mountain Pinyon-Juniper Woodland (photo by J. Coop).

The Southern Rocky Mountain Juniper Woodland and Savanna Group (G252) is dominated primarily by the short-statured *Juniperus monosperma*, a conifer that forms open to very open canopies (*P. edulis* is accidental or absent). On ELMA, we have described five associations for the group that generally lie below 2,000 m (7,200 ft) and that differ in distribution depending on lava flow. The *Juniperus monosperma* / *Fallugia paradoxa* Woodland PA and the *Juniperus monosperma* / *Fraxinus cuspidata* Woodland PA occur primarily on the younger McCartys and Bandera flows, and more rarely on the Hoya de Cibola and Twin Craters flows (they are not found on cinder cones). The *Juniperus monosperma* / *Fallugia paradoxa* Woodland PA is characterized by scattered shrubs growing in the cracks and fissures of the lava flows in the inter-tree spaces and often occurs in transition to *Fallugia paradoxa*

Figure 19. The Southern Rocky Mountain Juniper Woodland and Savanna Group includes scrub-like juniper woodlands represented here by the *Juniperus monosperma / Fallugia paradoxa* Woodland PA on the McCartys lava flow (photo by J. Coop).

Figure 20. The *Juniperus monosperma / Fraxinus cuspidata* Woodland PA tends to be found in more mesic sites such as this lava depression of a collapse feature on McCartys lava flow (photo by J. Coop).

Figure 21. The *Juniperus monosperma / Bouteloua gracilis* Woodland PA is typical of the savanna associations found within the Southern Rocky Mountain Juniper Woodland and Savanna Group. This stand was located on a hill slope composed of sedimentary limestone on the east side of the park, but the association is also common on the older lava flows and old basalt plains on the perimeter (photo by J. Coop).

shrublands (Fig. 19). The *Juniperus monosperma / Fraxinus cuspidata* Woodland PA is more mesic in character and often found in collapsed lava tube features as well as on the flow surface (this association is found primarily on the Bandera flow) (Fig. 20). The *Juniperus monosperma / Quercus × pauciloba* Woodland PA is prevalent on some of the younger lava flow sites, where scrub oaks dominate the inter-canopy spaces. It can also occur on the sandstone kipuka hills within the flows.

Two savanna types, the *Juniperus monosperma / Bouteloua gracilis* Woodland and *Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus* Woodland PAs are characterized by open to very open canopies (10 to 60%) of *J. monosperma*, with grassy inter-canopy spaces dominated by *Bouteloua gracilis* and/or *Sporobolus cryptandrus* bunch grasses, and covers ranging between 5 and 50%. In contrast to the shrubby juniper associations described above, the *Juniperus monosperma / Bouteloua gracilis* Woodland is primarily found on the older Pleistocene-age flows (Twin Craters, Hoya de Cibola and El Calderon) and on sandstone- or limestone-derived soils of the kipukas or eastern side bluffs (Fig. 21). On these sites, soils are deeper and more developed, fostering greater, often more or less continuous, grass cover in the inter-canopy spaces. On sites that have sandier soils or sand deposits overlain on the finer soils, the *Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus* Woodland PA can occur in a fashion similar to the occurrence of the *Pinus ponderosa / Sporobolus cryptandrus* Woodland PA described above.

These juniper associations are part of the Juniper Series of Layser and Schubert (1979), and the *Juniperus monosperma* Association within the Piñon-Juniper Series which Brown et al. (1979) described for the Southwest in general. Later, Larson and Moir (1987) identified several specific oneseed juniper associations for southern New Mexico, and Dick-Peddie (1993) identified a Oneseed Juniper Series with eight associations (Dick-Peddie [1993] referred to it as an ecotonal type of vegetation between dense woodlands and true grasslands). All of the associations have been described elsewhere in New Mexico (Anderson et al. 1998). The entire Rocky Mountain Two-needle Pinyon - Juniper Woodland macrogroup on ELMA would occur within Lindsey's (1951) Apache Plume Belt, along with the Southern Rocky Mountain Montane Shrublands described below.

Fire is an important disturbance factor in pinyon-juniper woodlands and, most recently, Romme et al. (2009) provided an overview of its 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, e.g., the *Juniperus monosperma / Bouteloua gracilis* Woodland or *Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Woodland PAs. The shrub-dominated associations, such as the *Pinus edulis - Juniperus monosperma / Quercus × pauciloba* Woodland or *Juniperus monosperma / Quercus × pauciloba* Woodland described here for the kipuka sites would be considered part of their "wooded shrubland," with a mixed fire regime of crown and surface fires of moderate to high intensity and frequency. Romme et al. (2009) also described a "persistent woodland" with limited surface fuels that would have either low-frequency, high-intensity crown fires or none, depending on canopy density. On ELMA, this would apply to the woodlands of the younger lava flows, such as the *Juniperus monosperma / Fallugia paradoxa* Woodland or *Juniperus monosperma / Fraxinus cuspidata* Woodland PAs that lack any fuel continuity, and in fact may never burn. But the higher-elevation *Pinus edulis / Achnatherum scribneri* Woodland of the kipukas would also fall into this category with its more closed canopy and only scattered grass cover, making it subject to low frequency crown fire (perhaps on the order of 200 to 400 years). Consideration of these differences among woodland communities can help formulate effective fire management strategies.

2 Shrubland & Grassland

2.B Temperate & Boreal Grassland & Shrubland

2.B.2 Temperate Grassland, Meadow & Shrubland

2.B.2. Na Western North American Grassland & Shrubland

MG049. Southern Rocky Mountain Montane Shrubland

On ELMA, this macrogroup is represented by three shrubland associations within the Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group (G276). They are associated with all of the lava flows except El Calderon. The *Fallugia paradoxa* / Rockland Shrubland is dominated by *F. paradoxa* growing in the fissures and cracks of the McCartys lava flow, or among the cinders of the Twin Craters group of cones (Fig. 22). Other scattered shrubs, grasses and forbs can occur in this association, but the main characteristic is extensive areas of bare basalt lava rock or loose cinder rubble. The *Rhus trilobata - Ribes cereum* Shrubland and *Fallugia paradoxa - Rhus trilobata* Shrubland PAs occur somewhat higher along the elevation gradient (>2110 m) on the Bandera, Twin Craters, and Hoya flows. Sites tend to be more mesic and, accordingly, the associations have a more mesic assemblage of species, e.g., *Rhus trilobata, Forestiera pubescens, Holodiscus dumosus*, and *Ribes cereum* among the shrubs, and *Piptatherum micranthum* (littleseed ricegrass) and

Figure 22. The *Fallugia paradoxa* / Rockland Shrubland PA is a member of the Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group, and is a dominant association on the McCartys lava flow (photo by J. Coop).

Figure 23. On ELMA, the Great Plains Sand Shrubland Group is represented by the *Artemisia filifolia / Bouteloua* (*curtipendula, gracilis*) Shrubland, which occurs off the lava flows on sandy substrates on the east side of the park (photo by J. Coop).

Poa fendleriana among the grasses. But these associations are still relatively sparse compared with off-lava representatives elsewhere, with extensive exposed lava and herbaceous canopy cover under 10%.

This group likely represents the core concept of Lindsey's (1951) Apache-Plume Belt, which he described for the area. To date, all three associations have only been described for ELMA, but likely occur elsewhere on mid-elevation lava and pumice substrates. They would also fall under the Dick-Peddie (1993) Montane Scrub Mountain Mahogany-Mixed Shrub Series and the Brown et al. (1979) Great Basin Montane Scrub biotic community.

M168 Rocky Mountain-Vancouverian Subalpine & High Montane Mesic Grass & Forb Meadow

This macrogroup is represented on ELMA by a single grassland association, *Bouteloua gracilis - Muhlenbergia montana* Herbaceous Vegetation, belonging to the Southern Rocky Mountain Montane-Subalpine Grassland Group (G268). These mid-elevation (2,240 to 2,375 m) grasslands dominated by *Bouteloua gracilis* and *Muhlenbergia montana* occur as small patches amongst forests and woodlands on the older flows (Hoya and El Calderon), where the soil mantle has accumulated sufficiently to support these bunch grasses. Consequently, grass cover can exceed 25% with the potential for frequent surface fire increasing commensurately. The association also occurs on sedimentary rock hills and intervening valleys. To date, this association has only been described from ELMA, but it likely occurs elsewhere in the southwestern US at mid-elevations.

2.B.2.Nb Great Plains Grassland & Shrubland

M052 Great Plains Sand Grassland & Shrubland

On ELMA, this macrogroup is limited to the *Artemisia filifolia / Bouteloua (curtipendula, gracilis)* Shrubland association on the Great Plains Sand Shrubland Group (G069). *Artemisia filifolia* (sand sagebrush) is a widespread dominant of shrublands on sandy substrates of the Great Plains and Inter-Mountain regions (e.g., the Plains-Mesa Sand Scrub Sand Sagebrush Series of Dick-Peddie [1993]). On ELMA, this association is found to a limited extent on wind-blown sediments that have accumulated in valleys and sedimentary rock hills off the lava flows along the eastern margin of the park (Fig. 23).

M053 Great Plains Shortgrass Prairie & Shrubland

The Great Plains Shortgrass Prairie Group (G144) within this macrogroup contains the most prevalent grassland associations on ELMA. The six associations are most common adjacent to the lava flows on alluvial and windblown sediment deposits or on the old basalt plains (Qb in Fig. 7) that the recent flows lie on. The *Artemisia frigida / Bouteloua gracilis* Dwarf-shrubland, which is dominated by fringed sage and blue grama grass, is particularly prevalent on the latter old basalt plains. It can be intermixed with nearly monotypic stands of blue grama (*Bouteloua gracilis* Herbaceous Vegetation PA). On sandy deposits, the *Bouteloua gracilis - Sporobolus cryptandrus* Herbaceous Vegetation PA, with mesa dropseed as a co-dominant with blue grama, can be common. Extensive areas of lowland bottoms are found along the eastern side of the park where heavier clay and silty sediments have accumulated from runoff from the adjacent hills against the lava flows. Here, where standing water can often occur, the *Pascopyrum smithii - Bouteloua gracilis* Herbaceous Vegetation PA dominates. Some sites in these lowland areas that have been inundated for long periods or disturbed by past grazing are dominated by the *Pascopyrum smithii / Grindelia squarrosa* Herbaceous Vegetation or *Bouteloua gracilis* Ruderal Herbaceous Vegetation PAs with their mix of weedy grasses and forbs (e.g., *Bassia scoparia* (burningbush), *Solanum jamesii* (wild potato), *Grindelia squarrosa* (curlycup gumweed), *Tragopogon dubius* (yellow salsify), *Verbesina encelioides* (golden crownbeard), and *Salsola tragus* (Russian thistle).

Figure 24. This stand of *Sporobolus airoides* Monotype Herbaceous Vegetation near the main visitors center is an example of the Intermountain Semi-Desert Grassland Group.

3 Desert & Semi-Desert

3.B Cool Semi-Desert Scrub & Grassland

3.B.1 Cool Semi-Desert Scrub & Grassland

3.B.1.Ne Western North American Cool Semi-Desert Scrub & Grassland

M171. Great Basin & Intermountain Dry Shrubland & Grassland

This macrogroup contains shrublands and grasslands that have the center of their distribution in the Intermountain West, including the Colorado Plateau; ELMA lies at its southern edge. *Bouteloua gracilis - Pleuraphis jamesii* Herbaceous Vegetation and *Sporobolus airoides* Monotype Herbaceous Vegetation associations that are part of Intermountain Semi-Desert Grassland Group (G311) are relatively minor elements in the ELMA landscape. The former is dominated by blue grama and galleta, respectively, and can be found intermixed with the woodlands and other grasslands on the older El Calderon lava flow. The latter alkali sacaton grasslands are typically associated with lowland areas or draws where they can form relatively uniform and low-diversity grasslands (Fig. 24).

Figure 25. The *Ericameria nauseosa / Bouteloua gracilis* Shrub Herbaceous Vegetation, shown here off the lava flows in the southeast portion of the park (near Lava Falls), is an example of shrub-steppe within the Intermountain Semi-Desert Shrubland & Steppe Group (i.e., a consistent mix of shrubs and grasses) (photo by J. Coop).

Within the Intermountain Semi-Desert Shrubland & Steppe Group (G310) there are two shrub-steppe associations that are significant components of the grasslands of the old basalt plains: *Ericameria nauseosa / Bouteloua gracilis* Shrub Herbaceous Vegetation and *Krascheninnikovia lanata / Bouteloua gracilis* Dwarf-shrub Herbaceous Vegetation (Fig. 25). These blue-grama grasslands are dominated by rubber rabbitbrush and winterfat, respectively, and can be found intermingled out on the plains with grasslands that lack a significant shrub component (e.g., the *Artemisia frigida / Bouteloua gracilis* Dwarf-shrubland described above). The *Sarcobatus vermiculatus / Sporobolus airoides* Shrubland has a limited distribution near the main visitor center. These sparse greasewood stands grade into adjacent alkali sacaton grasslands.

M093 Great Basin Saltbrush Scrub

This macrogroup is represented by the Intermountain Shadscale-Saltbush Scrub Group (G300), a common group on the Colorado Plateau. On ELMA, we identified three associations dominated by *Atriplex canescens* (fourwing saltbush) that occur typically in low-lying areas and alluvial flats and often intermix with associations of the Great Basin & Intermountain Dry Shrubland & Grassland (M171) above.

6 Rock Vegetation
6.C Desert & Semi-Desert Rock Vegetation

6.C.1 Warm Desert & Semi-Desert Cliff, Scree & Other Rock Vegetation

6.C.1. Na North American Warm Semi-Desert Cliff, Scree & Rock Vegetation

M117 North American Warm Semi-Desert Cliff, Scree & Rock Vegetation

As part of this macrogroup, a set of four barren land cover types were identified within a G569 North American Warm Semi-Desert Cliff, Scree & Pavement Sparse Vegetation: Sparse Vegetation / Alluvial Flat, Sparse Vegetation / Cinder Cone, Sparse Vegetation / Lava Flow, and Sparse Vegetation / Boulder Rockland.

2.3 Classification discussion

The classification presented in this report represents the most comprehensive classification developed to date for ELMA and the surrounding area. While sampling such a rugged lava landscape presents its challenges, based on our extensive reconnaissance and review of the aerial photography, we are confident that we surveyed and described the major associations of the park. However, we may have under sampled some microenvironments because of access and time limitations. We suspect there are other ice caves or cool openings still to be discovered and sampled, as well as collapse features that could generate unique environments and unusual combinations of species. Lastly, the *Pseudotsuga* and *Populus tremuloides* stands on the younger lava flows were often fragmentary and scattered in distribution and we would recommend searching out larger stands for further characterization in the future.

Daubenmire (1974) suggested that plant communities integrate all impinging environmental conditions. Thus, the classification and description of plant associations provides a framework for understanding the ecological composition and structure of a given landscape. Accordingly, plant associations are used 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, we can make general management observations and recommendations for each grouping. In addition, resource managers have found that the classification of vegetation into plant associations has provided insight as well as the ability to predict vegetation changes in response to various disturbance processes.

Yet, the development of a vegetation classification is an incremental process of successive approximation (Shimwell 1971). Many associations described here had not been described before, and further regional investigation is needed to determine if they are endemic to the park, representing a unique contribution to the world's biodiversity patterns. Clearly, isolation protects the woodlands on the younger lava flows from fire, except in very localized circumstances (e.g., lighting strikes of single trees).This has perhaps created a unique environment where species assemblages have developed in response to local terrain and climatic conditions not found elsewhere, which in turn make the park that much more special and unique.

3 El Malpais National Monument Vegetation Map

3.1 Mapping process overview

The vegetation map for El Malpais National Monument (ELMA) was developed using a combined strategy of 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. A working map legend of ecologically-based vegetation map units was developed using the vegetation 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), a combination of heads-up screen digitizing of polygons based on image interpretation and supervised image classifications were conducted. 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://www.usgs.gov/core_science_systems/csas/vip/index.html) call for spatial data to 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 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 ELMA 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 provided by the National Park Service for this project. These photos were acquired on 11/13/2003 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). The photos had been ortho-rectified into a Universal Transverse Mercator Projection, NAD83 Datum, Zone 13. They were mosaicked into two separate images representing the main park area and the headquarters area.

The resulting photo-mosaic provided a geometrically accurate map of ELMA with high spatial detail. The radiometric fidelity was consistent throughout. Unfortunately, visible wavelengths tend to be highly correlated with limited spectral information. In this case, except for discriminating between the lava and the non-lava covered landscapes, the imagery was relatively spectrally featureless.

3.2.1.2 Satellite imagery

To complement the digital aerial photography and in order to enhance the vegetative components of the landscape, Landsat Thematic Mapper (TM) satellite imagery data was acquired and processed to be used in conjunction with the ortho-photo map. Despite its coarser spatial resolution of 30 m, the Landsat imagery provided additional spectral data in the near-infrared and mid-infrared wavelengths (Table 6). In addition, as it is both publicly available for free and acquires images of the same area once every 16 days, we were able to acquire several images on different dates during the year, which helped us to detect differences in phenology among the plant communities.

Specifically, for this project, we tried to acquire imagery on dates that best bracketed the time of photo acquisition, when the sky was clear of clouds and smoke, and on days that lacked other confounding issues (such as snow cover), while at the same time were representative of important times in

Table 6. Landsat ETM+ spectral band descriptions (Jensen 2004).

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

the growing season. Based on these requirements, images from April 4, May 6, 2002, and September 22, 2003 were ultimately selected for this project (Table 7). These multi-temporal scenes captured the seasonal vegetation changes of (1) deciduous leaf-off, (2) initial deciduous green-up, (3) the transition from cool- to warm-season grasses, and (4) the end-of-monsoon maximum green-up. Although the TM images were already geo-corrected, they were further rectified to the ortho-photo mosaic base to ensure that the images overlaid each other directly, and then were resampled to a 20 m spatial resolution.

The TM data were further processed to create five vegetation indices using the two time periods represented by the scenes, which enhanced various vegetation or ecosystem characteristics. These were the Normalized Difference Senescent Vegetation Index (NDSVI) [Eq. 1], the NDVI [Eq. 2], a moisture index [Eq. 3], a vegetative moisture index [Eq. 4], and a Normalized Difference Senescent Vegetation Index 2 [Eq. 5], computed as follows:

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

Table 7. Compiled BAND image file of Landsat Thematic Mapper bands and derivatives used in subsequent vegetation map classification.

Image Bands	Band Description	Image Bands	Band Description
Band 1	April 4 2002 Landsat Visible Blue	Band 18	September 22 NDSVI (Eq. 1)
Band 2	May 6 2002 Landsat Visible Blue	Band 19	April 4 2002 NDSVI (Eq. 2)
Band 3	September 22 2003 Landsat Visible Blue	Band 20	May 6 2002 NDSVI (Eq. 2)
Band 4	April 4 2002 Landsat Visible Green	Band 21	September 22 NDSVI (Eq. 2)
Band 5	May 6 2002 Landsat Visible Green	Band 22	April 4 2002 NDVI
Band 6	September 22 2003 Landsat Visible Green	Band 23	May 6 2002 NDVI
Band 7	April 4 2002 Landsat Mid-Infrared Band 5	Band 24	September 22 NDVI
Band 8	May 6 2002 Landsat Mid-Infrared Band 5	Band 25	April 4 2002 Landsat Near Infra-red
Band 9	September 22 2003 Landsat Mid-Infrared Band 5	Band 26	May 6 2002 Landsat Near Infra-red
Band 10	April 4 2002 Landsat Mid-Infrared Band 7	Band 27	September 22 2003 Near Infra-red
Band 11	May 6 2002 Landsat Mid-Infrared Band 7	Band 28	April 4 2002 Landsat Visible Red
Band 12	September 22 2003 Landsat Mid-Infrared Band 7	Band 29	May 6 2002 Landsat Visible Red
Band 13	April 4 2002 Moisture Index	Band 30	September 22 2003 Visible Red
Band 14	May 6 2002 Moisture Index	Band 31	April 4 2002 Structure
Band 15	September 22 2003 Moisture Index	Band 32	May 6 2002 Structure
Band 16	April 4 2002 NDSVI (Eq. 1)	Band 33	September 22 2003 Structure
Band 17	May 6 2002 NDSVI (Eq. 1)		

NDVI = ((Band 4 – Band 3) / (Band 4 + Band 3) + 1) × 100   (Eq. 2)

Moisture index = ((Band 5 – Band 7) / (Band 5 + Band 7) + 1) × 100   (Eq. 3)

Vegetative Moisture index = ((Band 4 – Band 5) / (Band 4 + Band 5) + 1) × 100   (Eq. 4)

NDSVI2 = ((Band 7 – Band 3) / (Band 7 + Band 3) + 1) × 100   (Eq. 5)

Band ratios, in general, 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 two NDSVIs enhance 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 and Band 7). 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.

Once all of the images were generated, the multi-spectral bands and the band ratios of these files were aggregated to create a combined image file of 33 bands. This file was digitally merged with the ortho-photo base using a principal-components data-fusion technique, and the output was resampled to a 2 m spatial resolution. The 2 m spatial resolution was chosen over the original 1 m spatial resolution of the ortho-photo map because it provided a significant reduction in data size and time spent on follow-up processing and analysis, while the information loss resulting from changing the pixel area of coverage from 1 m^2 cells to 4 m^2 cells was considered minimal, given the final mapping goal of a 0.5-hectare minimum mapping unit.

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) to aid in the editing process. These were reprojected where necessary and imported into an ArcGIS geodatabase framework.

As the geology was considered a particularly important driver in the expression of vegetation communities on this geologically young landscape, the original 1:62,500 geologic map covering the park (Maxwell 1986) was scanned and geo-rectified to fit the ortho-photo map. At 1:62,500, the geologic map was at too coarse a scale for the level of precision at which the vegetation was being mapped, so we created a new geologic map using the scanned map as the baseline and imposing on it the polygon map described below. That is, the line work of the geology map was evaluated at a fine scale by classifying the small-segmented polygons where geologic lines crossed them. Any issues with regard to transitions were resolved through aerial photo interpretation using the aerial ortho-photography. This derivative geologic map was designed to aid our image analysis and was sufficient for our interpretation where no digital version of the original map existed. It does not constitute a sanctioned version of the map and it has not been externally reviewed.

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, alliances, etc.) described above with their spatial distribution as determined by the quality of 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 being able 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 relatively simple and defined by one or two primary plant associations, others were complexes of plant associations.

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 from Table 3, and an upper Level 1, which groups the Level 2 map units where possible to 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 predominant associations are identified as Primary Components of the unit (collectively greater than 50% of the areal extent of the unit), while associations known to be less common from ground reconnaissance are designated as Secondary Components (collectively <50% of the area). In addition, those associations estimated to occupy less than 10% of the area of the unit were designated as inclusions. Map unit component association assignment was based on the plot data. 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 provisional 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, the legend was further refined, both by lumping and splitting the draft units. The map and its legend went through several iterations as ground data were gathered and new imagery acquired.

3.2.3 Image analysis and map development

3.2.3.1 Base map development

To efficiently develop a base map with a polygon structure (versus raster/pixel) per NPS specifications, we employed eCognition, Definiens Cognition Network Technology® object-oriented classification software (Definiens http://www.definiens.com/). This software uses an image segmentation technique to delineate the imagery into objects (polygons) of similar color, contrast, and shape. The advantage of this approach is that these objects will preserve edge boundaries of detailed surface features, such as roads, cliffs, and drainages—features that would be lost or misclassified in a more traditional pixel-based classification.

The combined image file we created, as mentioned previously, was far too large for the software to handle. Given that the goal was to create polygons which preserved as much of the original spatial detail as possible, we created a new image which maintained the 1 m spatial resolution, but used a greatly reduced number of spectral data sets. Thus, the original ortho-photo map was modified by merging it with the most significant seven components resulting from a principal components analysis on the combined image file of 33 bands (the first seven components were found to account for over 99% of the data variance of the imagery). These components were digitally merged with the higher spatial resolution ortho-photo in order to provide a product that maintained the higher spatial resolution, but with the surface features' spectral response enhanced. This image was then used by the segmentation software to develop the polygons.

In this automated polygon delineation framework, the level of detail is controlled by a unitless scale parameter[4] that considers each polygon object based on its homogeneity of color and shape, each of which is weighted from zero to one. The smaller the scale parameter, the more detail is represented and the more the image is segmented into polygon objects, with a scale factor of "1" theoretically representing individual pixels of the original photography base.

In this project, the scale parameter was varied to see which provided the best model of landscape heterogeneity; it was decided that a scale parameter of 75 seemed to work best. The scale parameter is dependent on the weighting of the shape and color factors. In this case, the color factor and the shape factor were given equal weight of 0.5. The shape sub-factors of smoothness and compactness were also weighted equally (0.5). This process generated over 31,000 raw polygons for the main area of the park, and some 600 raw polygons for the headquarters area.

<u>3.2.3.2 Supervised classification</u>

A simultaneous raster-based image classification was conducted using a combined merged-image dataset. The classification was based on a supervised approach whereby 'seed' polygons were digitally drawn in spectrally homogeneous areas around selected vegetation field plots with the help of the ancillary data, such as field notes and photographs. From these polygons, image statistics were collected to perform a supervised classification. Supervised classifications are based on a maximum likelihood decision rule containing a Bayesian classifier that uses probabilities to weight the classification toward particular classes. In this study, the probabilities were unknown, so the maximum likelihood equation (Eq. 6) for each of the classes is given as:

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

where **D** is the weighted distance, $\mathbf{cov_c}$ is the covariance matrix for a particular class, **X** is the measurement vector of the pixel, $\mathbf{M_c}$ is the mean vector of the class and ^{T} is the matrix transpose function (ERDAS 2007, http://www.erdas.com). Each pixel is then assigned to the class with the lowest weighted distance. This technique assumes the statistical signatures have a normal distribution.

This decision rule is considered the most accurate, because it not only uses a spectral distance as the minimum-distance decision rule, but also takes into account the variance of each of the signatures. The variance is important when comparing a pixel to a signature representing, for example, a woodland community, which can be fairly heterogeneous due to numerous canopies and non-canopy interspaces, as compared to a grassland community, which is more homogeneous.

The initial classification resulted in 452 separate classes in the main park area and 10 classes in the headquarters area. Several iterations of editing the seed statistical profiles, as well as on-screen editing of some of the class boundaries, resulted in a final raw classification. Once the Level 2 map units had been decided, these two maps were recoded to classes which corresponded to the Level 2 classification schema.

3.2.4 Final map development

The final supervised raster classification was then used to classify the image polygons developed from the object-oriented classification. The image objects (primitives) were imported as a feature of the dataset polygon layer in ESRI ArcGIS (v. 10.0), the file quality controlled, and a topology built. The image polygons were then overlaid onto the recoded raster classification, and the majority map unit assigned to each polygon map unit to create the draft final map.

As a final step, the draft final map was subjected to a heads-up screen digitizing edit

[4]The scale parameter is an abstract term that determines the maximum-allowed heterogeneity for the resulting image objects (polygons). In heterogeneous data, the resulting objects for a given scale parameter are smaller than in more homogeneous data. By modifying the value in the "scale parameter" control, you can vary the size of the polygons.

using the most recent aerial photography. Accordingly, we accessed recent imagery through 2012 Microsoft Corporation Bing Imagery, available via ESRI ArcGis 10.0. As with all Bing imagery, the exact image date is not provided, but a search of the Digital Globe library indicates three possible dates: 2009-01-13, 2011-11-18, 2012-01-09, or a combination thereof. We think that it is not likely that the 2012 imagery had been posted to Bing, and that the 2011 imagery is the most likely candidate. We were also able to bring directly in additional 2009 New Mexico county imagery, and 2005 NAIP color-infrared and natural-color imagery at 1 m resolution.

During the final edit, the thematic composition and number of Level 1 and 2 map units were finalized and the final map product produced using NPS cartographic standards. While the minimum mapping requirements were at 1:24,000 scale with map unit delineations or polygons at 0.5 ha or larger, most of the final line work was completed at an operational scale between 1:12,000 and 1:3,000. Hence, polygons down to 0.25 ha were often maintained. For final map production, adjacent polygons of the same class were merged. Final map products included the geodatabase and a 1:44,000 poster map at Level 1 and 2.

3.3 Mapping results

A vegetation map for El Malpais National Monument and its associated legend were developed with 11 Level 1 vegetation units and four general land cover classes (Table 8). Within the Level 1 units, we delineated 42 Level 2 vegetation map units and seven non-vegetated land cover classes. In Figures 26 and 27, we present Level 1 and Level 2 maps, respectively, at a reduced scale for ease of inclusion in the report. Full-size maps at 1:44,000-scale are available in both a PDF and a shape file format for GIS use at http://www.usgs.gov/core_science_systems/csas/vip/. Where possible, the Level 1 units correspond to the Group level of the NVCS, but the Barren Rock and Ground (10) and Urban or Built-up Land (11) units are not explicitly represented in the NVCS. While the Level 1 units are tied to the group level of the NVC, the component structure of the Level 2 units typically reflect the characteristics of a given lava flow, and, less often, two or more lava flows (flows are designated per the summarized lava flow map provided in Figure 8).

In Table 8, each Level 2 map unit is defined in terms of its component plant associations—primary components, secondary components, and inclusions—and tied by database code to the NVC in Table 3. In Table 5, the plant associations are cross-referenced to the Level 2 map units of Table 8. While some map 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. In addition, the component structure of most of the Level 2 map units typically reflected the characteristics of a given lava flow or geologic unit per Figure 8. Some map units are found on multiple geologic units, but the relative component structure usually varied among geologic elements. Hence, the component structure by geologic element is also provided in Table 8 (in the geodatabase, the polygons are also attributed by geologic element to allow subsequent isolation of particular landscape elements as needed).

A complete annotated legend with summary descriptions of the units, distribution maps, aerial photo examples of map unit polygons, and representative photos is provided in Appendix E. To aid cross-referencing between map units and associations, we provide a NVC Association lookup table, organized by macrogroup, in Appendix F.

3.4 Mapping discussion

A combination of land-use history, geology, soils, and natural processes like fire and drought have likely shaped much of the vegetation pattern of ELMA. The ruggedness of much of the young lava flows on ELMA, in combination with little running

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Table 8. A hierarchical legend for the EL Malpais 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 (see Table 5). Under "Type," each association is designated either as a primary component (1), secondary component (2) or Related Inclusion (i) and these are portioned by geologic substrate, where M = McCartys lava flow, B = Bandera lava flow, T = Twin Craters lava flow, H = Hoya de Cibola lava flow, C = El Calderon lava flow, O = Old Basalt Lava flows and Holocene wind or water deposits, and S = Pennsylvanian or Jurassic sedimentary rocks (limestones or sandstones). The number of polygons representing the level 2 map unit is indicated, along with total area in hectares and acres.

Map unit L1	Map unit L2	Map unit name	Association	Type in Geologic Substrate M	B	T	H	C	O	S	# of poly-gons	Area (ha)	Area (ac)
		FORESTS and WOODLANDS											
1		Southern Rocky Mountain White Fir - Douglas-fir Dry Forest											
	A	Douglas-fir/Gooseberry Cinder Forest									14	22.4	55.4
			Pseudotsuga menziesii / Ribes (leptanthum, cereum) Woodland		1	1							
			Pseudotsuga menziesii / Muhlenbergia montana Forest		2	2							
			Populus tremuloides / Mixed Shrubs / Cinder Woodland		i	i							
			Sparse Vegetation / Cinder Cone		i	i							
			Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland			i							
	B	Douglas-fir/Rockspirea Lava Woodland									18	113.3	279.9
			Pseudotsuga menziesii / Holodiscus dumosus Lavaflow Woodland		1								
			Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland		2,i								
			Sparse Vegetation / Lava Flow		2								
			Populus tremuloides / Ribes cereum Woodland		i								
	C	Douglas-fir/Gambel Oak Foothill Forest									3	13.1	32.4
			Pseudotsuga menziesii / Quercus gambelii Forest							1			
			Pinus ponderosa / Quercus gambelii Woodland							i			

Table 8. A hierarchical legend for the El Malpais National Monument Vegetation Map *continued*

Map unit L1	L2	Map unit name	Association	Type M	B	T	H	C	O	S	# of poly-gons	Area (ha)	(ac)
			Pinus ponderosa / Quercus gambelii Woodland							i			
2		Southern Rocky Mountain Ponderosa Pine Forest & Woodland											
	A	Ponderosa Pine/Mountain Muhly-Gambel Oak Cinder Forest									19	433.7	1071.8
			Pinus ponderosa / Muhlenbergia montana Woodland		1	1							
			Pinus ponderosa / Quercus gambelii Woodland		2	2							
			Pinus ponderosa / Carex inops ssp. *heliophila* Woodland		2								
			Sparse Vegetation / Cinder Cone		i	i							
	B	Ponderosa Pine/Mutton Bluegrass Cinder Forest									11	35.7	88.1
			Pinus ponderosa / Poa fendleriana Woodland					1					
			Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland					2					
			Sparse Vegetation / Cinder Cone					i					
			Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland					i					
	C	Ponderosa Pine/Apache Plume Lava Woodland									328	7223.6	17849.8
			Pinus ponderosa / Fallugia paradoxa Woodland	1									
			Sparse Vegetation / Lava Flow	2									
			Pinus edulis - Juniperus spp. / *Fallugia paradoxa* Woodland	i									
			Fallugia paradoxa / Rockland Shrubland	i									
	D	Ponderosa Pine/Apache Plume-Wax Current Lava Woodland									122	601.5	1486.4
			Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland		1	1							
			Sparse Vegetation / Lava Flow		2	2							
			Populus tremuloides / Ribes cereum Woodland		i	i							

Table 8. A hierarchical legend for the El Malpais National Monument Vegetation Map *continued*

Map unit L1	L2	Map unit name	Association	Type M	B	T	H	C	O	S	# of poly-gons	Area (ha)	(ac)
			Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland		i	i							
	E	Ponderosa pine /Apache Plume/ Mountain Muhly Lava Woodland									82	3158.6	7805.0
			Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland		1								
			Pinus ponderosa / Muhlenbergia montana Woodland		2								
			Sparse Vegetation / Lava Flow		i								
			Pinus ponderosa / Bouteloua gracilis Woodland		i								
			Pinus ponderosa / Carex inops ssp. *heliophila* Woodland		i								
			Pinus ponderosa / Schizachyrium scoparium Woodland		i								
	F	Ponderosa Pine/Deer Sedge Lava Woodland									89	1304.6	3223.7
			Pinus ponderosa / Carex inops ssp. *heliophila* Woodland			1							
			Pinus ponderosa / Muhlenbergia montana Woodland			2							
			Sparse Vegetation / Lava Flow			2							
	G	Ponderosa Pine/Mountain Muhly-Deer Sedge Lava Woodland									116	4727.5	11681.8
			Pinus ponderosa / Muhlenbergia montana Woodland				1						
			Pinus ponderosa / Carex inops ssp. *heliophila* Woodland				2						
			Pinus ponderosa / Bouteloua gracilis Woodland				2						
			Sparse Vegetation / Lava Flow				2						
			Pseudotsuga menziesii / Muhlenbergia montana Forest				i						
			Pinus ponderosa / Schizachyrium scoparium Woodland				i						
			Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland				i						
			Populus tremuloides / Ribes cereum Woodland				i						
	H	Ponderosa Pine/Oak Lava Woodland									144	2067.1	5107.9
			Pinus ponderosa / Quercus × pauciloba Woodland	1	1								
			Pinus ponderosa / Quercus gambelii Woodland	2									

Table 8. A hierarchical legend for the El Malpais National Monument Vegetation Map *continued*

Map unit L1	L2	Map unit name	Association	Type M	B	T	H	C	O	S	# of poly-gons	Area (ha)	(ac)
			Sparse Vegetation / Lava Flow	2	i								
	I	Ponderosa Pine/Gambel Oak/Mountain Muhly Foothill Woodland									117	383.1	946.6
			Pinus ponderosa / *Quercus gambelii* Woodland							1			
			Pinus ponderosa / *Muhlenbergia montana* Woodland							2			
3		Southern Rocky Mountain Ponderosa Pine Savanna											
	A	Ponderosa Pine Cinder Forest Savanna									11	202.5	500.3
			Pinus ponderosa / *Muhlenbergia montana* Woodland						1				
			Pinus ponderosa / *Poa fendleriana* Woodland						2				
			Pinus ponderosa / *Festuca arizonica* Woodland						i				
			Pinus ponderosa / *Bouteloua gracilis* Woodland						i				
			Populus tremuloides / Mixed Shrubs / Cinder Woodland						i				
	B	Ponderosa Pine/Mountain Muhly Lava Woodland Savanna									222	4300.9	10627.7
			Pinus ponderosa / *Muhlenbergia montana* Woodland			2	1						
			Pinus ponderosa / *Bouteloua gracilis* Woodland			1	2						
			Pinus ponderosa / *Schizachyrium scoparium* Woodland			i	i						
			Sparse Vegetation / Lava Flow				i						
	C	Ponderosa Pine/Mountain Muhly-Blue Grama Plains and Valley Woodland Savanna									103	1212.8	2996.9
			Pinus ponderosa / *Muhlenbergia montana* Woodland						1	2			
			Pinus ponderosa / *Bouteloua gracilis* Woodland						2	1			
	D	Ponderosa Pine/Mesa Dropseed Sandy Plains Woodland Savanna									25	50.6	125.1
			Pinus ponderosa / *Sporobolus cryptandrus* Woodland						1				
			Pinus ponderosa / *Artemisia filifolia* Woodland						2				
4		Southern Rocky Mountain Pinyon - Juniper Woodland											
	A	Pinyon-Juniper Cinder Woodland									11	58.1	143.6

Table 8. A hierarchical legend for the El Malpais National Monument Vegetation Map *continued*

Map unit L1	L2	Map unit name	Association	Type M	B	T	H	C	O	S	# of poly-gons	Area (ha)	(ac)
			Pinus edulis - (*Juniperus* spp.) / Cinder Woodland			1		1					
			Pinus edulis - *Juniperus* spp. / *Fallugia paradoxa* Woodland			2							
			Sparse Vegetation / Cinder Cone			i		i					
	B	Pinyon-Juniper/Blue Grama Cinder Woodland Savanna									4	128.2	316.7
			Pinus edulis - (*Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Woodland						1				
			Pinus edulis - (*Juniperus* spp.) / Cinder Woodland						2				
	C	Pinyon-Juniper/Wavyleaf Oak Lava Woodland									82	691.1	1707.7
			Pinus edulis - *Juniperus monosperma* / *Quercus* × *pauciloba* Woodland	1	1								
			Juniperus monosperma / *Quercus* × *pauciloba* Woodland	2									
			Sparse Vegetation / Lava Flow	2	2								
	D	Pinyon-Juniper/Apache Plume Lava Woodland									319	2052.4	5071.5
			Pinus edulis - *Juniperus* spp. / *Fallugia paradoxa* Woodland	1									
			Sparse Vegetation / Lava Flow	2									
	E	Pinyon-Rocky Mountain Juniper/Rock-spirea Lava Woodland									127	929.2	2296.2
			Pinus edulis - *Juniperus scopulorum* / *Holodiscus dumosus* Woodland		1								
			Pinus edulis - *Juniperus* spp. / *Fallugia paradoxa* Woodland		2								
			Sparse Vegetation / Lava Flow		2								
			Populus tremuloides / *Ribes cereum* Woodland		i								
	F	Pinyon-Juniper/Blue Grama Lava Woodland Savanna									92	340.0	840.2

Table 8. A hierarchical legend for the El Malpais National Monument Vegetation Map *continued*

Map unit L1	L2	Map unit name	Association	Type M	B	T	H	C	O	S	# of poly-gons	Area (ha)	(ac)
			Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland					1	1				
			Sparse Vegetation / Lava Flow					i					
	G	Pinyon-Juniper/Blue Grama-Mesa Dropseed Sandy Plains and Valley Woodland Savanna									151	558.6	1380.3
			Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland						1	1			
			Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus Woodland						2				
	H	Pinyon-Juniper/Blue Grama-Needlegrass Foothill Woodland									73	668.9	1652.9
			Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland							1			
			Pinus edulis / Achnatherum scribneri Woodland							2			
			Pinus edulis - Juniperus monosperma / Quercus × pauciloba Woodland							2			
			Pinus edulis - Juniperus deppeana - Quercus grisea Woodland							i			
			Juniperus monosperma / Muhlenbergia pauciflora Woodland							i			
5		Southern Rocky Mountain Juniper Woodland & Savanna											
	A	Oneseed Juniper/Apache Plume Lava Woodland									69	523.0	1292.4
			Juniperus monosperma / Fallugia paradoxa Woodland	1									
			Sparse Vegetation / Lava Flow	2									
	B	Oneseed Juniper/Fragrant Ash-Wavyleaf Oak Lava Woodland									34	426.3	1053.4
			Juniperus monosperma / Fraxinus cuspidata Woodland		1								
			Juniperus monosperma / Quercus × pauciloba Woodland		2								

Table 8. A hierarchical legend for the El Malpais National Monument Vegetation Map *continued*

Map unit L1	L2	Map unit name	Association	Type M	B	T	H	C	O	S	# of poly-gons	Area (ha)	(ac)
			Sparse Vegetation / Lava Flow		i								
	C	Oneseed Juniper/Fragrant Ash Lava Woodland									16	140.8	348.0
			Juniperus monosperma / Fraxinus cuspidata Woodland			1							
			Sparse Vegetation / Lava Flow			2							
			Juniperus monosperma / Bouteloua gracilis Woodland			i							
	D	Oneseed Juniper/Blue Grama Lava Woodland									60	1054.0	2604.5
			Juniperus monosperma / Bouteloua gracilis Woodland				1						
			Sparse Vegetation / Lava Flow				2						
	E	Oneseed Juniper/Blue Grama Woodland Savanna									121	1048.4	2590.7
			Juniperus monosperma / Bouteloua gracilis Woodland			1	1						
			Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland			i	i						
	F	Oneseed Juniper/Blue Grama-Mesa Dropseed Sandy Plains Woodland Savanna									90	449.4	1110.6
			Juniperus monosperma / Bouteloua gracilis Woodland					1	1	1			
			Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus Woodland					2	2	2			
			Artemisia filifolia / Bouteloua (curtipendula, gracilis) Shrubland						i				
	G	Oneseed Juniper/Wavyleaf Oak/Blue Grama Foothill Woodland Savanna									21	63.9	157.8
			Juniperus monosperma / Bouteloua gracilis Woodland							1			
			Juniperus monosperma / Quercus × pauciloba Woodland							2			
		SHRUBLANDS											
6		Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland											

Table 8. A hierarchical legend for the El Malpais National Monument Vegetation Map *continued*

Map unit L1	L2	Map unit name	Association	Type M	B	T	H	C	O	S	# of poly-gons	Area (ha)	(ac)
	A	Apache Plume Cinder Scrub									12	12.6	31.1
			Fallugia paradoxa / Rockland Shrubland			1							
			Sparse Vegetation / Cinder Cone			2							
	B	Apache Plume-Skunkbush Sumac Lava Scrub									192	6289.8	15542.5
			Fallugia paradoxa / Rockland Shrubland	1									
			Fallugia paradoxa - *Rhus trilobata* Shrubland	2									
			Sparse Vegetation / Lava Flow	2									
	C	Skunkbush Sumac-Gooseberry-Apache Plume- Lava Scrub									208	572.5	1414.6
			Rhus trilobata - *Ribes cereum* Shrubland		1	1		1					
			Fallugia paradoxa - *Rhus trilobata* Shrubland		2		1	2					
			Sparse Vegetation / Lava Flow		2	2	2	2					
			Populus tremuloides / *Ribes cereum* Woodland		i	i	i	i					
7		Intermountain Shadscale-Saltbush Scrub											
	A	Fourwing Saltbush Shrub-Steppe									58	234.6	579.8
			Atriplex canescens / *Sporobolus airoides* Shrubland						1				
			Atriplex canescens / *Bouteloua gracilis* Shrubland						2				
			Atriplex canescens / *Panicum obtusum* Shrubland						2				
			Sparse Vegetation / Alluvial Flat						i				
8		Great Plains Sand Shrubland											
	A	Sand Sagebrush Sandy Plains Shrubland	*Artemisia filifolia* / *Bouteloua (curtipendula, gracilis)* Shrubland							1	38	65.8	162.7
		GRASSLANDS											
9		Great Plains Shortgrass Prairie											
	A	Rubber Rabbitbrush/Blue Grama Shrub-Steppe									136	369.7	913.6
			Ericameria nauseosa / *Bouteloua gracilis* Shrub Herbaceous Vegetation		1	1		1	1				

Table 8. A hierarchical legend for the El Malpais National Monument Vegetation Map *continued*

Map unit L1	L2	Map unit name	Association	Type M	B	T	H	C	O	S	# of poly-gons	Area (ha)	(ac)
			Bouteloua gracilis Herbaceous Vegetation		2	i		2	2				
			Krascheninnikovia lanata / Bouteloua gracilis Dwarf-shrub Herbaceous Vegetation						i				
	B	Blue Grama-Mountain Muhly Lava Plains-Foothill Grassland									218	528.0	1304.6
			Bouteloua gracilis - Muhlenbergia montana Herbaceous Vegetation				1	1	1	1			
			Bouteloua gracilis Herbaceous Vegetation				2		2	2			
			Bouteloua gracilis - Pleuraphis jamesii Herbaceous Vegetation					2		i			
	C	Fringed Sage/Blue Grama Lava Plains Grassland									161	863.9	2134.8
			Artemisia frigida / Bouteloua gracilis Dwarf-shrubland						1				
			Bouteloua gracilis Herbaceous Vegetation						2				
	D	Blue Grama/Mesa Dropseed Sandy Plains Grassland									72	223.8	553.1
			Bouteloua gracilis - Sporobolus cryptandrus Herbaceous Vegetation						1				
	E	Blue Grama Ruderal Grassland									28	77.7	192.0
			Bouteloua gracilis Ruderal Herbaceous Vegetation						1				
			Sparse Vegetation / Alluvial Flat						2				
	F	Blue Grama-Western Wheatgrass Low-land Grassland									102	501.0	1237.9
			Bouteloua gracilis Herbaceous Vegetation						1				
			Pascopyrum smithii - Bouteloua gracilis Herbaceous Swale Vegetation						1				
			Pascopyrum smithii / Grindelia squarrosa Herbaceous Vegetation						2				
			Sporobolus airoides Monotype Herbaceous Vegetation						2				
			Sparse Vegetation / Alluvial Flat						i				
			Sarcobatus vermiculatus / Sporobolus airoides Shrubland						i				

Table 8. A hierarchical legend for the El Malpais National Monument Vegetation Map *continued*

Map unit L1	L2	Map unit name	Association	Type M	B	T	H	C	O	S	# of poly-gons	Area (ha)	(ac)
		OTHER LAND COVER											
10		Barren Rock and Ground											
	A	Barren Lava Flow									198	1064.0	2629.1
			Sparse Vegetation / Lava Flow	1	1	1	1	1					
	B	Barren Cinder Volcano									17	47.8	118.0
			Sparse Vegetation / Cinder Cone		1	1	1	1					
	C	Barren Alluvial Flat									16	50.6	125.2
			Sparse Vegetation / Alluvial Flat						1				
	D	Rockland/Scarp/Cliff									17	28.8	71.2
			Sparse Vegetation / Boulder Rockland							1			
11		Urban or Built-up Land											
	A	Urban or Built-up Land									11	8.7	21.5
	B	Roads, Parking Lots									20	227.4	561.9
	C	Building									12	0.3	0.8

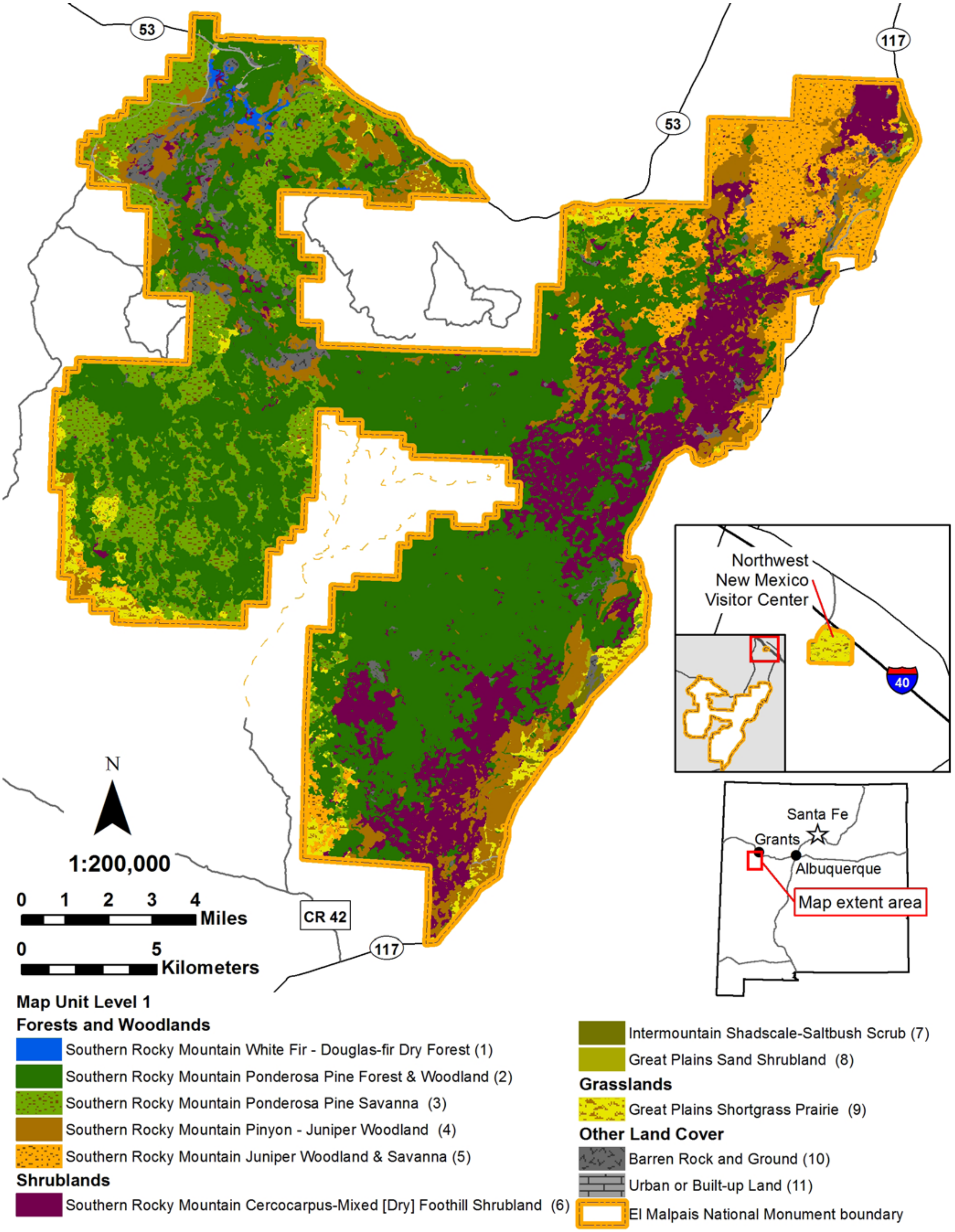

Figure 26. A vegetation map of El Malpais National Monument portraying the Level 1 units (see Table 8 for map unit definitions). A full-scale, 1:44,000 version is available at http://www.usgs.gov/core_science_systems/csas/vip/products.html.

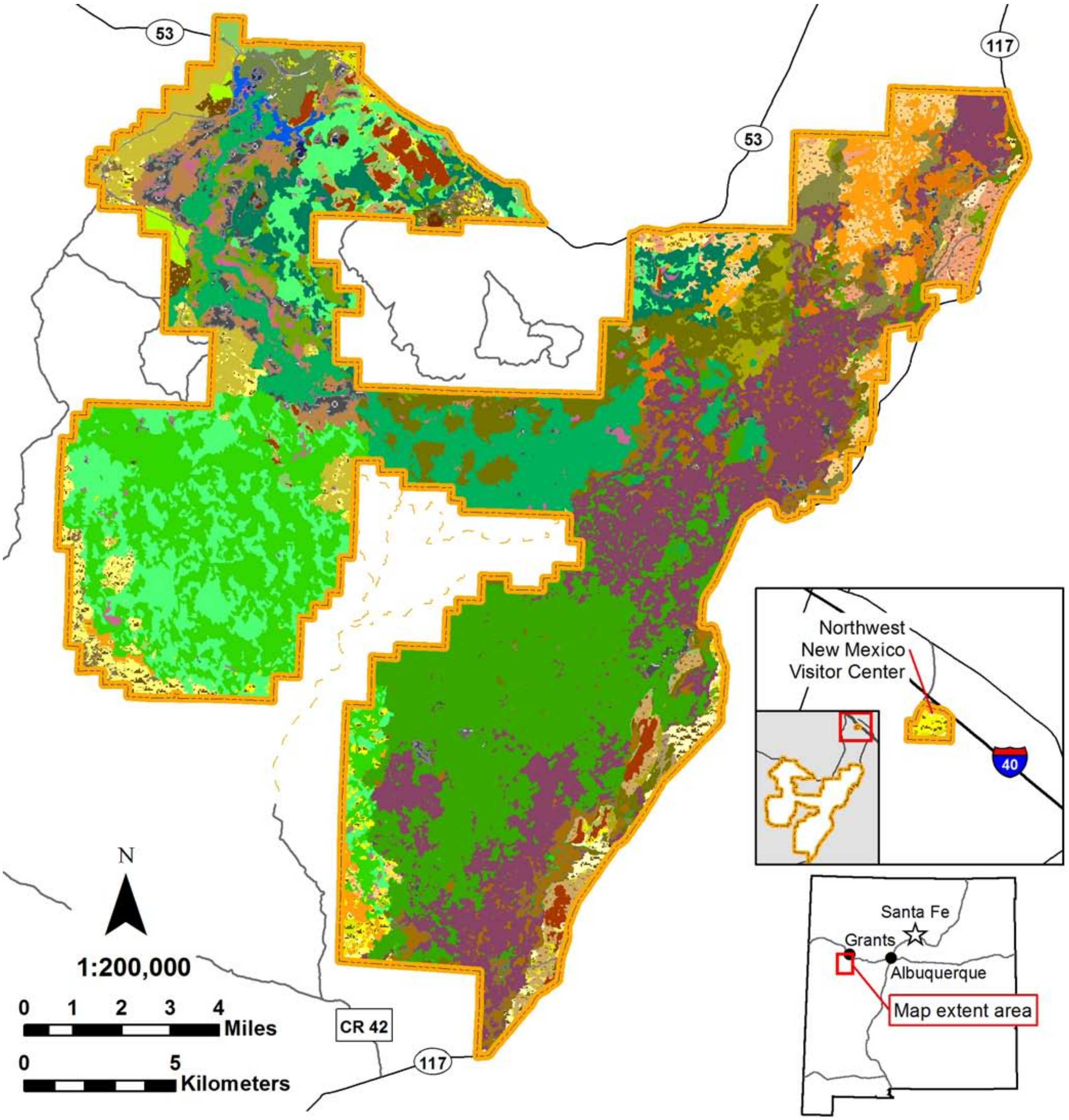

Figure 27. A vegetation map of El Malpais National Monument portraying the Level 2 units (see Table 8 and Appendix E for map unit definitions). A full-scale, 1:44,000 version is available at http://www.usgs.gov/core_science_systems/csas/vip/products.html.

Map Unit Level 2

Forests and Woodlands

- Douglas-fir/Gooseberry Cinder Forest (1A)
- Douglas-fir/Rockspirea Lava Woodland (1B)
- Douglas-fir/Gambel Oak Foothill Forest (1C)
- Ponderosa Pine/Mountain Muhly-Gambel Oak Cinder Forest (2A)
- Ponderosa Pine/Mutton Bluegrass Cinder Forest (2B)
- Ponderosa Pine/Apache Plume Lava Woodland (2C)
- Ponderosa Pine/Apache Plume-Wax Current Lava Woodland (2D)
- Ponderosa pine /Apache Plume/ Mountain Muhly Lava Woodland (2E)
- Ponderosa Pine/Deer Sedge Lava Woodland (2F)
- Ponderosa Pine/Mountain Muhly-Deer Sedge Lava Woodland (2G)
- Ponderosa Pine/Oak Lava Woodland (2H)
- Ponderosa Pine/Gambel Oak/Mountain Muhly Foothill Woodland (2I)
- Ponderosa Pine Cinder Forest Savanna (3A)
- Ponderosa Pine/Mountain Muhly Lava Woodland Savanna (3B)
- Ponderosa Pine/Mountain Muhly-Blue Grama Plains and Valley Woodland Savanna (3C)
- Ponderosa Pine/Mesa Dropseed Sandy Plains Woodland Savanna (3D)
- Pinyon-Juniper Cinder Woodland (4A)
- Pinyon-Juniper/Blue Grama Cinder Woodland Savanna (4B)
- Pinyon-Juniper/Wavyleaf Oak Lava Woodland (4C)
- Pinyon-Juniper/Apache Plume Lava Woodland (4D)
- Pinyon-Rocky Mountain Juniper/Rockspirea Lava Woodland (4E)
- Pinyon-Juniper/Blue Grama Lava Woodland Savanna (4F)
- Pinyon-Juniper/Blue Grama-Mesa Dropseed Sandy Plains and Valley Woodland Savanna (4G)
- Pinyon-Juniper/Blue Grama-Needlegrass Foothill Woodland (4H)
- Oneseed Juniper/Apache Plume Lava Woodland (5A)
- Oneseed Juniper/Fragrant Ash-Wavyleaf Oak Lava Woodland (5B)
- Oneseed Juniper/Fragrant Ash Lava Woodland (5C)
- Oneseed Juniper/Blue Grama Lava Woodland (5D)
- Oneseed Juniper/Blue Grama Woodland Savanna (5E)
- Oneseed Juniper/Blue Grama-Mesa Dropseed Sandy Plains Woodland Savanna (5F)
- Oneseed Juniper/Wavyleaf Oak/Blue Grama Foothill Woodland Savanna (5G)

Shrublands

- Apache Plume Cinder Scrub (6A)
- Apache Plume-Skunkbush Sumac Lava Scrub (6B)
- Skunkbush Sumac-Gooseberry-Apache Plume- Lava Scrub (6C)
- Fourwing Saltbush Shrub-Steppe (7A)
- Sand Sagebrush Sandy Plains Shrubland (8A)

Grasslands

- Rubber Rabbitbrush/Blue Grama Shrub-Steppe (9A)
- Blue Grama-Mountain Muhly Lava Plains-Foothill Grassland (9B)
- Fringed Sage/Blue Grama Lava Plains Grassland (9C)
- Blue Grama/Mesa Dropseed Sandy Plains Grassland (9D)
- Blue Grama Ruderal Grassland (9E)
- Blue Grama-Western Wheatgrass Lowland Grassland (9F)

Other Land Cover

- Barren Lava Flow (10A)
- Barren Cinder Volcano (10B)
- Barren Alluvial Flat (10C)
- Rockland/Scarp/Cliff (10D)
- Urban or Built-up Land (11A)
- Roads, Parking Lots (11B)
- Building (11C)

...continued from page 44

or ponding water, likely limited grazing in the 20th century, and therefore, these flows may still reflect much of their natural, presettlement character (although 19th century sheep grazing may still have been a factor). Even on older flows like Hoya de Cibola, where the soil mantle and the grass cover is more continuous, the fire regime has remained relatively intact into the 20th century (Grissino-Mayer and Swetnam 1997), which suggests limited impacts of grazing. The high degree of thematic resolution provided in the Level 2 units supports fire management by clearly delineating those units where grass and shrub cover may be more significant than in others (while not done in this effort, standard fuel models could be applied to each unit, based on plant association composition, and refined with field validation). The high thematic content may also inform our understanding of wildlife habitat use.

Even though some areas deep within the lava flows and those under other ownership were inaccessible to field sampling, the patterns within lava-flows were sufficiently uniform that we felt confident that the major patterns of vegetation for ELMA were well-mapped. The rugged terrain did create small inclusions of unique environments with corresponding unique combinations of plant species, some of which we sampled. While ecologically interesting to a degree, they most often fall well below the minimum map unit delineation size and were considered inclusions to be described in future studies. Overall, the combination of the annotated legend (Appendix E) and the detailed floristic and site descriptions of individual plant associations (Appendix D) provide for a vegetation map that is rich in ecological information, and one that can serve multiple purposes in the management of this park and the broader network of parks.

4 Accuracy assessment

The thematic accuracy of the ELMA vegetation map was assessed 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 producer's and user's 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 the user's and producer's 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 allows us to assume that all products derived from them are well within National Map Accuracy Standards for 1:12,000-scale maps (±10 m or ±30 ft). Given that resources were limited, and following the recommendations of Cogan (2007), we did not assess the positional accuracy. However, there are known issues in the ELMA 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's accuracy.

4.1 Accuracy assessment methods

Overall, 42 Level 2 vegetation units and four non-vegetated units were available for accuracy assessment (AA). Urban and built-up land units were excluded. 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 areal extent, we targeted at least 30 sample points, but we also attempted to not fall below five for less common units. Following the NPS guidelines, multiple samples within any given delineated polygon were acceptable and considered independent samples. In effect, each sample was intended to represent a pseudo-polygon at the minimum map unit size of 0.5 ha.

The AA sampling was conducted between 6/2/2009 and 7/17/2009. To support field sampling, paper maps were created at a 1:12,000 scale with target sample points and the underlying imagery and topography, but no designations or delineations. These were used by the field crew as guidance in developing optimal sampling strategies with respect to map-unit targets and logistics, and for reconnoitering in the field. Crews would navigate to the point location in the field 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 key was to avoid sampling small patches or fragments of plant associations not typical of the target stand.

At the sample location, a validation plot was taken 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)
- four representative digital photos (following NHNM standard plot methods per Appendix A).

A total of 1,190 accuracy assessment (AA) plots were used in the assessment (Fig. 28).

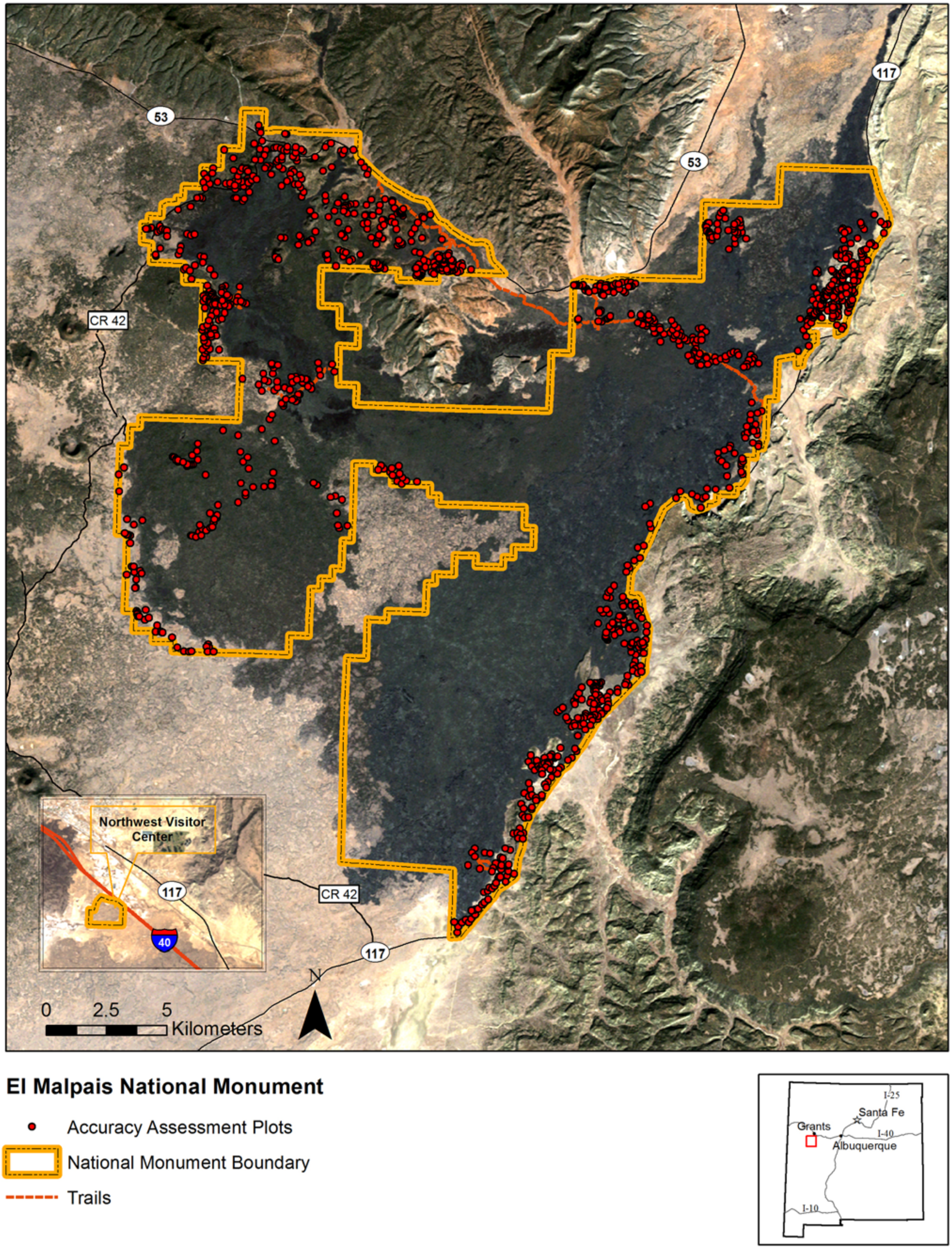

Figure 28. Distribution of the 1190 accuracy assessment points for the El Malpais National Monument Vegetation Map.

4.1.1 Analysis methods

Initially, we classified each AA point into a plant association following the ELMA vegetation classification and dichotomous key (Table 5 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 8, 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 their estimated extent met or exceeded the minimum map-unit size of 0.5 ha. 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 that polygon and the adjacent one for accuracy.

For each level of the map legend, we calculated both a user's and producer's accuracy (Congalton and Green 1999) for each map unit. Producer's 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 user's 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, with 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) at each level examined. 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, which show the producer's and user's 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 tAAevents tables in the NPS-developed Plot_v3_BE_ELMA.mdb relational database.

4.2 Accuracy assessment results

Map accuracies are reported hierarchically in the form of individual contingency tables for the broadest classes (forest/woodland, shrubland, grassland, and other non-vegetated units), followed by Level 1 and then Level 2 map units (Tables 9, 10 and 11).
At the broadest scale of the physiognomic classes of woodland, shrubland, grassland, and other, overall accuracy was high, at 97% (94% KHAT adjusted) (Table 9). The largest producer error (88%) was associated with the "Grassland" category where grasslands were mapped as shrublands or barren flats about 5% percent of the time and, to lesser degree, woodlands. This suggests that accurately detecting shrubs among grasslands,

Table 9. Accuracy assessment contingency table for the El Malpais National Monument Vegetation Map at broadest scale of the physiognomic classes of woodland, shrubland, and grassland. We provide the Producer's and User's 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 adjusted accuracy Kappa (KHAT) index.

		Point as observed				User's accuracy				
		Forest/ Woodland	Shrubland	Grassland	Other	*n*	Correct	90% CI	90% CI-	90% CI+
Point as mapped	Forest/ Woodland	779	6	4		789	0.99	0.007	0.980	0.995
	Shrubland	4	136	12		152	0.89	0.044	0.850	0.939
	Grassland		1	199		200	1.00	0.011	0.984	1.006
	Other		1	10	38	49	0.78	0.108	0.667	0.884
Producer's accuracy	*n*	783	144	225	38	1190				
	Correct	0.99	0.94	0.88	1.00					
	90% CI	0.005	0.035	0.037	0.013					
	90% CI-	0.990	0.910	0.847	0.987					
	90% CI+	1.000	0.979	0.922	1.013					

Overall accuracy = 0.968
Overall 90% CI = 0.009
Overall 90% CI- = 0.959
Overall 90% CI+ = 0.977

Adjusted accuracy (KHAT) = 0.938
Adjusted 90% CI = 0.012
Adjusted 90% CI- = 0.926
Adjusted 90% CI+ = 0.950

and low cover of grasses in the imagery, can be a challenge, particularly with respect to boundary conditions (i.e., when cover ranges between 10% and 25% for shrubs or trees). Similarly, most forest/woodland and shrubland producer errors revolved around estimating tree density in the images where trees were sparse. With respect to user accuracy, the patterns were similar. For example, areas that we mapped as "Other" (often mostly barren alluvial flats), were actually grasslands on the ground about 20% of the time. Overall, cross-classifications at this level were low and mostly to closely related units.

At Level 1, the NVCS Group level of the legend hierarchy, the overall accuracy exceeded the 80% accuracy standard, at 88% (85% KHAT adjusted)(Table 10). With respect to producer accuracies, nine out of the ten units exceeded the 80% standard. Southern Rocky Mountain Juniper Woodland & Savanna (5) missed the target by 5%, and was primarily mis-mapped (18%) as the closely related but denser Southern Rocky Mountain Pinyon - Juniper Woodland (4). It was also mapped as Southern Rocky Mountain Ponderosa Pine Forest & Woodland (2) or Southern Rocky Mountain Ponderosa Pine Savanna (3) 8% of the time, primarily because of uncertainty regarding tree height and tree shape in the imagery. A similar pattern also occurred among the other woodland and forest units, but to a lesser degree (units 2, 3, & 4).

Individual unit user accuracies ranged from 78% to nearly 100%. Again, most errors reflected tree height and density issues, e.g., Southern Rocky Mountain Ponderosa Pine Savanna (3) as mapped was actually other types of forest and woodland on the ground (units 2, 4, or 5) 22% of the time. Another source of error was areas mapped as Barren Rock and Ground (10), specifically Barren Alluvial Flat (Level 2 10C in Table 11), that were actually mostly grassland (9). In addition, points mapped as either Intermountain

Continued on page 66...

Table 10. Accuracy assessment contingency table for the El Malpais National Monument Vegetation Map at Level 1. We provide the Producer's and User's 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 adjusted Kappa (KHAT) index. Below the table is a key to various Level 1 classes.

		Point as observed										User's accuracy				
	Map unit	1	2	3	4	5	6	7	8	9	10	n	Correct	90% CI	90% CI-	90% CI+
Point as mapped	1	11	2									13	0.85	0.203	0.643	1.049
	2		210	1	17	8	3			2		241	0.87	0.038	0.834	0.909
	3		8	94	11	7						120	0.78	0.066	0.717	0.849
	4		10	5	228	28				1		272	0.84	0.039	0.800	0.877
	5		1	1	8	129	1	2		1		143	0.90	0.044	0.858	0.946
	6		1		2	1	72					76	0.95	0.049	0.899	0.996
	7							40	1	7		48	0.83	0.099	0.734	0.932
	8							1	22	5		28	0.79	0.145	0.640	0.931
	9							1		199		200	1.00	0.011	0.984	1.006
	10							1		10	38	49	0.78	0.108	0.667	0.884
Producer's accuracy	n	11	232	101	266	173	76	45	23	225	38	1190				
	Correct	1.00	0.91	0.93	0.86	0.75	0.95	0.89	0.96	0.88	1.00					
	90% CI	0.045	0.034	0.047	0.037	0.057	0.049	0.088	0.092	0.037	0.013					
	90% CI-	0.955	0.871	0.884	0.820	0.688	0.899	0.801	0.865	0.847	0.987					
	90% CI+	1.045	0.939	0.977	0.894	0.803	0.996	0.977	1.048	0.922	1.013					

Key to map unit codes

1 Southern Rocky Mountain White Fir - Douglas-fir Dry Forest
2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland
3 Southern Rocky Mountain Ponderosa Pine Savanna
4 Southern Rocky Mountain Pinyon - Juniper Woodland
5 Southern Rocky Mountain Juniper Woodland & Savanna
6 Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland
7 Intermountain Shadscale-Saltbush Scrub
8 Great Plains Sand Shrubland
9 Great Plains Shortgrass Prairie
10 Barrren Rock and Ground

Overall accuracy = 0.88
Overall 90% CI = 0.016
Overall 90% CI- = 0.860
Overall 90% CI+ = 0.893

Adjusted accuracy (KHAT) = 0.85
Adjusted 90% CI = 0.017
Adjusted 90% CI- = 0.836
Adjusted 90% CI+ = 0.871

Table 11. Accuracy statistics for the El Malpais National Monument vegetation map at Level 2. We provide the Producer's and User's accuracies with 10% confidence interval (CI) ranges and sample sizes. The total number of accuracy assessment plots was 1190.

	Level 2 map class	User's accuracy	90% CI[1] (range)	User's total	Producer's accuracy	90% CI (range)	Producer's total
FORESTS and WOODLANDS							
1A	Douglas-fir/Gooseberry Cinder Forest	0.60	0.139–1.06	5	1.00	0.833–1.166	3
1B	Douglas-fir/Rockspirea Lava Woodland	1.00	0.5–1.5	1	1.00	0.5–1.5	1
1C	Douglas-fir/Gambel Oak Foothill Forest	1.00	0.928–1.071	7	1.00	0.928–1.071	7
2A	Ponderosa Pine/Mountain Muhly-Gambel Oak Cinder Forest	0.82	0.684–0.958	28	0.82	0.684–0.958	28
2B	Ponderosa Pine/Mutton Bluegrass Cinder Forest	0.00	-0.166–0.166	3	0.00	-0.1–0.1	5
2C	Ponderosa Pine/Apache Plume Lava Woodland	0.84	0.713–0.963	31	0.60	0.47–0.738	43
2D	Ponderosa Pine/Apache Plume-Wax Current Lava Woodland	0.89	0.661–1.116	9	0.67	0.401–0.932	12
2E	Ponderosa pine /Apache Plume/ Mountain Muhly Lava Woodland	0.81	0.703–0.913	47	0.86	0.767–0.96	44
2F	Ponderosa Pine/Deer Sedge Lava Woodland	0.58	0.307–0.859	12	0.64	0.352–0.92	11
2G	Ponderosa Pine/Mountain Muhly-Deer Sedge Lava Woodland	0.92	0.84–0.992	48	0.86	0.773–0.951	51
2H	Ponderosa Pine/Oak Lava Woodland	0.64	0.483–0.789	33	0.78	0.627–0.927	27
2I	Ponderosa Pine/Gambel Oak/Mountain Muhly Foothill Woodland	0.37	0.205–0.528	30	1.00	0.954–1.045	11
3A	Ponderosa Pine Cinder Forest Savanna	0.90	0.799–1.006	31	0.93	0.841–1.024	30
3B	Ponderosa Pine/Mountain Muhly Lava Woodland Savanna	0.79	0.655–0.92	33	0.93	0.83–1.026	28
3C	Ponderosa Pine/Mountain Muhly-Blue Grama Plains and Valley Woodland Savanna	0.86	0.752–0.969	36	0.84	0.724–0.951	37
3D	Ponderosa Pine/Mesa Dropseed Sandy Plains Woodland Savanna	0.30	0.106–0.493	20	1.00	0.916–1.083	6
4A	Pinyon-Juniper Cinder Woodland	0.82	0.642–1.005	17	0.64	0.444–0.827	22
4B	Pinyon-Juniper/Blue Grama Cinder Woodland Savanna	0.82	0.684–0.958	28	0.62	0.476–0.766	37
4C	Pinyon-Juniper/Wavyleaf Oak Lava Woodland	0.38	0.144–0.605	16	0.32	0.114–0.517	19
4D	Pinyon-Juniper/Apache Plume Lava Woodland	0.79	0.64–0.931	28	0.88	0.753–1.006	25
4E	Pinyon-Rocky Mountain Juniper/Rockspirea Lava Woodland	0.80	0.663–0.936	30	0.96	0.875–1.044	25
4F	Pinyon-Juniper/Blue Grama Lava Woodland Savanna	0.94	0.872–1.005	49	0.98	0.933–1.023	47
4G	Pinyon-Juniper/Blue Grama-Mesa Dropseed Sandy Plains and Valley Woodland Savanna	0.68	0.561–0.798	50	1.00	0.985–1.014	34
4H	Pinyon-Juniper/Blue Grama-Needlegrass Foothill Woodland	0.74	0.633–0.848	54	0.70	0.593–0.81	57
5A	Oneseed Juniper/Apache Plume Lava Woodland	0.50	-0.036–1.036	4	0.18	-0.054–0.418	11
5B	Oneseed Juniper/Fragrant Ash-Wavyleaf Oak Lava Woodland	0.77	0.538–0.999	13	0.83	0.614–1.051	12
5C	Oneseed Juniper/Fragrant Ash Lava Woodland	1.00	0.954–1.045	11	1.00	0.954–1.045	11

Table 11. Accuracy statistics for the El Malpais National Monument vegetation map at Level 2 (*continued*)

Level 2 map class		User's accuracy	90% CI[1] (range)	User's total	Producer's accuracy	90% CI (range)	Producer's total
FORESTS AND WOODLANDS (*continued*)							
5D	Oneseed Juniper/Blue Grama Lava Woodland	1.00	0.75–1.25	2	0.25	-0.064–0.564	8
5E	Oneseed Juniper/Blue Grama Woodland Savanna	0.94	0.864–1.021	35	0.94	0.864–1.021	35
5F	Oneseed Juniper/Blue Grama-Mesa Dropseed Sandy Plains Woodland Savanna	0.86	0.771–0.942	56	0.77	0.678–0.869	62
5G	Oneseed Juniper/Wavyleaf Oak/Blue Grama Foothill Woodland Savanna	0.86	0.72–1.006	22	0.70	0.54–0.866	27
SHRUBLANDS							
6A	Apache Plume Cinder Scrub	1.00	0.5–1.5	1	1.00	0.5–1.5	1
6B	Apache Plume-Skunkbush Sumac Lava Scrub	0.98	0.921–1.028	40	0.91	0.822–0.991	43
6C	Skunkbush Sumac-Gooseberry-Apache Plume- Lava Scrub	0.91	0.822–1.006	35	1.00	0.984–1.015	32
7A	Fourwing Saltbush Shrub-Steppe	0.83	0.734–0.932	48	0.89	0.8–0.977	45
8A	Sand Sagebrush Sandy Plains Shrubland	0.79	0.64–0.931	28	0.73	0.583–0.882	30
GRASSLANDS							
9A	Rubber Rabbitbrush/Blue Grama Shrub-Steppe	0.92	0.803–1.03	24	0.59	0.448–0.74	37
9B	Blue Grama-Mountain Muhly Lava Plains-Foothill Grassland	0.78	0.681–0.882	55	0.78	0.681–0.882	55
9C	Fringed Sage/Blue Grama Lava Plains Grassland	0.83	0.674–0.977	23	0.76	0.599–0.92	25
9D	Blue Grama/Mesa Dropseed Sandy Plains Grassland	0.66	0.51–0.803	35	0.70	0.55–0.843	33
9E	Blue Grama Ruderal Grassland	0.78	0.588–0.966	18	0.67	0.473–0.859	21
9F	Blue Grama-Western Wheatgrass Lowland Grassland	0.93	0.861–1.005	45	0.78	0.675–0.88	54
OTHER LAND COVER							
10A	Barren Lava Flow	1.00	0.983–1.016	30	1.00	0.983–1.016	30
10B	Barren Cinder Volcano	1.00	0.875–1.125	4	1.00	0.875–1.125	4
10C	Barren Alluvial Flat	0.29	0.051–0.52	14	1.00	0.875–1.125	4
10D	Rockland/Scarp/Cliff	0.00	0–0	1	0.00	0–0	0

Overall accuracy = 0.80
Overall 90% CI = 0.02
Overall 90% CI- = 0.78
Overall 90% CI+ = 0.82

Adjusted accuracy (KHAT) = 0.79
Adjusted 90% CI = 0.02
Adjusted 90% CI- = 0.77
Adjusted 90% CI+ = 0.81

...continued from page 62.

Shadscale-Saltbush Scrub shrublands (7) or Great Plains Sand Shrubland (8) lacked sufficient shrubs and were actually Great Plains Shortgrass Prairie (9). In general, we consider Level 1 errors to be relatively minor in extent and the map to be a good representation of the major vegetation types of the monument.

At Level 2, overall accuracy dropped 8% to 80% (79% KHAT adjusted), with a mixture of individual unit performances (Table 11, previous page). With respect to producer's accuracies, 25 of the 46, or 54% of the units tested exceeded the 80% accuracy standard; 11 (24%) ranged between 50% and 75%; and only five (11%) fell below 50%. The distribution was similar among user's accuracies, with 27 of the 46 units exceeding 80%; 7 between 50% and 75%; and six below 50%. The medium performers (50% to 80%) were concentrated among the Great Plains Shortgrass Prairie units (9A-9F), reflecting the long-standing problem of discerning grassland types with remote sensing.

Another concentration of lower performers was among ponderosa pine units, where five of the nine units fell below the 80% threshold from a producer's perspective, and four from the user's. In particular, Ponderosa Pine/Mutton Bluegrass Cinder Forest (2B) was not effectively mapped, from either a user or producer perspective. This suggests that this minor unit might be best lumped with the other ponderosa pine cinder unit, Ponderosa Pine Mountain/ Muhly-Gambel Oak Cinder Forest (2A). However, the sample size was limited, so we would encourage additional field sampling to confirm this. Ponderosa Pine/Apache Plume Lava Woodland (2C) was occasionally mis-mapped as other shrubby types dominated by apache plume or wavyleaf oak (2E, 2H, 4C, and 4D), although from a user's perspective, the error was acceptable (84% of the 2C polygons were mapped correctly). Similarly, Ponderosa Pine/Apache Plume-Wax Current Lava Woodland (2D) stands were mapped 33% of the time as the pinyon-juniper equivalent, Pinyon-Rocky Mountain Juniper/Rockspirea Lava Woodland (4E), but had a good user accuracy (89%). Grass cover again played a role where the sparse Ponderosa Pine/Deer Sedge Lava Woodland (2F) stands on the Twin Craters flow were also confused with the closely related but grassier Ponderosa Pine/Mountain Muhly Lava Woodland Savanna (3B) about a third of the time. Ponderosa Pine/Gambel Oak/ Mountain Muhly Foothill Woodland (2I) was a poor performer from a user's perspective, with several polygons actually Apache plume-dominated in the understory (2E) or pinyon-juniper woodland with oak (4C) (producer accuracy in contrast was 100%, i.e., all 21 ground points were mapped correctly). Ponderosa Pine/Mesa Dropseed Sandy Plains Woodland Savanna (3D) also had a poor user's value (30%), but did well from a producer's viewpoint (100%).

Among pinyon-juniper woodlands, Pinyon-Juniper/Blue Grama Cinder Woodland Savanna (4B) had the most heterogeneous producer errors, but these were still mostly confined to confusion in the mapping process between the somewhat taller ponderosa and the diminutive pinyon-dominated stands. Pinyon-Juniper/Wavyleaf Oak Lava Woodland (4C) was confused mostly with the ponderosa pine version (2H), or with the closely related Apache plume version (4D), particularly with respect to the producer's accuracy. Detecting pinyon in the imagery could sometimes be problematic and was compounded by the die-off of pinyon following the 2003 drought. For example, we tested 50 polygons mapped as Pinyon-Juniper/Blue Grama-Mesa Dropseed Sandy Plains and Valley Woodland Savanna (4G). Of these, 12 were Oneseed Juniper/ Blue Grama-Mesa Dropseed Sandy Plains Woodland Savanna (5F) when sampled on the ground. The error was primarily because recent pinyon die-off was not detected in the imagery.

With respect to shrublands, individual units of Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland (6A-6C) and Fourwing Saltbush Shrub-Steppe (7A) were mapped well, at between 89% and 100% producer's accuracy and 83% to 100% for user's accuracy. Sand Sagebrush Sandy Plains Shrubland (8A) was somewhat lower, where stands were sometimes mapped as Ponderosa Pine/Mesa Dropseed Sandy Plains Woodland Savanna (3D) if only a few trees were present or, if shrubs could not be detected in the imagery, they were designated as grasslands (9 units).

4.3 Accuracy assessment discussion

The main sources of error in the El Malpais NM vegetation map that were discovered during the accuracy assessment process were primarily due to

- the thematic content of the units and the associated limits to the image interpretation (fundamental error)
- the positional accuracy of the AA points (particularly with respect to narrow linear polygons)
- the structure and accuracy of the classification key.

With respect to the AA methodology itself, the randomized approach where AA points represent independent samples of the minimum mapping unit-size polygon is perhaps best from the point of view of user's accuracy, but it may not address producer's accuracy effectively because multiple samples within a polygon are not independent of the producer's call for the polygon at large. For example, if a polygon has multiple samples that are linked to a single call, that single polygon call carries more weight than others with less sampling. While analytically more complex, this should perhaps be taken into consideration in future NPS AA procedures.

In summary, overall accuracy for each level met the 80% standard. Most errors were associated with the finer scale at Level 2, although the majority of these units also met the standard. Where they did not, the confusion was by and large explainable as fundamental error, or that the sample sizes were too small. The issues identified here can be resolved with future higher-resolution imagery combined with a small amount of supplemental sampling. Hence, at this time, we recommend that the units be retained as is pending future in-depth analysis at finer scales of specific target areas.

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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 El Malpais 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 El Malpais 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 bringing 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

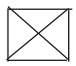
The Standard Data Form is a combination of the General Plot Description (Form 2) and the Floristic Inventory (Form 3) on a single page, with the data fields in the same order as the previous forms. This form can be used for Standard Plots, Quick Plots, and Observation Points.

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			

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___

USGS-NPS Vegetation Mapping Program
El Malpais National Monument

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: El Malpais National Monument Plant Species List

Appendix B is a list of plant species recorded on vegetation plots at El Malpais National Monument as part of the vegetation mapping project between 2006 and 2009. Plant voucher specimens were collected to confirm field identifications as necessary and are housed at the University of New Mexico Herbarium. Specimens were identified by Natural Heritage New Mexico (NHNM) botanist Yvonne Chauvin to lowest level possible given the material at hand and names 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 common name, plant family, the NHNM database acronym, the PLANTS database symbol, and the number of plot observations.

Plant species list for El Malpais National Monument

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of obser-vations
Tree	*Juniperus deppeana*	alligator juniper	Cupressaceae	JUDE2	JUNDEP	121
Tree	*Juniperus monosperma*	oneseed juniper	Cupressaceae	JUMO	JUNMON	1089
Tree	*Juniperus scopulorum*	Rocky Mountain juniper	Cupressaceae	JUSC2	JUNSCO	390
Tree	*Juniperus* spp.	juniper	Cupressaceae	JUNIP	JUNIPE	3
Tree	*Pinus edulis*	pinyon pine	Pinaceae	PIED	PINEDU	1438
Tree	*Pinus flexilis*	limber pine	Pinaceae	PIFL2	PINFLE	1
Tree	*Pinus ponderosa*	ponderosa pine	Pinaceae	PIPO	PINPON	1125
Tree	*Populus tremuloides*	quaking aspen	Salicaceae	POTR5	POPTRE	88
Tree	*Populus x acuminata*	lanceleaf cottonwood	Salicaceae	POAC5	POPACU	1
Tree	*Prunus virginiana*	common chokecherry	Rosaceae	PRVI	PRUVIR	13
Tree	*Prunus virginiana* var. *melano-carpa*	black chokecherry	Rosaceae	PRVIM	PRUVIR	1
Tree	*Pseudotsuga menziesii*	Douglas-fir	Pinaceae	PSME	PSEMEN	112
Tree	*Quercus gambelii*	Gambel's oak	Fagaceae	QUGA	QUEGAM	152
Tree	*Quercus grisea*	gray oak	Fagaceae	QUGR3	QUEGRI	15
Tree	*Tamarix chinensis*	saltcedar	Tamaricaceae	TACH2	TAMCHI	1
Shrub	*Artemisia filifolia*	sand sagebrush	Asteraceae	ARFI2	ARTFIL	84
Shrub	*Atriplex canescens*	fourwing saltbush	Chenopodiaceae	ATCA2	ATRCAN	177
Shrub	*Baccharis pteronioides*	yerba de pasmo	Asteraceae	BAPT	BACPTE	1
Shrub	*Berberis fendleri*	Colorado barberry	Berberidaceae	BEFE	BERFEN	4
Shrub	*Brickellia californica*	California brickellbush	Asteraceae	BRCA3	BRICAL	36
Shrub	*Brickellia* spp.	brickellbush	Asteraceae	BRICK	BRICKE	2
Shrub	*Ceanothus fendleri*	Fendler's ceanothus	Rhamnaceae	CEFE	CEAFEN	6
Shrub	*Cercocarpus montanus*	mountain mahogany	Rosaceae	CEMO2	CERMON	51
Shrub	*Cercocarpus montanus* var. *paucidentatus*	shaggy mountain ma-hogany	Rosaceae	CEMOP	CERMON	7
Shrub	*Clematis columbiana*	rock clematis	Ranunculaceae	CLCO2	CLECOL	3
Shrub	*Clematis ligusticifolia*	western white clematis	Ranunculaceae	CLLI2	CLELIG	10
Shrub	*Clematis* spp.	clematis	Ranunculaceae	CLEMA	CLEMAT	1
Shrub	*Cylindropuntia imbricata*	tree cholla	Cactaceae	CYIM2	CLYIMB	216
Shrub	*Ericameria nauseosa*	rubber rabbitbrush	Asteraceae	ERNA10	ERINAU	412

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of obser-vations
Shrub	*Ericameria nauseosa* var. *bigelovii*	rubber rabbitbrush	Asteraceae	ERNAB2	ERINAU	6
Shrub	*Ericameria parryi*	Parry's rabbitbrush	Asteraceae	ERPA30	ERIPAR	4
Shrub	*Ericameria parryi* var. *attenuata*	Parry's rabbitbrush	Asteraceae	ERPAA4	ERIPAR	5
Shrub	*Ericameria* spp.	heath goldenrod	Asteraceae	ERICA2	ERICAM	3
Shrub	*Eriogonum microthecum* var. *simpsonii*	Simpson's buckwheat	Polygonaceae	ERMIS2	ERIMIC	1
Shrub	*Fallugia paradoxa*	Apacheplume	Rosaceae	FAPA	FALPAR	428
Shrub	*Forestiera pubescens*	New Mexico olive	Oleaceae	FOPU2	FORPUB	184
Shrub	*Forestiera pubescens* var. *pubescens*	New Mexico olive	Oleaceae	FOPUP	FORPUB	26
Shrub	*Fraxinus cuspidata*	fragrant ash	Oleaceae	FRCU	FRACUS	58
Shrub	*Holodiscus dumosus*	rockspirea	Rosaceae	HODU	HOLDUM	135
Shrub	*Krascheninnikovia lanata*	winterfat	Chenopodiaceae	KRLA2	KRALAN2	40
Shrub	*Lonicera arizonica*	Arizona honeysuckle	Caprifoliaceae	LOAR	LONARI	3
Shrub	*Lorandersonia pulchella*	southwestern rabbitbrush	Asteraceae	CHPU4	LORPUL	24
Shrub	*Lycium pallidum*	pale wolfberry	Solanaceae	LYPA	LYCPAL	22
Shrub	*Mahonia haematocarpa*	red barberry	Berberidaceae	MAHA4	MAHHAE	1
Shrub	*Quercus ×pauciloba*	wavyleaf oak	Fagaceae	QUPA4	QUEPAU	210
Shrub	*Quercus turbinella*	shrub live oak	Fagaceae	QUTU2	QUETUR	1
Shrub	*Rhus glabra*	smooth sumac	Anacardiaceae	RHGL	RHUGLA	16
Shrub	*Rhus trilobata*	skunkbush sumac	Anacardiaceae	RHTR	RHUTRI	351
Shrub	*Ribes cereum*	wax currant	Grossulariaceae	RICE	RIBCER	301
Shrub	*Ribes leptanthum*	trumpet gooseberry	Grossulariaceae	RILE	RIBLEP	4
Shrub	*Ribes mescalarium*	Mescalero currant	Grossulariaceae	RIME2	RIBMES	3
Shrub	*Ribes* spp.	currant; gooseberry	Grossulariaceae	RIBES	RIBES	1
Shrub	*Ribes wolfii*	Wolf's currant	Grossulariaceae	RIWO	RIBWOL	1
Shrub	*Rosa woodsii*	Woods' rose	Rosaceae	ROWO	ROSWOO	1
Shrub	*Rubus idaeus*	Red Raspberry	Rosaceae	RUID	RUBIDA	4
Shrub	*Rubus idaeus* ssp. *strigosus*	grayleaf red raspberry	Rosaceae	RUIDS2	RUBIDA	5
Shrub	*Salix scouleriana*	Scouler's willow	Salicaceae	SASC	SALSCO	2
Shrub	*Sarcobatus vermiculatus*	greasewood	Chenopodiaceae	SAVE4	SARVER	1
Shrub	*Symphoricarpos oreophilus*	whortleleaf snowberry	Caprifoliaceae	SYOR2	SYMORE	1
Shrub	*Symphoricarpos oreophilus* var. *utahensis*	Utah snowberry	Caprifoliaceae	SYORU	SYMORE	2
Shrub	*Symphoricarpos* spp.	snowberry	Caprifoliaceae	SYMPH	SYMPHO	2
Shrub	*Tetradymia canescens*	spineless horsebrush	Asteraceae	TECA2	TETCAN	192
Shrub	*Vitis arizonica*	canyon grape	Vitaceae	VIAR2	VITARI	24
Shrub	*Yucca baccata*	banana yucca	Agavaceae	YUBA	YUCBAC	143
Shrub	*Yucca baileyi* var. *intermedia*	intermediate yucca	Agavaceae	YUBAI	YUCBAI	2
Shrub	*Yucca glauca*	soapweed yucca	Agavaceae	YUGL	YUCGLA	6
Subshrub	*Ageratina herbacea*	fragrant snakeroot	Asteraceae	AGHE5	AGEHER	5
Subshrub	*Artemisia bigelovii*	Bigelow's sagebrush	Asteraceae	ARBI3	ARTBIG	2

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of obser-vations
Subshrub	*Artemisia frigida*	fringed sagewort	Asteraceae	ARFR4	ARTFRI	84
Subshrub	*Brickellia eupatorioides* var. *chlorolepis*	false boneset	Asteraceae	BREUC2	BRIEUP	7
Subshrub	*Brickellia grandiflora*	tasselflower brickellbush	Asteraceae	BRGR	BRIGRA	16
Subshrub	*Calliandra humilis*	dwarf stickpea	Fabaceae	CAHU	CALHUM	2
Subshrub	*Chrysothamnus depressus*	longflower rabbitbrush	Asteraceae	CHDE2	CHRDEP	22
Subshrub	*Chrysothamnus greenei*	Greene's rabbitbrush	Asteraceae	CHGR6	CHRGRE	1
Subshrub	*Echinocereus coccineus*	scarlet hedgehog cactus	Cactaceae	ECCO5	ECHCOC	147
Subshrub	*Echinocereus fendleri*	pinkflower hedgehog cactus	Cactaceae	ECFE	ECHFEN	11
Subshrub	*Echinocereus fendleri* var. *fendleri*	Fendler's hedgehog cactus	Cactaceae	ECFEF2	ECHFEN	17
Subshrub	*Echinocereus* spp.	hedgehog cactus	Cactaceae	ECHIN3	ECHINO2	81
Subshrub	*Echinocereus triglochidiatus*	kingcup cactus	Cactaceae	ECTR	ECHTRI	10
Subshrub	*Echinocereus viridiflorus*	nylon hedgehog cactus	Cactaceae	ECVI2	ECHVIR	1
Subshrub	*Escobaria* spp.	beehive cactus	Cactaceae	ESCOB	ESCOBA	1
Subshrub	*Escobaria vivipara*	spinystar	Cactaceae	ESVI2	ESCVIV	50
Subshrub	*Escobaria vivipara* var. *vivipara*	spinystar	Cactaceae	ESVIV	ESCVIV	1
Subshrub	*Gutierrezia sarothrae*	broom snakeweed	Asteraceae	GUSA2	GUTSAR	401
Subshrub	*Mahonia repens*	Oregongrape	Berberidaceae	MARE11	MAHREP	22
Subshrub	*Mammillaria meiacantha*	little nipple cactus	Cactaceae	MAME6	MAMMEI	1
Subshrub	*Mammillaria wrightii*	Wright's nipple cactus	Cactaceae	MAWR2	MAMWRI	6
Subshrub	*Menodora scabra*	rough menodora	Oleaceae	MESC	MENSCA	13
Subshrub	*Menodora* spp.	menodora	Oleaceae	MENOD	MENODO	1
Subshrub	*Opuntia phaeacantha*	tulip pricklypear	Cactaceae	OPPH	OPUPHA	297
Subshrub	*Opuntia polyacantha*	plains pricklypear	Cactaceae	OPPO	OPUPOL	284
Subshrub	*Opuntia* spp.	pricklypear	Cactaceae	OPUNT	OPUNTI	152
Subshrub	*Paxistima myrsinites*	myrtle boxleaf	Celastraceae	PAMY	PAXMYR	2
Subshrub	*Penstemon ambiguus*	gilia beardtongue	Scrophulariaceae	PEAM	PENAMB	31
Subshrub	*Penstemon ambiguus* var. *laevis-simus*	pink plains beardtongue	Scrophulariaceae	PEAML2	PENAMB	1
Subshrub	*Penstemon linarioides*	toadflax penstemon	Scrophulariaceae	PELI2	PENLIN	17
Subshrub	*Penstemon linarioides* ssp. *colo-radoensis*	toadflax penstemon	Scrophulariaceae	PELIC	PENLIN	4
Grass	*Achnatherum hymenoides*	Indian ricegrass	Poaceae	ACHY	ACHHYM	22
Grass	*Achnatherum perplexum*	New Mexico needlegrass	Poaceae	ACPE13	ACHPER	2
Grass	*Achnatherum scribneri*	Scribner's needlegrass	Poaceae	ACSC11	ACHSCR	35
Grass	*Andropogon gerardii*	big bluestem	Poaceae	ANGE	ANDGER	31
Grass	*Andropogon hallii*	sand bluestem	Poaceae	ANHA	ANDHAL	1
Grass	*Aristida adscensionis*	sixweeks threeawn	Poaceae	ARAD	ARIADS	1
Grass	*Aristida arizonica*	Arizona threeawn	Poaceae	ARAR6	ARIARI	24
Grass	*Aristida divaricata*	poverty threeawn	Poaceae	ARDI5	ARIDIV	13
Grass	*Aristida havardii*	Havard's threeawn	Poaceae	ARHA3	ARIHAV	1
Grass	*Aristida purpurea*	purple threeawn	Poaceae	ARPU9	ARIPUR	164

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of obser-vations
Grass	*Aristida purpurea* var. *fendleriana*	Fendler's threeawn	Poaceae	ARPUF	ARIPUR	1
Grass	*Aristida purpurea* var. *longiseta*	red threeawn	Poaceae	ARPUL	ARIPUR	4
Grass	*Aristida* spp.	threeawn	Poaceae	ARIST	ARISTI	1
Grass	*Blepharoneuron tricholepis*	pine dropseed	Poaceae	BLTR	BLETRI	74
Grass	*Bouteloua barbata*	sixweeks grama	Poaceae	BOBA2	BOUBAR	4
Grass	*Bouteloua curtipendula*	sideoats grama	Poaceae	BOCU	BOUCUR	259
Grass	*Bouteloua curtipendula* var. *caespitosa*	sideoats grama	Poaceae	BOCUC	BOUCUR	1
Grass	*Bouteloua eriopoda*	black grama	Poaceae	BOER4	BOUERI	7
Grass	*Bouteloua gracilis*	blue grama	Poaceae	BOGR2	BOUGRA	1273
Grass	*Bouteloua hirsuta*	hairy grama	Poaceae	BOHI2	BOUHIR	47
Grass	*Bromus ciliatus*	fringed brome	Poaceae	BRCI2	BROCIL	16
Grass	*Bromus frondosus*	weeping brome	Poaceae	BRFR2	BROFRO	2
Grass	*Bromus lanatipes*	woolly brome	Poaceae	BRLA6	BROLAN	37
Grass	*Bromus* spp.	brome	Poaceae	BROMU	BROMUS	1
Grass	*Bromus tectorum*	cheatgrass	Poaceae	BRTE	BROTEC	27
Grass	*Buchloe dactyloides*	buffalograss	Poaceae	BODA2	BUCDAC	1
Grass	*Carex filifolia*	threadleaf sedge	Cyperaceae	CAFI	CARFIL	1
Grass	*Carex geophila*	White Mountain sedge	Cyperaceae	CAGE	CARGEO	87
Grass	*Carex occidentalis*	western sedge	Cyperaceae	CAOC2	CAROCC	3
Grass	*Carex rossii*	Ross' sedge	Cyperaceae	CARO5	CARROS	60
Grass	*Carex* spp.	sedge	Cyperaceae	CAREX	CAREX	1
Grass	*Carex* spp. - upland small	sm. upland sedge <25 cm	Cyperaceae	CAREX	CAREX	34
Grass	*Cyperus esculentus*	chufa flatsedge	Cyperaceae	CYES	CYPESC	2
Grass	*Cyperus fendlerianus*	Fendler's flatsedge	Cyperaceae	CYFE2	CYPFEN	28
Grass	*Cyperus schweinitzii*	Schweinitz's flatsedge	Cyperaceae	CYSC3	CYPSCH	5
Grass	*Elymus elymoides*	bottlebrush squirreltail	Poaceae	ELEL5	ELYELY	488
Grass	*Enneapogon desvauxii*	nineawn pappusgrass	Poaceae	ENDE	ENNDES	1
Grass	*Eragrostis cilianensis*	stinkgrass	Poaceae	ERCI	ERACIL	1
Grass	*Eragrostis mexicana*	mexican lovegrass	Poaceae	ERME	ERAMEX	1
Grass	*Eragrostis pectinacea*	tufted lovegrass	Poaceae	ERPE	ERAPEC	2
Grass	*Erioneuron pilosum*	hairy woollygrass	Poaceae	ERPI5	ERIPIL	2
Grass	*Festuca arizonica*	Arizona fescue	Poaceae	FEAR2	FESARI	16
Grass	*Hesperostipa comata*	needle-and-thread grass	Poaceae	HECO26	HESCOM	43
Grass	*Hesperostipa neomexicana*	New Mexico needlegrass	Poaceae	HENE5	HESNEO	1
Grass	*Hesperostipa* spp.	needle and thread	Poaceae	HESPE11	HESPER	2
Grass	*Hordeum jubatum*	foxtail barley	Poaceae	HOJU	HORJUB	1
Grass	*Koeleria macrantha*	prairie junegrass	Poaceae	KOMA	KOEMAC	75
Grass	*Lycurus setosus*	bristly wolfstail	Poaceae	LYSE3	LYCSET	67
Grass	*Muhlenbergia depauperata*	sixweeks muhly	Poaceae	MUDE	MUHDEP	2
Grass	*Muhlenbergia dubia*	pine muhly	Poaceae	MUDU	MUHDUB	2

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Grass	*Muhlenbergia fragilis*	delicate muhly	Poaceae	MUFR	MUHFRA	13
Grass	*Muhlenbergia minutissima*	annual muhly	Poaceae	MUMI2	MUHMIN	8
Grass	*Muhlenbergia montana*	mountain muhly	Poaceae	MUMO	MUHMON	476
Grass	*Muhlenbergia pauciflora*	New Mexico muhly	Poaceae	MUPA2	MUHPAU	36
Grass	*Muhlenbergia pungens*	sandhill muhly	Poaceae	MUPU2	MUHPUN	22
Grass	*Muhlenbergia repens*	creeping muhly	Poaceae	MURE	MUHFEP	28
Grass	*Muhlenbergia* spp.	muhly	Poaceae	MUHLE	MUHLEN	5
Grass	*Muhlenbergia torreyi*	ring muhly	Poaceae	MUTO2	MUHTOR	118
Grass	*Muhlenbergia wrightii*	spike muhly	Poaceae	MUWR	MUHWRI	33
Grass	*Munroa squarrosa*	false buffalograss	Poaceae	MUSQ3	MUNSQU	38
Grass	*Panicum capillare*	witchgrass	Poaceae	PACA6	PANCAP	1
Grass	*Panicum obtusum*	vine mesquite	Poaceae	PAOB	PANOBT	6
Grass	*Pascopyrum smithii*	western wheatgrass	Poaceae	PASM	PASSMI	114
Grass	*Piptatherum micranthum*	littleseed ricegrass	Poaceae	PIMI7	PIPMIC	61
Grass	*Pleuraphis jamesii*	galleta	Poaceae	PLJA	PLEJAM	80
Grass	*Poa compressa*	Canada bluegrass	Poaceae	POCO	POACOM	1
Grass	*Poa fendleriana*	muttongrass	Poaceae	POFE	POAFEN	443
Grass	*Poa fendleriana fendleriana*	skyline blugrass	Poaceae	POFEF	POAFEN	3
Grass	*Poa pratensis*	Kentucky bluegrass	Poaceae	POPR	POAPRA	1
Grass	*Schedonnardus paniculatus*	tumblegrass	Poaceae	SCPA	SCHPAN	4
Grass	*Schizachyrium scoparium*	little bluestem	Poaceae	SCSC	SCHSCO	430
Grass	*Setaria viridis*	green bristlegrass	Poaceae	SEVI4	SETVIR	1
Grass	*Sporobolus airoides*	alkali sacaton	Poaceae	SPAI	SPOAIR	28
Grass	*Sporobolus contractus*	spike dropseed	Poaceae	SPCO4	SPOCON	15
Grass	*Sporobolus cryptandrus*	sand dropseed	Poaceae	SPCR	SPOCRY	259
Grass	*Sporobolus flexuosus*	mesa dropseed	Poaceae	SPFL2	SPOFLE	39
Grass	*Sporobolus* spp.	dropseed	Poaceae	SPORO	SPOROB	3
Grass	*Tragus berteronianus*	spiked burr grass	Poaceae	TRBE	TRABER	1
Grass	*Vulpia octoflora*	sixweeks fescue	Poaceae	VUOC	VULOCT	1
Forb	*Abronia angustifolia*	purple sand verbena	Nyctaginaceae	ABAN	ABRANG	3
Forb	*Acalypha phleoides*	shrubby copperleaf	Euphorbiaceae	ACPH3	ACAPHL	1
Forb	*Achillea millefolium*	common yarrow	Asteraceae	ACMI2	ACHMIL	11
Forb	*Agastache micrantha*	white giant hyssop	Lamiaceae	AGMI	AGAMIC	1
Forb	*Agastache pallidiflora* ssp. *neo-mexicana*	New Mexican giant hyssop	Lamiaceae	AGPAN	AGAPAL	33
Forb	*Agastache* spp.	hyssop	Lamiaceae	AGAST	AGASTA	5
Forb	*Allium cernuum*	nodding onion	Liliaceae	ALCE2	ALLCER	11
Forb	*Amaranthus acanthochiton*	greenstripe	Amaranthaceae	AMAC	AMAACA	1
Forb	*Amaranthus powellii*	Powell's amaranth	Amaranthaceae	AMPO2	AMAPOW	2
Forb	*Amaranthus* spp.	amaranth	Amaranthaceae	AMARA	AMARAN	22
Forb	*Amaranthus torreyi*	Torrey's amaranthus	Amaranthaceae	AMTO6	AMATOR	3
Forb	*Ambrosia acanthicarpa*	flatspine burr ragweed	Asteraceae	AMAC2	AMBACA	1
Forb	*Ambrosia artemisiifolia*	annual ragweed	Asteraceae	AMAR2	AMBART	2

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Forb	*Ambrosia confertiflora*	weakleaf bur ragweed	Asteraceae	AMCO3	AMBCON	1
Forb	*Ambrosia* spp.	ragweed	Asteraceae	AMBRO	AMBROS	3
Forb	*Androsace septentrionalis*	pygmyflower rockjasmine	Primulaceae	ANSE4	ANDSEP	1
Forb	*Antennaria marginata*	whitemargin pussytoes	Asteraceae	ANMA5	ANTMAR	7
Forb	*Antennaria parvifolia*	smallleaf pussytoes	Asteraceae	ANPA4	ANTPAR	13
Forb	*Antennaria* spp.	pussytoes	Asteraceae	ANTEN	ANTENN	1
Forb	*Aquilegia chrysantha* var. *chaplinei*	Chaplin's golden colum-bine	Ranunculaceae	AQCHC	AQUCHR	1
Forb	*Arabis* spp.	rockcress	Brassicaceae	ARABI2	ARABIS	22
Forb	*Arenaria lanuginosa* ssp. *saxosa*	spreading sandwort	Caryophyllaceae	ARLAS	ARELAN	1
Forb	*Artemisia campestris*	field sagewort	Asteraceae	ARCA12	ARTCAM	63
Forb	*Artemisia campestris* ssp. *pacifica*	Pacific wormwood	Asteraceae	ARCAP2	ARTCAM	1
Forb	*Artemisia carruthii*	Carruth's sagewort	Asteraceae	ARCA14	ARTCAR	571
Forb	*Artemisia dracunculus*	tarragon	Asteraceae	ARDR4	ARTDRA	110
Forb	*Artemisia ludoviciana*	white sagebrush	Asteraceae	ARLU	ARTLUD	37
Forb	*Artemisia* spp.	sagewort, sagebrush	Asteraceae	ARTEM	ARTEMI	1
Forb	*Asclepias asperula*	spider milkweed	Asclepiadaceae	ASAS	ASCASP	13
Forb	*Asclepias macrotis*	longhood milkweed	Asclepiadaceae	ASMA	ASCMAC	1
Forb	*Asclepias subverticillata*	whorled milkweed	Asclepiadaceae	ASSU2	ASCSUB	2
Forb	*Asclepias tuberosa* ssp. *interior*	butterfly milkweed	Asclepiadaceae	ASTUI	ASCTUB	1
Forb	*Asplenium septentrionale*	forked spleenwort	Aspleniaceae	ASSE	ASPSEP	7
Forb	*Asplenium trichomanes*	maidenhair spleenwort	Aspleniaceae	ASTR2	ASPTRI	1
Forb	*Astragalus calycosus*	Torrey's milkvetch	Fabaceae	ASCA9	ASTCAL	2
Forb	*Astragalus ceramicus* var. *filifolius*	painted milkvetch	Fabaceae	ASCEF	ASTCER	1
Forb	*Astragalus egglestonii*	Eggleston's milkvetch	Fabaceae	ASEG	ASTEGG	4
Forb	*Astragalus humistratus*	groundcover milkvetch	Fabaceae	ASHU2	ASTHUM2	1
Forb	*Astragalus humistratus* var. *humivagans*	groundcover milkvetch	Fabaceae	ASHUH2	ASTHUM2	1
Forb	*Astragalus mollissimus*	woolly milkvetch	Fabaceae	ASMO7	ASTMOL	3
Forb	*Astragalus* spp.	milkvetch	Fabaceae	ASTRA	ASTRAG	11
Forb	*Bahia dissecta*	ragleaf bahia	Asteraceae	BADI	BAHDIS	154
Forb	*Boechera fendleri*	Fendler's rockcress	Brassicaceae	BOFE	BOEFEN	12
Forb	*Boechera fendleri* × *pallidifolia*	Fendler's rockcress hybrid	Brassicaceae		BOEFENP	56
Forb	*Boerhavia linearifolia*	Narrowleaf spiderling	Nyctaginaceae	BOLI2	BOELIN	1
Forb	*Brassicaceae*	mustard family	Brassicaceae	BRASSI	BRASSI2	1

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Forb	*Brickellia brachyphylla*	plumed brickellbush	Asteraceae	BRBR2	BRIBRA	83
Forb	*Castilleja integra*	wholeleaf Indian paint-brush	Scrophulariaceae	CAIN14	CASINT	21
Forb	*Castilleja linariifolia*	Wyoming Indian paint-brush	Scrophulariaceae	CALI4	CASLIN	1
Forb	*Chaetopappa ericoides*	rose heath	Asteraceae	CHER2	CHAERI	93
Forb	*Chamaesaracha coronopus*	greenleaf five eyes	Solanaceae	CHCO2	CHACOR	10
Forb	*Chamaesaracha* spp.	five eyes	Solanaceae	CHAMA8	CHAMAE	3
Forb	*Chamaesyce chaetocalyx*	bristlecup sandmat	Euphorbiaceae	CHCH5	CHACHA	2
Forb	*Chamaesyce fendleri*	Fendler's sandmat	Euphorbiaceae	CHFE3	CHAFEN	12
Forb	*Chamaesyce maculata*	spotted spurge	Euphorbiaceae	CHMA15	CHAMAC	2
Forb	*Chamaesyce revoluta*	threadstem sandmat	Euphorbiaceae	CHRE4	CHAREV	1
Forb	*Chamaesyce serpyllifolia*	thymeleaf sandmat	Euphorbiaceae	CHSE6	CHASER2	67
Forb	*Chamaesyce* spp.	sandmat	Euphorbiaceae	CHAMA15	CHAMAE2	3
Forb	*Cheilanthes feei*	slender lipfern	Pteridaceae	CHFE	CHEFEE	1
Forb	*Cheilanthes fendleri*	Fendler's lipfern	Pteridaceae	CHFE2	CHEFEN	4
Forb	*Chenopodium fremontii*	Fremont's goosefoot	Chenopodiaceae	CHFR3	CHEFRE	9
Forb	*Chenopodium graveolens*	fetid goosefoot	Chenopodiaceae	CHGR2	CHEGRA	113
Forb	*Chenopodium leptophyllum*	narrowleaf goosefoot	Chenopodiaceae	CHLE4	CHELEP	20
Forb	*Chenopodium neomexicanum*	New Mexico goosefoot	Chenopodiaceae	CHNE3	CHENEO	1
Forb	*Chenopodium pratericola*	desert goosefoot	Chenopodiaceae	CHPR5	CHEPRA	2
Forb	*Chenopodium* spp.	goosefoot	Chenopodiaceae	CHENO	CHENOP	128
Forb	*Chenopodium watsonii*	Watson's goosefoot	Chenopodiaceae	CHWA	CHEWAT	1
Forb	*Cirsium neomexicana*	New Mexico thistle	Asteraceae	CINE	CIRNEO	2
Forb	*Cirsium ochrocentrum* var. *ochrocentrum*	yellowspine thistle	Asteraceae	CIOCO2	CIROCH	2
Forb	*Cirsium* spp.	thistle	Asteraceae	CIRSI	CIRSIU	5
Forb	*Cirsium undulatum*	wavyleaf thistle	Asteraceae	CIUN	CIRUND	5
Forb	*Cirsium wheeleri*	Wheeler's thistle	Asteraceae	CIWH	CIRWHE	1
Forb	*Cleome serrulata*	Rocky Mountain beeplant	Capparaceae	CLSE	CLESER	2
Forb	*Commelina dianthifolia*	birdbill dayflower	Commelinaceae	CODI4	COMDIA	36
Forb	*Commelina dianthifolia* var. *longispatha*	birdbill dayflower	Commelinaceae	CODIL	COMDIA	1

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Forb	*Conopholis alpina*	alpine cancer-root	Orobanchaceae	COAL6	CONALP	1
Forb	*Convolvulus arvensis*	field bindweed	Convolvulaceae	COAR4	CONARV	3
Forb	*Conyza canadensis*	Canadian horseweed	Asteraceae	COCA5	CONCAN	2
Forb	*Cordylanthus wrightii*	Wright's birdbeak	Scrophulariaceae	COWR2	CORWRI	1
Forb	*Cryptantha cinerea*	James' catseye	Boraginaceae	CRCI3	CRYCIN	24
Forb	*Cryptantha cinerea* var. *cinerea*	James' catseye	Boraginaceae	CRCIC	CRYCIN	1
Forb	*Cryptantha crassisepala*	hiddenflower	Boraginaceae	CRCR3	CRYCRA	1
Forb	*Cryptantha fendleri*	sanddune cryptantha	Boraginaceae	CRFE3	CRYFEN	5
Forb	*Cuscuta* spp.	dodder	Cuscutaceae	CUSCU	CUSCUT	6
Forb	*Cuscuta umbellata*	flatglobe dodder	Cuscutaceae	CUUM	CUSUMB	2
Forb	*Dalea candida*	slender white prairie-clover	Fabaceae	DACA7	DALCAN	1
Forb	*Dalea candida* var. *oligophylla*	white prairieclover	Fabaceae	DACAO	DALCAN	2
Forb	*Dalea lanata*	woolly prairieclover	Fabaceae	DALA3	DALLAN	1
Forb	*Dalea polygonoides*	sixweeks prairie clover	Fabaceae	DAPO3	DALPOL	8
Forb	*Dalea* spp.	prairieclover	Fabaceae	DALEA	DALEA	1
Forb	*Descurainia obtusa* ssp. *obtusa*	blunt tansymustard	Brassicaceae	DEOBO	DESOBT	3
Forb	*Descurainia pinnata*	western tanseymustard	Brassicaceae	DEPI	DESPIN	2
Forb	*Descurainia* spp.	tansymustard	Brassicaceae	DESCU	DESCUR	4
Forb	*Dieteria canescens*	hoary aster	Asteraceae	MACA2	DIECAN	4
Forb	*Dimorphocarpa wislizeni*	spectacle pod	Brassicaceae	DIWI2	DIMWIS	72
Forb	*Drymaria glandulosa*	fendler's drymary	Caryophyllaceae	DRGL5	DRYGLA	6
Forb	*Drymaria molluginea*	slimleaf drymary	Caryophyllaceae	DRMO2	DRYMOL	1
Forb	*Dryopteris filix-mas*	male fern	Dryopteridaceae	DRFI2	DRYFIL	1
Forb	*Dyssodia papposa*	fetid marigold	Asteraceae	DYPA	DYSPAP	7
Forb	*Echeandia flavescens*	Torrey's craglily	Liliaceae	ECFL	ECHFLA	11
Forb	*Eremogone fendleri*	Fendler's sandwort	Caryophyllaceae	ERFE3	AREFEN	3
Forb	*Erigeron aphanactis*	rayless shaggy fleabane	Asteraceae	ERAP	ERIAPH	1
Forb	*Erigeron bellidiastrum* var. *bellidiastrum*	western daisy fleabane	Asteraceae	ERBEB	ERIBEL	2
Forb	*Erigeron canus*	hoary fleabane	Asteraceae	ERCA4	ERICAN	1
Forb	*Erigeron divergens*	spreading fleabane	Asteraceae	ERDI4	ERIDIV	60

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Forb	*Erigeron flagellaris*	trailing fleabane	Asteraceae	ERFL	ERIFLA	35
Forb	*Erigeron formosissimus*	beautiful fleabane	Asteraceae	ERFO3	ERIFOR	23
Forb	*Erigeron speciosus*	aspen fleabane	Asteraceae	ERSP4	ERISPE	9
Forb	*Erigeron* spp.	fleabane	Asteraceae	ERIGE2	ERIGER	36
Forb	*Eriogonum alatum*	winged buckwheat	Polygonaceae	ERAL4	ERIALA	16
Forb	*Eriogonum annuum*	annual buckwheat	Polygonaceae	ERAN4	ERIANN	1
Forb	*Eriogonum cernuum*	nodding buckwheat	Polygonaceae	ERCE2	ERICER	2
Forb	*Eriogonum jamesii*	James' buckwheat	Polygonaceae	ERJA	ERIJAM	199
Forb	*Eriogonum polycladon*	sorrel buckwheat	Polygonaceae	ERPO4	ERIPOL	1
Forb	*Eriogonum racemosum*	redroot buckwheat	Polygonaceae	ERRA3	ERIRAC	30
Forb	*Eriogonum* spp.	buckwheat	Polygonaceae	ERIOG	ERIOGO	1
Forb	*Erodium cicutarium*	redstem stork's bill	Geraniaceae	ERCI6	EROCIC	4
Forb	*Erysimum capitatum*	sanddune wallflower	Brassicaceae	ERCA14	ERYCAP	7
Forb	*Euphorbia exstipulata*	squareseed spurge	Euphorbiaceae	EUEX4	EUPEXS	1
Forb	*Euphorbia palmeri*	woodland spurge	Euphorbiaceae	EUPA4	EUPPAL	7
Forb	*Evolvulus nuttallianus*	shaggy dwarf morning-glory	Convolvulaceae	EVNU	EVONUT	1
Forb	*Fragaria vesca*	woodland strawberry	Rosaceae	FRVE	FRAVES	1
Forb	*Froelichia gracilis*	slender snakecotton	Amaranthaceae	FRGR3	FROGRA	3
Forb	*Funastrum cynanchoides*	fringed twinevine	Asclepiadaceae	FUCY	FUNCYN	2
Forb	*Gaura coccinea*	scarlet beeblossom	Onagraceae	GACO5	GAUCOC	5
Forb	*Gaura hexandra* ssp. *gracilis*	harlequinbush	Onagraceae	GAHEG	GAUHEX	4
Forb	*Gaura* spp.	beeblossom	Onagraceae	GAURA	GAURA	1
Forb	*Gayophytum ramosissimum*	pinyon groundsmoke	Onagraceae	GARA2	GAYRAM	1
Forb	*Geranium caespitosum*	pineywoods geranium	Geraniaceae	GECA3	GERCAE	9
Forb	*Geranium lentum*	Mogollon geranium	Geraniaceae	GELE	GERLEN	75
Forb	*Glandularia bipinnatifida*	Dakota mock vervain	Verbenaceae	GLBI2	GLABIP	122
Forb	*Glandularia bipinnatifida* var. *ciliata*	Davis Mountain mock vervain	Verbenaceae	GLBIC	GLABIP	1
Forb	*Grindelia squarrosa*	curlycup gumweed	Asteraceae	GRSQ	GRISQU	18
Forb	*Hedeoma drummondii*	Drummond's false pen-nyroyal	Lamiaceae	HEDR	HEDDRU	9
Forb	*Helianthella parryi*	Parry's dwarf-sunflower	Asteraceae	HEPA	HELPAR2	2

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Forb	*Helianthus petiolaris*	prairie sunflower	Asteraceae	HEPE	HELPET	13
Forb	*Helianthus* spp.	common sunflower	Asteraceae	HELIA3	HELIAN	3
Forb	*Heliomeris longifolia* var. *annua*	longleaf falsegoldeneye	Asteraceae	HELOA2	HELLON	1
Forb	*Heliomeris multiflora*	showy goldeneye	Asteraceae	HEMU3	HELMUL	61
Forb	*Heterosperma pinnatum*	wingpetal	Asteraceae	HEPI2	HETPIN	22
Forb	*Heterotheca villosa*	hairy goldenaster	Asteraceae	HEVI4	HETVIL	472
Forb	*Hieracium fendleri*	yellow hawkweed	Asteraceae	HIFE	HIEFEN	8
Forb	*Houstonia wrightii*	pygmy bluet	Rubiaceae	HOWR	HOUWRI	6
Forb	*Hymenopappus filifolius*	fineleaf hymenopappus	Asteraceae	HYFI	HYMFIL	55
Forb	*Hymenopappus filifolius* var. *cinereus*	fineleaf hymenopappus	Asteraceae	HYFIC	HYMFIL	8
Forb	*Hymenopappus flavescens*	collegeflower	Asteraceae	HYFL	HYMFLA	2
Forb	*Hymenopappus flavescens* var. *canotomentosus*	collegeflower	Asteraceae	HYFLC	HYMFLA	2
Forb	*Hymenopappus* spp.	Hymenopappus	Asteraceae	HYMEN4	HYMENO2	1
Forb	*Hymenoxys bigelovii*	Bigelow's rubberweed	Asteraceae	HYBI2	HYMBIG	1
Forb	*Hymenoxys richardsonii*	pingue hymenoxys	Asteraceae	HYRI	HYMRIC	118
Forb	*Hymenoxys richardsonii* var. *floribunda*	Colorado rubberweed	Asteraceae	HYRIF	HYMRIC	1
Forb	*Hymenoxys* spp.	rubberweed	Asteraceae	HYMEN7	HYMENO	17
Forb	*Ipomoea costellata*	crestrib morningglory	Convolvulaceae	IPCO2	IPOCOS	6
Forb	*Ipomoea cristulata*	transpecos morningglory	Convolvulaceae	IPCR	IPOCRI	3
Forb	*Ipomoea plummerae*	Plummer's morning-glory	Convolvulaceae	IPPL	IPOPLU	3
Forb	*Ipomopsis aggregata*	skyrocket gilia	Polemoniaceae	IPAG	IPOAGG	41
Forb	*Ipomopsis aggregata* ssp. *ag-gregata*	skyrocket gilia	Polemoniaceae	IPAGA3	IPOAGG	1
Forb	*Ipomopsis longiflora*	flaxflowered ipomopsis	Polemoniaceae	IPLO2	IPOLON	10
Forb	*Ipomopsis multiflora*	manyflowered gilia	Polemoniaceae	IPMU3	IPOMUL	4
Forb	*Ipomopsis* spp.	gilia	Polemoniaceae	IPOMO2	IPOMOP	1
Forb	*Iris missouriensis*	Rocky Mountain iris	Iridaceae	IRMI	IRIMIS	1
Forb	*Kallstroemia parviflora*	warty caltrop	Zygophyllaceae	KAPA	KALPAR	1
Forb	*Kochia scoparia*	common kochia	Chenopodiaceae	BASC5	KOCSCO	58
Forb	*Krameria lanceolata*	trailing krameria	Krameriaceae	KRLA	KRALAN	8

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Forb	*Lactuca serriola*	prickly lettuce	Asteraceae	LASE	LACSER	1
Forb	*Laennecia* spp.	laennicia	Asteraceae	LAENN	LAENNE	1
Forb	*Lappula occidentalis*	flatspine stickseed	Boraginaceae	LAOC3	LAPOCC	4
Forb	*Lappula occidentalis* var. *cupu-lata*	flatspine stickseed	Boraginaceae	LAOCC	LAPOCC	1
Forb	*Lathyrus* spp.	peavine	Fabaceae	LATHY	LATHYR	1
Forb	*Limonium limbatum*	Transpecos sealavender	Plumbaginaceae	LILI4	LIMLIM	1
Forb	*Linum australe* var. *australe*	southern flax	Linaceae	LIAUA	LINAUS	8
Forb	*Linum lewisii*	prairie flax	Linaceae	LILE3	LINLEW	7
Forb	*Linum neomexicanum*	New Mexico yellow flax	Linaceae	LINE	LINNEO	6
Forb	*Lithospermum multiflorum*	manyflowered gromwell	Boraginaceae	LIMU3	LITMUL	25
Forb	*Lithospermum* spp.	gromwell	Boraginaceae	LITHO3	LITHOS	3
Forb	*Lotus wrightii*	Wright's deervetch	Fabaceae	LOWR	LOTWRI	75
Forb	*Lupinus kingii*	King's lupine	Fabaceae	LUKI	LUPKIN	23
Forb	*Lupinus* spp.	lupine	Fabaceae	LUPIN	LUPINU	1
Forb	*Machaeranthera* spp.	tansyaster	Asteraceae	MACHA	MACHAE	1
Forb	*Machaeranthera tanacetifolia*	tanseyleaf aster	Asteraceae	MATA2	MACTAN	15
Forb	*Marrubium vulgare*	horehound	Lamiaceae	MAVU	MARVUL	4
Forb	*Melilotus officinalis*	yellow sweetclover	Fabaceae	MEOF	MELOFF	2
Forb	*Mentzelia multiflora*	manyflowered mentzelia	Loasaceae	MEMU3	MENMUL	2
Forb	*Mentzelia multiflora* var. *mul-tiflora*	Adonis blazingstar	Loasaceae	MEMUM2	MENMUL	1
Forb	*Mentzelia rusbyi*	Rusby's blazingstar	Loasaceae	MERU	MENRUS	3
Forb	*Mentzelia* spp.	mentzelia	Loasaceae	MENTZ	MENTZE	3
Forb	*Microsteris gracilis*	slender phlox	Polemoniaceae	MIGR	MICGRA	1
Forb	*Mirabilis albida*	white four o'clock	Nyctaginaceae	MIAL4	MIRABI	12
Forb	*Mirabilis glabra*	smooth four o'clock	Nyctaginaceae	MIGL3	MIRGLA	2
Forb	*Mirabilis linearis*	narrowleaf four o'clock	Nyctaginaceae	MILI3	MIRLIN	15
Forb	*Mirabilis multiflora*	Colorado four o'clock	Nyctaginaceae	MIMU	MIRMUL	95
Forb	*Mirabilis oxybaphoides*	smooth spreading four o'clock	Nyctaginaceae	MIOX	MIROXY	32
Forb	*Mirabilis* spp.	four o'clock	Nyctaginaceae	MIRAB	MIRABI	6
Forb	*Mollugo cerviana*	threadstem carpetweed	Molluginaceae	MOCE	MOLCER	3

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of obser-vations
Forb	*Monarda pectinata*	pony beebalm	Lamiaceae	MOPE	MONPEC	2
Forb	*Monarda punctata* var. *occidentalis*	spotted beebalm	Lamiaceae	MOPUO	MONPUN	1
Forb	*Monarda* spp.	beebalm	Lamiaceae	MONAR	MONARD	1
Forb	*Nama dichotomum*	wishbone fiddleleaf	Hydrophyllaceae	NADI	NAMDIC	8
Forb	*Noccaea montanum* var. *montanum*	alpine pennycress	Brassicaceae	NOMOM	NOCMON	8
Forb	*Oenothera caespitosa*	tufted eveningprimrose	Onagraceae	OECA10	OENCAE	6
Forb	*Oenothera pallida* ssp. *runcinata*	pale eveningprimrose	Onagraceae	OEPAR	OENPAL	2
Forb	*Oenothera* spp.	eveningprimrose	Onagraceae	OENOT	OENOTH	2
Forb	*Oxalis alpina*	alpine woodsorrel	Oxalidaceae	OXAL2	OXAALP	17
Forb	*Oxalis* spp.	woodsorrel	Oxalidaceae	OXALI	OXALIS	3
Forb	*Packera cynthioides*	White Mountain ragwort	Asteraceae	PACY9	PACCYN	2
Forb	*Packera fendleri*	Fendler's ragwort	Asteraceae	PAFE4	PACFEN	1
Forb	*Packera multilobata*	lobeleaf groundsel	Asteraceae	PAMU11	PACMUL	13
Forb	*Packera neomexicana*	New Mexico groundsel	Asteraceae	PANE7	PACNEO	37
Forb	*Packera neomexicana* var. *mutabilis*	New Mexico groundsel	Asteraceae	PANEM	PACNEO	12
Forb	*Packera* spp.	ragwort	Asteraceae	PACKE	PACKER	6
Forb	*Pennellia micrantha*	mountain mock thelypody	Brassicaceae	PEMI7	PENMIC	5
Forb	*Penstemon barbatus*	beardlip penstemon	Scrophulariaceae	PEBA2	PENBAR	29
Forb	*Penstemon* spp.	beardtongue	Scrophulariaceae	PENST	PENSTE	1
Forb	*Pericome caudata*	mountain leaftail	Asteraceae	PECA10	PERCAU	26
Forb	*Peteria scoparia*	rush peteria	Fabaceae	PESC3	PETSCO	1
Forb	*Phacelia alba*	white phacelia	Hydrophyllaceae	PHAL9	PHAALB	1
Forb	*Phacelia coerulea*	skyblue scorpionweed	Hydrophyllaceae	PHCO	PHACOE	1
Forb	*Phacelia serrata*	cinders phacelia	Hydrophyllaceae	PHSE5	PHASER2	10
Forb	*Phacelia* spp.	phacelia	Hydrophyllaceae	PHACE	PHACEL	3
Forb	*Phaseolus angustissimus*	slimleaf bean	Fabaceae	PHAN3	PHAANG	2
Forb	*Phaseolus* spp.	bean	Fabaceae	PHASE	PHASEO	1
Forb	*Phemeranthus brevicaulis*	dwarf fameflower	Portulacaceae	PHBR15	PHEBRE	3
Forb	*Phemeranthus parviflorus*	sunbright	Portulacaceae	PHPA29	PHEPAR	41
Forb	*Phemeranthus* spp.	flameflower	Portulacaceae	PHEME	PHEMER	4

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of obser-vations
Forb	*Physalis hederifolia* var. *fendleri*	Fendler's groundcherry	Solanaceae	PHHEF	PHYHED	7
Forb	*Physalis subulata* var. *neomexicana*	New Mexican ground-cherry	Solanaceae	PHSUN	PHYSUB	4
Forb	*Physaria rectipes*	straight bladderpod	Brassicaceae	LERE3	PHYREC	22
Forb	*Plantago argyrea*	saltmeadow plantain	Plantaginaceae	PLAR9	PLAARG	8
Forb	*Plantago* spp.	plantain	Plantaginaceae	PLANT	PLANTA	1
Forb	*Polygala alba*	white milkwort	Polygalaceae	POAL4	POLALB	4
Forb	*Polygonum douglasii* ssp. *johnstonii*	Johnston's knotweed	Polygonaceae	PODOJ2	POLDOU	7
Forb	*Polygonum erectum*	erect knotweed	Polygonaceae	POER2	POLERE	8
Forb	*Pomaria jamesii*	James's hog-potato	Fabaceae	POJA5	POMJAM	2
Forb	*Portulaca halimoides*	silkcotton purslane	Portulacaceae	POHA5	PORHAL	26
Forb	*Portulaca oleracea*	common purslane	Portulacaceae	POOL	POROLE	127
Forb	*Portulaca* spp.	hogweed	Portulacaceae	PORTU	PORTUL	3
Forb	*Potentilla crinita*	bearded cinquefoil	Rosaceae	POCR4	POTCRI2	2
Forb	*Potentilla hippiana*	woolly cinquefoil	Rosaceae	POHI6	POTHIP	12
Forb	*Potentilla pensylvanica*	Pennsylvania cinquefoil	Rosaceae	POPE8	POTPEN	3
Forb	*Potentilla subviscosa*	Navajo cinquefoil	Rosaceae	POSU6	POTSUB	2
Forb	*Pseudocymopterus montanus*	alpine false springparsley	Apiaceae	PSMO	PSEMON	23
Forb	*Pseudognaphalium macounii*	Macoun's cudweed	Asteraceae	PSMA11	PSEMAC	3
Forb	*Pseudognaphalium* spp.	cudweed	Asteraceae	PSEUD43	PSEUDO2	2
Forb	*Psilostrophe tagetina*	woolly paperflower	Asteraceae	PSTA	PSITAG	26
Forb	*Psoralidium tenuiflorum*	slimflower scurfpea	Fabaceae	PSTE5	PSOTEN	16
Forb	*Pteridium aquilinum*	western brackenfern	Dennstaedtiaceae	PTAQ	PTEAQU	1
Forb	*Ratibida columnifera*	upright prairie cone-flower	Asteraceae	RACO3	RATCOL	2
Forb	*Rumex* spp.	dock	Polygonaceae	RUMEX	RUMEX	1
Forb	*Salsola collina*	slender Russian thistle	Chenopodiaceae	SACO8	SALCOL	1
Forb	*Salsola tragus*	prickly Russian thistle	Chenopodiaceae	SATR12	SALTRA	125
Forb	*Salvia reflexa*	lanceleaf sage	Lamiaceae	SARE3	SALREF	8
Forb	*Salvia subincisa*	sawtooth sage	Lamiaceae	SASU7	SALSUB	19
Forb	*Sanvitalia abertii*	Albert's creeping zinnia	Asteraceae	SAAB	SANABE	27
Forb	*Schkuhria multiflora*	manyflower false thread-leaf	Asteraceae	SCMU6	SCHMUL	20

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of obser- vations
Forb	*Schoenocrambe linearifolia*	slimleaf plainsmustard	Brassicaceae	SCLI12	SCHLIN	52
Forb	*Selaginella mutica* var. *mutica*	bluntleaf spikemoss	Selaginellaceae	SEMUM	SELMUT	1
Forb	*Senecio flaccidus*	threadleaf ragwort	Asteraceae	SEFL3	SENFLA	9
Forb	*Senecio flaccidus* var. *flaccidus*	threadleaf ragwort	Asteraceae	SEFLF	SENFLA	7
Forb	*Senecio spartioides*	broom groundsel	Asteraceae	SESP3	SENSPA	2
Forb	*Senecio wootonii*	Wooton's ragwort	Asteraceae	SEWO	SENWOO	1
Forb	*Silene antirrhina*	sleepy silene	Caryophyllaceae	SIAN2	SILANT	1
Forb	*Silene laciniata*	Mexican campion	Caryophyllaceae	SILA2	SILLAC	5
Forb	*Silene scouleri* ssp. *pringlei*	Pringle's campion	Caryophyllaceae	SISCP	SILSCO	1
Forb	*Solanum elaeagnifolium*	silverleaf nightshade	Solanaceae	SOEL	SOLELA	1
Forb	*Solanum fendleri*	Fendler's horsenettle	Solanaceae	SOFE	SOLFEN	2
Forb	*Solanum jamesii*	wild potato	Solanaceae	SOJA	SOLJAM	47
Forb	*Solidago missouriensis*	Missouri goldenrod	Asteraceae	SOMI2	SOLMIS	1
Forb	*Solidago mollis*	velvety goldenrod	Asteraceae	SOMO	SOLMOL	1
Forb	*Solidago* spp.	goldenrod	Asteraceae	SOLID	SOLIDA	15
Forb	*Solidago velutina* ssp. *sparsiflora*	threenerve goldenrod	Asteraceae	SOSP5	SOLVEL	1
Forb	*Solidago wrightii*	Wright's goldenrod	Asteraceae	SOWR	SOLWRI	5
Forb	*Sphaeralcea coccinea*	scarlet globemallow	Malvaceae	SPCO	SPHCOC	244
Forb	*Sphaeralcea digitata*	slippery globemallow	Malvaceae	SPDI3	SPHDIG	5
Forb	*Sphaeralcea fendleri*	Fendler's globemallow	Malvaceae	SPFE	SPHFEN	91
Forb	*Sphaeralcea* spp.	globemallow	Malvaceae	SPHAE	SPHAER	58
Forb	*Stephanomeria pauciflora*	brownplume wirelettuce	Asteraceae	STPA4	STEPAU	11
Forb	*Taraxacum officinale*	common dandelion	Asteraceae	TAOF	TAROFF	2
Forb	*Tetraneuris argentea*	perkysue	Asteraceae	TEAR4	TETARG	17
Forb	*Tetraneuris scaposa*	stemmy four-nerve daisy	Asteraceae	TESC2	TETSCA	3
Forb	*Thalictrum fendleri*	Fendler's meadowrue	Ranunculaceae	THFE	THAFEN	20
Forb	*Thelesperma megapotamicum*	Hopi tea greenthread	Asteraceae	THME	THEMEG	12
Forb	*Thelesperma* spp.	greenthread	Asteraceae	THELE	THELES	1
Forb	*Thermopsis montana* var. *montana*	mountain goldenbanner	Fabaceae	THMOM3	THE-MONM	2
Forb	*Tradescantia occidentalis*	prairie spiderwort	Commelinaceae	TROC	TRAOCC	15
Forb	*Tradescantia occidentalis* var. *occidentalis*	prairie spiderwort	Commelinaceae	TROCO	TRAOCC	2

Life form	Scientific name	Common name	Family	NHNM acronym	PLANTS symbol	# of obser-vations
Forb	*Tragia ramosa*	branched noseburn	Euphorbiaceae	TRRA5	TRARAM	14
Forb	*Tragopogon dubius*	yellow salsify	Asteraceae	TRDU	TRADUB	1
Forb	*Tragopogon pratensis*	meadow salsify	Asteraceae	TRPR	TRAPRA	1
Forb	*Verbascum thapsus*	common mullein	Scrophulariaceae	VETH	VERTHA	56
Forb	*Verbesina encelioides*	golden crownbeard	Asteraceae	VEEN	VERENC	2
Forb	*Vicia americana*	American vetch	Fabaceae	VIAM	VICAME	3
Forb	*Viguiera cordifolia*	heartleaf goldeneye	Asteraceae	VICO	VIGCOR	6
Forb	*Woodsia neomexicana*	New Mexico cliff fern	Dryopteridaceae	WONE	WOONEO	4
Forb	*Woodsia plummerae*	Plummer's cliff fern	Dryopteridaceae	WOPL	WOOPLU	6
Forb	*Woodsia* spp.	cliff fern	Dryopteridaceae	WOODS	WOODSI	1
Forb	*Wyethia scabra*	badlands wyethia	Asteraceae	WYSC	WYESCA	1
Forb	*Xanthisma gracile*	slender goldenweed	Asteraceae	MAGR10	XANGRA	4
Forb	*Xanthisma spinulosum*	lacy tansyaster	Asteraceae	MAPI	XANSPI2	26
Forb	*Xanthium strumarium*	rough cocklebur	Asteraceae	XAST	XANSTR	1
Forb	*Zinnia grandiflora*	Rocky Mountain zinnia	Asteraceae	ZIGR	ZINGRA	6

Appendix C: Plant Association Key

The dichotomous keys to plant associations of El Malpais National Monument below use 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., forests and 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 bare ground, rocks and/or boulders with total vegetation cover <5% or dominated by lithomorphic species: **KEY 4—Lithmorphic Vegetation, sparse vegetation and other land cover types** (page C6)

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

B. Trees dominant, typically >25% canopy cover; or if <25%, clearly the dominant and/or the characteristic growth form (usually >10% cover): **KEY 1—Forests and Woodlands** (page C1)

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

C. Shrubs >25%, or if <25%, clearly the dominant and/or the characteristic growth form (usually >10% cover): **KEY 2—Shrublands (page C5)**

C. Shrubs <25%, herbs clearly the dominant and/or characteristic growth form: **KEY 3—Herbaceous Vegetation** (page C5)

KEY 1—Forests and Woodlands

1. *Populus tremuloides* dominant, >75% relative cover: **Forest Sub-key I. *Populus tremuloides* Forests**

1. *Populus tremuloides* codominant, subordinate, or absent, <75% relative cover: (2)

2 (1). *Pseudotsuga menziesii* dominant or codominant, usually >25% relative cover: **Forest Sub - key II. *Pseudotsuga menziesii* Forests**

2. *Pseudotsuga menziesii* subordinate or absent, usually <25% relative cover: (3)

3 (2). *Pinus ponderosa* dominant or codominant, usually >25% relative cover: **Forest Sub-key III. *Pinus ponderosa* Forests**

3. *Pinus ponderosa* subordinate or absent, usually <25% relative cover, and *Pinus edulis*, *Juniperus monosperma*, or *Juniperus scopulorum* dominant or codominant: **Forest Sub-key IV. *Pinus edulis* and *Juniperus* sp. Woodlands**

Forest Sub-key I. *Populus tremuloides* Forests

1. *Ribes cereum* common, usually the dominant shrub; *Ribes leptanthum* accidental or absent, sites usually on lava flows: ***Populus tremuloides / Ribes cereum* Forest**

1. *Ribes cereum* uncommon or absent, mixture of other shrubs often well represented (e.g., *Prunus virginiana*, *Ribes leptanthum*); sites usually on cinder cones: ***Populus tremuloides* / Mixed Shrubs Cinder Woodland**

Forest Sub-key II. *Pseudotsuga menziesii* Forests

1. *Holodiscus dumosus* well represented, the dominant shrub: ***Pseudotsuga menziesii / Holodiscus dumosus* Lava flow Woodland**

1. *Holodiscus dumosus* poorly represented, clearly the subordinate shrub or absent: (2)

2 (1). *Ribes leptanthum* dominant: ***Pseudotsuga menziesii / Ribes leptanthum* Forest**

2. *Ribes leptanthum* scarce or absent: (3)

3 (2). *Quercus gambelii* well represented: ***Pseudotsuga menziesii - Quercus gambelii* Forest**

3. *Quercus gambelii* poorly represented or absent: ***Pseudotsuga menziesii / Muhlenbergia montana* Forest**

Forest Sub-key III. *Pinus ponderosa* Forests

1. Shrubs well represented, typically greater than 10% cover: (2)

1. Shrubs poorly represented, understory grass dominated or very sparse: (6)

2 (1). *Quercus gambelii* well represented, the dominant shrub: ***Pinus ponderosa - Quercus gambelii* Woodland**

2. *Quercus gambelii* poorly represented or absent: (3)

3 (2). *Quercus* × *pauciloba* common to well represented, the dominant shrub: ***Pinus ponderosa / Quercus × pauciloba* Woodland**

3. *Quercus* ×*pauciloba* scarce and accidental, or absent: (4)

4 (3). *Artemisia filifolia* well represented, the dominant shrub: ***Pinus ponderosa / Artemisia filifolia* Forest**

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

5 (4). *Ribes cereum* and/or *Holodiscus dumosus* common: ***Pinus ponderosa / Fallugia paradoxa - Ribes cereum* Forest**

5. *Ribes cereum* and *Holodiscus dumosus* accidental or absent: ***Pinus ponderosa / Fallugia paradoxa* Woodland**

6 (1). *Festuca arizonica* well represented: ***Pinus ponderosa / Festuca arizonica* Woodland**

6. *Festuca arizonica* uncommon and accidental, or absent: (7)

7 (6). *Sporobolus cryptandrus* well represented, dominant: ***Pinus ponderosa / Sporobolus cryptandrus* Forest**

7. *Sporobolus cryptandrus* poorly represented or absent: (8)

8 (7). *Bouteloua gracilis* or *B. curtipendula* well represented to abundant, dominant or codominant grass: ***Pinus ponderosa / Bouteloua gracilis* Woodland**

8. *Bouteloua gracilis* poorly represented, subordinate, or absent: (9)

9 (8). *Muhlenbergia montana* common, dominant or codominant: ***Pinus ponderosa / Muhlenbergia montana* Woodland**

9. *Muhlenbergia montana* uncommon, accidental, or absent: (10)

10 (9). *Schizachyrium scoparium* common, dominant: ***Pinus ponderosa / Schizachyrium scoparium* Woodland**

10. *Schizachyrium scoparium* uncommon, accidental or absent: (11)

11 (10). *Poa fendleriana* well represented, dominant: ***Pinus ponderosa / Poa fendleriana* Woodland**

11. *Poa fendleriana* uncommon, accidental or absent; *Carex geophila*, *C. inops* ssp. *heliophila*, *C. rossii,* or *Bouteloua curtipendula* scattered to common; sites tend to be sparse, species poor: ***Pinus ponderosa / C. inops* ssp. *heliophila* Woodland**

Forest Sub-key IV. *Pinus edulis* and *Juniperus* sp. Woodlands

1. *Pinus edulis* well represented, >25% of the total pygmy conifer cover (i.e., relative to *Juniperus* sp.): (2)

1. *Pinus edulis* poorly represented, <25% of the total pygmy conifer cover (i.e., relative to *Juniperus* sp.): (10)

2 (1). Shrubs well represented, typically >10% cover: (3)

2. Shrubs poorly represented, typically <5% cover: (14)

3 (2). *Quercus gambelii* well represented: ***Pinus edulis - Juniperus* spp. / Cinder Woodland**

3. *Quercus gambelii* poorly represented or absent: (4)

4 (3). *Quercus* × *pauciloba* well represented: ***Pinus edulis – Juniperus monosperma / Quercus × pauciloba* Woodland**

4. *Quercus* ×*pauciloba* poorly represented or absent: (5)

5 (4). *Holodiscus dumosus* common, the dominant shrub, or codominant with *Ribes cereum*: ***Pinus edulis - Juniperus scopulorum* / *Holodiscus dumosus* Woodland**

5. *Holodiscus dumosus* uncommon, clearly subordinate to other shrubs, or absent: (6)

6 (5). *Fallugia paradoxa* common to very abundant, the dominant shrub, or codominant with *Rhus trilobata:* ***Pinus edulis - Juniperus* spp. / *Fallugia paradoxa* Woodland**

6. *Fallugia paradoxa* uncommon or absent: (7)

7 (6). *Quercus grisea* well represented: ***Pinus edulis - Juniperus deppeana - Quercus grisea* Woodland**

7. *Quercus grisea* poorly represented or absent: (8)

8 (7). *Achnatherum scribneri* or *Achnatherum perplexum* common to well represented, not accidental: ***Pinus edulis* / *Achnatherum scribneri* Woodland**

8. *Achnatherum scribneri* uncommon, accidental, or absent: (9)

9 (8). *Bouteloua gracilis* usually well - represented to abundant, dominant; at least >25% of the total grass cover (other grasses may include *Poa fendleriana, Elymus elymoides, Koeleria macrantha*, or *Muhlenbergia montana*): ***Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Woodland**

9. *Bouteloua gracilis* uncommon or absent, graminoid cover typically < 1%, understories sparse, low in diversity: ***Pinus edulis (Juniperus* spp.) / Cinder Woodland**

10 (1). Shrubs well represented, typically >10% cover: (11)

10. Shrubs poorly represented, typically <5% cover: (14)

11 (10). *Fraxinus cuspidata* well represented: ***Juniperus monosperma* / *Fraxinus cuspidata* Woodland**

11. *Fraxinus cuspidate* poorly represented or absent: (12)

12 (11). *Holodiscus dumosus* common, the dominant shrub, or codominant with *Ribes cereum; Juniperus scopulorum* typically the dominant conifer: ***Pinus edulis - Juniperus scopulorum* / *Holodiscus dumosus* Woodland**

12. *Holodiscus dumosus* uncommon, clearly subordinate to other shrubs, or absent: (13)

13 (12). *Quercus × pauciloba* well represented: ***Juniperus monosperma* / *Quercus × pauciloba* Woodland**

13. *Quercus × pauciloba* poorly represented or absent; *Fallugia paradoxa* common to very abundant, the dominant shrub, or codominant with *Rhus trilobata* or *Mahonia repens* (can be dominant on rare occasions): ***Juniperus monosperma* / *Fallugia paradoxa* Woodland**

14 (2). *Muhlenbergia pauciflora* well represented and dominant; *Bouteloua gracilis* usually poorly represented; <25% of the total grass cover: ***Juniperus monosperma* / *Muhlenbergia pauciflora* Woodland**

14. *Muhlenbergia pauciflora* poorly represented or absent; *Bouteloua gracilis* usually well represented to abundant, dominant; at least >25% of the total grass cover: (15)

15 (14) *Sporobolus cryptandrus* or other sandy drop seeds common: ***Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus* Woodland**

15. *Sporobolus cryptandrus* uncommon or absent; *Bouteloua eriopoda* and/or *B. gracilis* well represented: ***Juniperus monosperma / Bouteloua gracilis* Woodland**

KEY 2 – Shrublands

1. *Artemisia filifolia* well represented, dominant: ***Artemisia filifolia / Bouteloua (curtipendula, gracilis)* Shrubland**

1. *Artemisia filifolia* uncommon or absent: (2)

2 (1). *Atriplex canescens* well represented, dominant: (3)

2. *Atriplex canescens* scarce or absent: (5)

3 (2). *Panicum obtusum* well represented: ***Atriplex canescens / Panicum obtusum* Shrubland**

3. *Panicum obtusum* poorly represented or absent: (4)

4 (3). *Bouteloua gracilis* or *Pascopyron smithii* well represented: ***Atriplex canescens / Bouteloua gracilis* Shrubland**

4. *Bouteloua gracilis* poorly represented or absent; *Sporobolus airoides* uncommon to common: ***Atriplex canescens / Sporobolus airoides* Shrubland**

5 (2). *Sarcobatus vermiculatus* well represented: ***Sarcobatus vermiculatus / Sporobolus airoides* Shrubland**

5. *Sarcobatus vermiculatus* absent: (6)

6 (5). *Fallugia paradoxa* common to very abundant, dominant, or codominant with *Rhus trilobata* or *Ribes cereum*: (7)

6. *Fallugia paradoxa* uncommon or absent: (8)

7 (6). *Rhus trilobata* or *Ribes cereum* present: ***Fallugia paradoxa - Rhus trilobata* Shrubland**

7. *Rhus trilobata* or *Ribes cereum* absent: ***Fallugia paradoxa* / Rockland Shrubland**

8 (6). *Rhus trilobata* or *Ribes cereum* common: ***Rhus trilobata - Ribes cereum* Shrubland**

8. *Rhus trilobata* or *Ribes cereum* scarce or absent; *Ericameria nauseosa* well represented to abundant: ***Ericameria nauseosa / Bouteloua gracilis* Shrub Herbaceous Vegetation**

KEY 3 – Herbaceous Vegetation

1. *Sporobolus airoides* abundant, clear dominant: ***Sporobolus airoides* / Monotypic Herbaceous Vegetation**.

1. *Sporobolus airoides* poorly represented: (2)

2 (1). *Pascopyrum smithii* well represented to abundant, dominant, or codominant: (3)

2. *Pascopyrum smithii* poorly represented or absent: (4)

3 (2). *Grindelia squarrosa* common to abundant: ***Pascopyrum smithii / Grindelia squarrosa* Herbaceous Vegetation**

3. *Grindelia squarrosa* poorly represented or absent; *B. gracilis* usually codominant: ***Pascopyrum smithii - Bouteloua gracilis* Herbaceous Vegetation**

4 (2). *Krascheninnikovia lanata* well represented, dominant shrub: ***Krascheninnikovia lanata / Bouteloua gracilis* Dwarf - shrub Herbaceous Vegetation**

4. *Krascheninnikovia lanata* poorly represented or absent: (5)

5 (4). *Ericameria nauseosa* or *Artemisia frigida* common to abundant: (6)

5. *Ericameria nauseosa* or *Artemisia frigida* uncommon or absent: (7)

6 (5). *Ericameria nauseosus* common to abundant; *Artemisia frigida* poorly represented, scattered: ***Ericameria nauseosa / Bouteloua gracilis* Shrub Herbaceous Vegetation**

6. *Ericameria nauseosus* uncommon, accidental or absent, *Artemisia frigida* typically well represented, not accidental: ***Artemisia frigida / Bouteloua gracilis* Dwarf-shrubland**

7 (5). *Muhlenbergia montana* common to well represented: ***Bouteloua gracilis - Muhlenbergia montana* Herbaceous Vegetation**

7. *Muhlenbergia montana* uncommon, accidental, or absent: (8)

8 (7). *Bouteloua gracilis* typically well represented to very abundant, dominant or codominant: (9)

8. *Bouteloua gracilis* uncommon, accidental, or absent: (11)

9 (8). *Pleuraphis jamesii* common, usually well represented and the primary codominant: ***Bouteloua gracilis - Pleuraphis jamesii* Herbaceous Vegetation**

9. *Pleuraphis jamesii* uncommon, accidental, or absent: (10)

10 (9). *Sporobolus cryptandrus* common, usually well represented and the primary codominant: ***Bouteloua gracilis - Sporobolus cryptandrus* Herbaceous Vegetation**

10. *Sporobolus cryptandrus* uncommon, accidental, or absent: (11)

11 (10). *Kochia scoparia* well represented and dominant and other ruderal forbs such as *Salsola tragus* or *Portulaca oleracea*: ***Bouteloua gracilis* / Ruderal Herbaceous Vegetation**

11. *Kochia scoparia* poorly represented or absent; other forbs and graminoids uncommon, scattered, or absent: ***Bouteloua gracilis* Herbaceous Vegetation**

KEY 4 Lithomorphic and Sparsely Vegetated, and other land cover types.

1. Substrate of exposed soil that has been water deposited in lowlands (natural barren alluvial fill); little rock or gravel: **Sparse Vegetation / Alluvial Flat**

1. Substrate of volcanic basalt pumice or basalt lava, or sedimentary (limestone or sandstone) rocks or boulders (2)

2 (1). Substrate of sedimentary (limestone or sandstone) rocks or boulders: **Sparse Vegetation / Boulder Rockland**

2. Sedimentary rocks absent; sparsely vegetated pumice or lava rocks and gravels: (3)

3. (2) Basalt cinders or pumice dominate; *Phacelia serrata* may be common on occasion: **Sparse Vegetation / Cinder Cone**

3. Sparsely vegetated lava flows of basalt: **Sparse Vegetation / Lava Flow**

Appendix D: Plant Association Descriptions for El Malpais National Monument

As part of the El Malpais National Monument (ELMA) vegetation classification and mapping project, plant association descriptions were written for the 50 plant associations (PAs) identified for the park during the classification and mapping phase. Detailed vegetation descriptions are essential for recognizing floristic vegetation types (association and alliance levels of the NVC) in the field. Local and global descriptions "provide specific information on the geographical 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). The two levels of vegetation description are valuable for comparing each association as it appears in the park with the global range of variation for that association (Clark et al. 2009).

The following descriptions were prepared collaboratively by Natural Heritage New Mexico (NHNM) at the University of New Mexico and the Western Regional Office of NatureServe. These descriptions reflect NHNM and NatureServe's accumulated data and analysis. Global descriptions of NVC associations are also available on NatureServe's Explorer website (http://www.natureserve.org/explorer); local descriptions are not. In this appendix, the arrangement of the plant associations follows the NVCS hierarchy (Version 2; FGDC 2008) and Table 5 of the main report. The descriptions often use specific adjectives that relate to species canopy cover as shown in Table D-1.

Table D-1. Definitions for the canopy cover descriptions found in the plant association descriptions

Canopy cover description	Definition
Absent	Individuals 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.

Plant Associations

1. FOREST TO OPEN WOODLAND

1.B.1. Warm Temperate Forest

1.B.1.Nd. Madrean & Southwest Great Plains Warm Temperate Woodland & Scrub

Madrean Lowland Evergreen Woodland (M010)

Madrean Juniper Savanna & Woodland Group (G487)

1.B.2. Cool Temperate Forest

1.B.2.Nb. Rocky Mountain Cool Temperate Forest

Rocky Mountain Subalpine & High Montane Conifer Forest (M020)

Rocky Mountain Subalpine & Montane Aspen Forest & Woodland Group (G222)

Southern Rocky Mountain Lower Montane Forest (M022)

Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (G228)

Southern Rocky Mountain Ponderosa Pine Savanna Group (G229)

Southern Rocky Mountain White Fir - Douglas-fir Dry Forest Group (G226)

1.B.2.Nc. Western North American Cool Temperate Woodland & Scrub

Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027)

Southern Rocky Mountain Juniper Woodland & Savanna Group (G252)

4. PARK SPECIALS

5. SPARSE VEGETATION

1. Forest to Open Woodland

Juniperus monosperma / Muhlenbergia pauciflora Woodland

One-seed Juniper / New Mexico Muhly Woodland

CODE	CEGL005387
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Warm Temperate Forest (1B1)
PHYSIOGNOMIC DIVISION	Madrean & Southwest Great Plains Warm Temperate Woodland & Scrub (1.B.1.Nd)
MACROGROUP	Madrean Lowland Evergreen Woodland (M010)
GROUP	Madrean Juniper Savanna & Woodland Group (G487)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

This Madrean woodland or savanna occurs in central and south-central New Mexico and is a major association of the San Andres Mountains. Sites are typically found on cool aspects of steep scarp slopes at elevations of 1700 to 2150 m (5500-7000 feet). Occasionally it is found on more gentle dipslopes or along the toeslopes of mountain valleys. Soils are mostly shallow and loamy with significant gravel, cobble and even a stony component (50% or more of the profile can be made up of coarse fragments). Vegetation is characterized by an open canopy of mature *Juniperus monosperma*; saplings or seedlings are also common. Occasionally seedling or sapling *Pinus edulis* can be present, commonly under the canopy of *Juniperus monosperma*. The understory is characterized by scattered bunches of *Muhlenbergia pauciflora* with a scattering of forbs. Other grasses may be well-represented or abundant, including *Bouteloua curtipendula*, *Hesperostipa comata*, *Muhlenbergia setifolia*, *Tridens muticus*, and *Achnatherum scribneri* (= *Stipa scribneri*). A wide variety of forbs can occur, but forb species richness and abundance on a stand-by-stand basis are low; *Lesquerella fendleri*, *Melampodium leucanthum*, and *Viguiera dentata* are most constant. Shrubs are usually present and may form an open layer (>5% cover) with *Gutierrezia sarothrae*, *Rhus trilobata*, and *Yucca baccata* being the most abundant and constant.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

The association occurs on top of a steep slope at 2140 m (7010 feet) elevation. The substrate is colluvium derived from Lower Permian sedimentary deposits.

Global Environment

Within Salinas Pueblo Missions National Monument in central New Mexico, this association occurs at 1830 m (6010 feet) in elevation on a steep, northwest-facing slope. Soils are developed in rocky colluvium derived from sandstone of the Permian Abo Formation. The ground surface is typically rocky and gravelly with scattered grass patches and litter. Within White Sands Missile Range, this association is typically found on cool aspects of steep scarp slopes at elevations of 1700 to 2150 m (5500-7000+ feet). Occasionally it is found on more gentle dipslopes or along the toeslopes of mountain valleys. Soils are mostly shallow Inceptisols or weakly developed Alfisols. They are usually loamy with significant gravel, cobble and even a stony component (50% or more of the profile can be made up of coarse fragments). Calcium carbonate accumulations are also common lower in the profile (Muldavin, Chauvin, et al. 2000).

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Juniperus monosperma is the dominant tree species in this Southern Rocky Mountain juniper savanna association. Tree cover ranges between 10 and 25%, and *Pinus edulis* may be present but is clearly subordinate. Individuals of both species are mature. The shrub cover is typically less than 5%, with *Atriplex canescens* the most abundant (2.5% cover), and with *Krascheninnikovia lanata*, *Gutierrezia sarothrae*, *Opuntia phaeacantha*, and *Echinocereus coccineus* making up the balance. In the inter-tree spaces, *Muhlenbergia pauciflora* is well-represented to abundant and the dominant grass among the cobbles and rocks, followed by *Hesperostipa comata* at 7.5% cover. Forb species are few in number (5) and a small portion of the cover, about 3%. *Hedeoma drummondii* is the most abundant.

Global Vegetation

Within Salinas Pueblo Missions National Monument in central New Mexico, this Madrean woodland or savanna is characterized by an open canopy of mature *Juniperus monosperma*; saplings or seedlings are also common. Occasionally seedling or sapling *Pinus edulis* can be present, commonly under the canopy of *Juniperus monosperma*. The understory is characterized by scattered bunches of *Muhlenbergia pauciflora* with a scattering of forbs. Within White Sands Missile Range in south-central New Mexico, this woodland is dominated by abundant *Juniperus monosperma*, with a grassy understory dominated by *Muhlenbergia pauciflora*. Scattered mature *Pinus edulis* may also be present. The shrub layer can be well-represented by a wide variety of species (38 species), with *Gutierrezia sarothrae*, *Rhus trilobata*, and *Yucca baccata* being the most abundant and constant. *Cercocarpus montanus* may also be present but is not dominant. In addition to *Muhlenbergia pauciflora*, other grasses may be well-represented or abundant, including *Bouteloua curtipendula*, *Hesperostipa comata*, *Muhlenbergia setifolia*, *Tridens muticus*, and *Achnatherum scribneri* (= *Stipa scribneri*). A wide variety of forbs can occur, but forb species richness and abundance on a stand-by-stand basis are low; *Lesquerella fendleri*, *Melampodium leucanthum*, and *Viguiera dentata* are most constant (Muldavin, Chauvin, et al. 2000).

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Atriplex canescens*
Herb (field)	Graminoid	*Muhlenbergia pauciflora*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Herb (field)	Graminoid	*Muhlenbergia pauciflora*

CHARACTERISTIC SPECIES

El Malpais National Monument

Atriplex canescens, Hesperostipa comata, Juniperus monosperma, Krascheninnikovia lanata, Muhlenbergia pauciflora

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (13-May-2009)

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is found on the Zuni-Acoma Trail.

Global Range

This association is known to occur within Salinas Pueblo Missions National Monument in central New Mexico, El Malpais National Monument in west-central New Mexico and White Sands Missile Range in south-central New Mexico. It is a major association of the San Andres Mountains.

Nations: US

States/Provinces: NM

Federal Lands: DOD (White Sands Missile Range); NPS (El Malpais, Salinas Pueblo Missions)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 1 rapid field plot from 2006: 06JC277.

Local Description Authors: E. Muldavin and A. Cully

Global Description Authors: K.S. King, mod. K.A. Schulz

REFERENCES

Dwyer and Pieper 1967; Fischer and Bradley 1987; Muldavin, Chauvin, et al. 2000; Muldavin, Harper et al. 2000; Western Ecology Working Group n.d.; Wright et al. 1979

Populus tremuloides / Mixed Shrubs / Cinder Woodland

Quaking Aspen / Mixed Shrubs / Cinder Woodland

CODE	CEGL005034
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Rocky Mountain Subalpine & High Montane Conifer Forest (M020)
GROUP	Rocky Mountain Subalpine & Montane Aspen Forest & Woodland Group (G222)

ECOLOGICAL SYSTEM(S)

Rocky Mountain Aspen Forest and Woodland (CES306.813)

ELEMENT CONCEPT

Global Summary

This woodland association is currently only known from El Malpais National Monument in New Mexico, and the following description is based on occurrences there. Additional information will be added as it becomes available. This association occurs from 2365 to 2470 m (7760-8090 feet) elevation on steep sideslopes and the bottom of Bandera Crater. Litter is abundant along with patches of soil, gravel, and coarse woody debris. Cryptogamic cover is sparse. The mesic broadleaf, moderate canopy (40-60% canopy cover) is dominated by *Populus tremuloides*. In some stands, many of the trees are dead, but sucker regeneration can be seen, and sapling *Populus tremuloides* can be abundant. Conifers such as *Pinus ponderosa* and *Pseudotsuga menziesii* from the surrounding mixed conifer stands can be interspersed in the canopy, as well as occasional *Juniperus scopulorum* saplings or mature individuals in the subcanopy. The understory of this association is characteristically shrubby and dominated by *Ribes leptanthum*, *Holodiscus dumosus*, *Symphoricarpos oreophilus*, and *Rhus trilobata*. In contrast, the herbaceous stratum is poorly developed and is typically less than 5% cover; *Carex rossii*, *Poa fendleriana*, and *Piptatherum micranthum* are the most abundant graminoids. Forbs are few and low in cover, and may include *Artemisia campestris*, *Arabis fendleri* (= *Boechera fendleri*), *Packera neomexicana* var. *mutabilis*, *Achillea millefolium*, *Erigeron formosissimus*, and *Fragaria vesca*.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs from 2365 to 2470 m (7760-8090 feet) elevation on steep sideslopes and the bottom of Bandera Crater. Litter is abundant along with patches of soil, gravel, and coarse woody debris. Cryptogamic cover is sparse.

Global Environment

This association is only known from El Malpais National Monument, therefore no global information is available.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

The mesic broadleaf, moderate canopy (40-60% canopy cover) is dominated by *Populus tremuloides*. In some stands, many of the trees are dead, but sucker regeneration can be seen, and sapling *Populus tremuloides* can be abundant. Conifers such as *Pinus ponderosa* and *Pseudotsuga menziesii* from the surrounding mixed conifer stands can be interspersed in the canopy, as well as occasional *Juniperus scopulorum* saplings or mature individuals in the subcanopy. The understory of this association is characteristically shrubby and dominated by *Ribes leptanthum*, *Ribes cereum*, *Holodiscus dumosus*, *Symphoricarpos oreophilus*, and *Rhus trilobata*. In contrast, the herbaceous stratum is poorly developed and is typically less than 5% cover; *Carex rossii*, *Poa fendleriana*, and *Piptatherum micranthum* are the most abundant graminoids. Forbs are few and low in cover, and may include *Artemisia campestris*, *Arabis fendleri* (= *Boechera fendleri*), *Packera neomexicana* var. *mutabilis*, *Achillea millefolium*, *Erigeron formosissimus*, and *Fragaria vesca*.

Global Vegetation

This association is only known from El Malpais National Monument, therefore no global information is available.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Holodiscus dumosus, Ribes cereum*

CHARACTERISTIC SPECIES

El Malpais National Monument

Populus tremuloides, *Holodiscus dumosus*, *Ribes cereum*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Bandera and Bandera Crater.

Global Range

This association is currently only known from El Malpais National Monument in New Mexico. Additional range information will be added as it becomes available.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 3 field plots (3 standard) from 2006: 06AB210, 06AB213, 06JC348.

Local Description Authors: E. Muldavin and A. Cully

Global Description Authors: E. Muldavin and A. Cully

REFERENCES

Western Ecology Working Group n.d.

Pinus ponderosa / Carex inops ssp. *heliophila* Woodland

Ponderosa Pine / Sun Sedge Woodland

CODE	CEGL000849
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (G228)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648), Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna (CES303.650)

ELEMENT CONCEPT

Global Summary

This ponderosa pine / sedge woodland is found in the Black Hills region, along the Rocky Mountain Front Range from Montana to Colorado, and in north-central and western New Mexico. Along the Rocky Mountains, this association occurs from the foothills to 2900 m (9500 feet) in elevation, although its elevation decreases farther north. Stands occur in relatively mesic savanna habitats, on gentle to moderate south- and west-facing slopes. In north-central New Mexico, this association occurs at mid-elevation (1920-2560 m [6300-8400 feet]) on sites with moderate to high solar exposure that increases with elevation. Aspects tend to be more northerly at lower elevation, more southerly on higher sites. Slopes range from gentle to moderate (8-20%), and occasionally very steep (>50%). Substrates are variable and may include the following soil types: poorly-developed and rocky Inceptisols from rhyolitic colluviums; finer-textured Alfisols from rhyolitic slope alluvium; gravely Mollisols from rhyolite tuff; or pumice slope alluvium. Some sites are predominantly rock outcrop. At El Malpais National Monument in west-central New Mexico, it typically occurs on gently rolling basalt lava plateaus and collapse features, though occasionally it is found on steep sideslopes of cinder cones and cinder fields. The ground surface is characterized by scattered bunch grasses and sedges intermixed with litter, and some sites are very rocky. Diagnostic characteristics of this association are the open canopy of *Pinus ponderosa* over a graminoid layer dominated by *Carex inops* ssp. *heliophila*. Occasional canopy associates include *Juniperus scopulorum*, *Pseudotsuga menziesii*, or *Quercus macrocarpa* in the subcanopy, depending on which portion of the geographic range the stand is found. The understory has a characteristically sparse (<5%) cover of shrubs, most frequently *Quercus* × *pauciloba*, *Ribes cereum*, and *Rhus trilobata*. The herbaceous layer is dominated by *Carex inops* ssp. *heliophila*, with inclusions of *Danthonia spicata*, *Poa fendleriana*, *Muhlenbergia montana*, *Schizachyrium scoparium*, *Pseudoroegneria spicata*, and *Bouteloua gracilis*, generally in areas with more open canopies. Within Bandelier National Monument in north-central New Mexico, canopy cover ranges from open woodland to closed-canopied forests (25% to >60% cover). Density of mature *Pinus ponderosa* is moderate and reproduction is rare or absent. Other conifers such as *Abies concolor*, *Pseudotsuga menziesii*, and *Pinus flexilis* are rare or absent in the overstory. Shrubs are a minor component of the stands. The herbaceous layer is rich in species but variable in cover. The most diagnostic and abundant graminoid is *Carex inops* ssp. *heliophila*, with other abundant species including deer sedges (*Carex occidentalis*, *Carex rossii*, and *Carex geophila*). While forbs are diverse, composition is variable from stand to stand and usually less than 5% total cover.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

Sites occur between 2100 and 2450 m (6900-8025 feet) elevation, typically on gently rolling basalt lava plateaus and collapse features (Hoya de Cibola, Bandera Crater, and Twin Craters flows), though occasionally it is found on steep sideslopes of cinder cones and cinder fields. The ground surface is characterized by scattered bunch grasses and deer sedges intermixed with litter, with some sites having significant exposed lava and pumice rock. Charring on logs and fire-scarred trees provide evidence of past fires, and downed trees and stumps indicate that logging also has taken place in some plots.

Global Environment

This community is often found on gentle and moderate south- to west-facing slopes in the western Dakotas and eastern parts of Wyoming and Montana (Hoffman and Alexander 1987, Hansen and Hoffman 1988). Along the Rocky Mountains from Montana to Colorado, this association occurs from the foothills to 2900 m (9500 feet) in elevation, although its elevation decreases farther north. Stands occur in relatively mesic savanna habitats, on gentle to moderate south- and west-facing slopes. In north-central New Mexico, this association occurs at mid-elevation (1920-2560 m [6300-8400 feet]) on sites with moderate to high solar exposure that increases with elevation. Aspects tend to be more northerly at lower elevation, more southerly on higher sites. Slopes range from gentle to moderate (8-20%) and occasionally very steep (>50%). Substrates are variable and may include the following soil types: poorly-developed and rocky Inceptisols from rhyolitic colluviums; finer-textured Alfisols from rhyolitic slope alluvium; gravely Mollisols from rhyolite tuff; or pumice slope alluvium. Some sites are predominantly rock outcrop (Hibner 2009). At El Malpais National Monument in west-central New Mexico, it typically occurs on gently rolling basalt lava plateaus and collapse features, though occasionally it is found on steep sideslopes of cinder cones and cinder fields. The ground surface is characterized by scattered bunch grasses and sedges intermixed with litter, and some sites are very rocky.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

These open-canopied (10-30% cover) tall woodlands are dominated by *Pinus ponderosa* with short-statured conifers such as *Juniperus scopulorum* sometimes present in the subcanopy along with scattered *Pinus ponderosa* regeneration. *Pseudotsuga menziesii* and *Populus tremuloides* occur occasionally but are clearly subordinate or incidental in microsites. The understory has a characteristically sparse (<5%) cover of shrubs, most frequently *Quercus* × *pauciloba* , *Ribes cereum*, and *Rhus trilobata*. Graminoids are also sparse and include scattered deer sedges (*Carex inops* ssp. *heliophila*, *Carex rossii*, and *Carex geophila*) along with *Poa fendleriana*, *Schizachyrium scoparium*, and *Muhlenbergia montana*. Forbs are poorly represented in terms of cover and frequency; they are variable from plot to plot and may include *Artemisia carruthii*, *Antennaria marginata*, *Brickellia brachyphylla*, *Heterotheca villosa*, *Lotus wrightii*, *Astragalus egglestonii*, and *Thalictrum fendleri*.

Global Vegetation

Diagnostic characteristics of this association are the canopy of *Pinus ponderosa* over a graminoid layer dominated by *Carex inops* ssp. *heliophila*. *Juniperus scopulorum*, *Quercus macrocarpa*, or *Pseudotsuga menziesii* are occasionally found in the subcanopy, depending on which portion of the geographic range the stand is found. The understory has a characteristically sparse (<5%) cover of shrubs, most frequently *Quercus* × *pauciloba*, *Ribes cereum*, and *Rhus trilobata*. The herbaceous layer is dominated by *Carex inops* ssp. *heliophila*, with other abundant species including deer sedges (*Carex occidentalis*, *Carex rossii*, and *Carex geophila*) and inclusions of *Danthonia spicata*, *Poa fendleriana*, *Muhlenbergia montana*, *Schizachyrium scoparium*, *Pseudoroegneria spicata*, and *Bouteloua gracilis*, generally in areas with more open canopies. Other common herbaceous species that occur with low cover include *Artemisia ludoviciana*, *Piptatherum micranthum* (= *Oryzopsis micrantha*), *Nassella viridula*, and *Poa pratensis* (H. Marriott pers. comm. 1999), as well as *Andropogon gerardii*, *Muhlenbergia montana*, *Sporobolus heterolepis*, *Arctostaphylos uva-ursi*, and *Heuchera richardsonii* (CONHP 2000).

Within Bandelier National Monument in north-central New Mexico, canopy cover ranges from open woodland to closed-canopied forests (25% to >60% cover). Density of mature *Pinus ponderosa* is moderate and reproduction is rare or absent. Other conifers such as *Abies concolor*, *Pseudotsuga menziesii*, and *Pinus flexilis* are rare or absent in the overstory. Shrubs are a minor component (rarely exceeding 3% total cover), and, in particular, *Quercus gambelii* is usually poorly represented or absent. The herbaceous layer is rich in species but variable in cover (5-40%). The graminoids are the most abundant with *Carex inops* ssp. *heliophila* and other deer sedges (*Carex occidentalis*, *Carex rossii*, and *Carex geophila*) diagnostic and often abundant. *Elymus elymoides*, *Koeleria macrantha*, *Muhlenbergia montana*, and *Poa fendleriana* are frequent and often well-represented associates. While forbs are diverse, composition is variable from stand to stand and usually less than 5% total cover. The most frequent and abundant forb species include *Achillea millefolium*, *Allium cernuum*, *Antennaria parvifolia*, *Artemisia ludoviciana*, *Erigeron speciosus*, *Erigeron subtrinervis*, *Heterotheca villosa*, *Penstemon barbatus*, and *Psoralidium tenuiflorum*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Carex geophila, Carex inops* ssp. *heliophila, Carex rossii, Poa fendleriana*

Globally

Stratum	Lifeform	Species
Tree (canopy & subcanopy)	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Carex inops* ssp. *heliophila*

CHARACTERISTIC SPECIES

El Malpais National Monument

Carex geophila, *Carex inops* ssp. *heliophila*, *Carex rossii*, *Muhlenbergia montana*, *Pinus ponderosa*, *Poa fendleriana*, *Quercus* × *pauciloba*, *Rhus trilobata*, *Ribes cereum*, *Schizachyrium scoparium*

Global

Carex inops ssp. *heliophila*

CONSERVATION STATUS RANK

Global Rank & Reasons: G3G4 (26-May-2000).

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

El Malpais National Monument Comments

Two provisional phases were identified based on substrate. The most common is the Lava Flow phase (10 plots) and one plot on a cinder cone referenced as a the Cinder phase.

Global Comments

The stands used by Hoffman and Alexander (1987) and Hansen and Hoffman (1988) to document the *Pinus* *ponderosa* / *Carex inops* ssp. *heliophila* Woodland habitat type had very high basal area and densities for a woodland, possibly due to their sampling procedure. The dense structure may have affected the floristic makeup of the stands. This type is expected to have an open canopy where natural fire disturbances occur.

Global Similar Associations

- *Pinus ponderosa / (Andropogon gerardii, Schizachyrium scoparium)* Woodland (CEGL000841)
- *Pinus ponderosa / Quercus gambelii / Carex inops* ssp. *heliophila* Woodland (CEGL005372)--is similar to CEGL000849 except for the significant shrub component.
- *Pinus ponderosa / Schizachyrium scoparium* Woodland (CEGL000201)--is differentiated from this community by high coverages of Schizachyrium scoparium.

Global Related Concepts

- *Pinus ponderosa* / *Carex* heliophila Habitat Type (Hansen 1985) =
- *Pinus ponderosa* / *Carex* heliophila Habitat Type (Hansen and Hoffman 1988) =
- *Pinus ponderosa* / *Carex* heliophila Plant Association (Johnston 1987) =
- *Pinus ponderosa* / *Carex* inops ssp. heliophila Woodland Habitat Type (Hoffman and Alexander 1987) =
- *Pinus ponderosa* /*Carex* inops ssp. heliophila (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the northwest portion of the monument (from Little Hole-In-The-Wall and the Hoya de Cibola flow westward), Cerritos de Jaspe, Encerrito West, and the Zuni-Acoma Trail.

Global Range

This ponderosa pine / sun sedge woodland is found in the Black Hills region, along the Rocky Mountain Front Range from Montana to Colorado, and in north-central and western New Mexico.

Nations: US

States/Provinces: CO:S2, MT:S3S4, NM, SD, WY:S2S3

Federal Lands: NPS (Bandelier, Devils Tower, El Malpais, Jewel Cave, Rocky Mountain, Wind Cave); USFS (Valles Caldera)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 11 field plots (6 standard and 5 rapid plots) from 2006: 06AB231, 06JC317, 06JC224, 06JC324, 06YC013, 06YC025, 06YC026, 06YC033, 06YC037, 06YC082, and 06YC083.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: A.G. McAdams, mod. S.L. Neid, K.S. King, M.E. Hall

REFERENCES

Ahlenslager 1988, Baker 1984, Bourgeron and Engelking 1994, CONHP 2000, CONHP unpubl. data 2003, Driscoll et al. 1984, Hall 1967, Hall 1973, Hansen 1985, Hansen and Hoffman 1988, Hibner 2009, Hoffman and Alexander 1976, Hoffman and Alexander 1987, Johnston 1987, Kooiman and Linhart 1986, Livingston 1947, Livingston 1949, MTNHP 2002, Marriott and Faber-Langendoen 2000, Marriott pers. comm., McAdams et al. unpubl. data 1998, Muldavin and Tonne 2003, Muldavin et al. 2006, Western Ecology Working Group n.d.

Pinus ponderosa / Fallugia paradoxa Woodland

Ponderosa Pine / Apache Plume Woodland

CODE	CEGL002999
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (G228)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

No data are available.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

Sites occur between 2,150 and 2,200 m (7,050 - 7,200 ft) on rolling basalt lava plateaus associated with the youngest McCarty's flow (generally the pahoehoe lava type). Sites may include collapse features, and are characterized by exposed, lightly weathered lava rock and scattered litter with vegetation growing primarily from cracks and fissures in the lava flow.

Global Environment

No data are available.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

These opened-canopied (10-40% cover) tall woodlands are dominated by *Pinus ponderosa* with short-statured conifers such as *Juniperus scopulorum*, J. monosperma, or *Pinus edulis* sometimes present in the sub-canopy. Sapling P. ponderosa can occasionally be present. Shrubs are well represented and dominated by *Fallugia paradoxa*. *Rhus trilobata* and *Forestiera pubescens* are frequent associates along with succulent subshrubs such as *Echinocereus coccineus*, *Opuntia polyacantha*, and O. phaeacantha. Herbaceous cover is limited with scattered grasses and forbs in lava cracks. *Bouteloua gracilis*, B. curtipendula, and *Schizachyrium scoparium* are the most common and consistent graminoids, while *Heterotheca villosa*, *Artemisia carruthii*, and *Bahia dissecta* are the most prevalent forbs.

Global Vegetation

No data are available.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Fallugia paradoxa*

CHARACTERISTIC SPECIES

El Malpais National Monument

Echinocereus coccineus, *Forestiera pubescens*, *Opuntia polyacantha*, O. phaeacantha, *Rhus trilobata*, *Schizachyrium scoparium*, *Bouteloua gracilis*, *Bouteloua curtipendula*, *Heterotheca villosa*, *Artemisia carruthii*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 – Moderate

Global Similar Associations

- *Pinus ponderosa / Fallugia paradoxa - Ribes cereum* Woodland [Provisional] (CEGL005032)

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the southern portion of the McCarty's flow.

Global Range

No date are available.

Nations: US

States/Provinces: NM, AZ

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 13 field plots from 2005, 2006, and 2007: 05MA008, 05MA009, 06JC360, 06JC362, 06JC363, 06JC366, 06JC380, 06JC381, 07AB006, 07AB008, 07AB009, 07AB012, and 07AB013.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: NA

REFERENCES

Western Ecology Working Group n.d.

Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland [Provisional]

Ponderosa Pine / Apache Plume - Wax Currant Woodland

CODE	CEGL005032
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (G228)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

This woodland association is currently only known from El Malpais National Monument in New Mexico, and the following description is based on occurrences there. Additional information will be added as it becomes available. Sites occur between 2280 and 2325 m (6850-7625 feet) elevation on gently rolling lava plateaus and collapse features of the Bandera lavaflow (the second youngest flow). The ground surface is characterized by exposed, lightly weathered lava rock and scattered litter with vegetation growing primarily from cracks and fissures in the lavaflow. These open-canopied (10-30% cover) tall woodlands are dominated by *Pinus ponderosa* with short-statured conifers such as *Juniperus scopulorum* and/or *Pinus edulis* sometimes present in the subcanopy. The understory of this association is characteristically shrubby and dominated by *Fallugia paradoxa* in combination with more mesic species such as *Ribes cereum*, *Forestiera pubescens*, *Holodiscus dumosus*, and *Rhus trilobata*. Succulent subshrubs such as *Echinocereus coccineus* and *Opuntia polyacantha* can be common. The herbaceous layer is commonly well-represented and can occasionally range as high as 40% total cover with 16 graminoids and 18 forbs recorded for the association. Grasses predominate, with *Bouteloua gracilis* the most frequent and abundant. Other grass species include *Poa fendleriana*, *Schizachyrium scoparium*, *Muhlenbergia montana*, *Carex rossii*, *Elymus elymoides*, and *Blepharoneuron tricholepis*. Among forbs, *Artemisia carruthii*, *Heterotheca villosa*, *Brickellia brachyphylla*, *Glandularia bipinnatifida*, and *Geranium lentum* are the most prevalent.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

Sites occur between 2280 and 2325 m (6850-7625 feet) elevation on gently rolling lava plateaus and collapse features of the Bandera lavaflow (the second youngest flow). The ground surface is characterized by exposed, lightly weathered lava rock and scattered litter with vegetation growing primarily from cracks and fissures in the lavaflow.

Global Environment

This association is only known from El Malpais National Monument, therefore no global information is available.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

These open-canopied (10-30% cover) tall woodlands are dominated by *Pinus ponderosa* with short-statured conifers such as *Juniperus scopulorum* and/or *Pinus edulis* sometimes present in the subcanopy. The understory of this association is characteristically shrubby and dominated by *Fallugia paradoxa* in combination with more mesic species such as *Ribes cereum*, *Forestiera pubescens*, *Holodiscus dumosus*, and *Rhus trilobata*. Succulent subshrubs such as *Echinocereus coccineus* and *Opuntia polyacantha* can be common. The herbaceous layer is commonly well-represented and can occasionally range as high as 40% total cover with 16 graminoids and 18 forbs recorded for the association. Grasses predominate, with *Bouteloua gracilis* the most frequent and abundant followed by *Poa fendleriana*, *Schizachyrium scoparium*, *Muhlenbergia montana*, *Carex rossii*, *Elymus elymoides*, and *Blepharoneuron tricholepis*. Among forbs, *Artemisia carruthii*, *Heterotheca villosa*, *Brickellia brachyphylla*, *Glandularia bipinnatifida*, and *Geranium lentum* are the most prevalent.

Global Vegetation

This association is only known from El Malpais National Monument, therefore no global information is available.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Ribes cereum*
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Fallugia paradoxa*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia carruthii, Bouteloua gracilis, Brickellia brachyphylla, Carex rossii, Echinocereus coccineus, Fallugia paradoxa, Geranium lentum, Glandularia bipinnatifida, Heterotheca villosa, Juniperus scopulorum, Muhlenbergia montana, Opuntia polyacantha, Pinus ponderosa, Poa fendleriana, Rhus trilobata, Ribes cereum, Schizachyrium scoparium

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Provisional

Classification Confidence: 3 - Weak

Global Similar Associations

- *Pinus ponderosa / Fallugia paradoxa* Woodland (CEGL002999)

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the western potion of the monument (Bandera lavaflow west of Little Hole-In-

The-Wall and Hole-In-The-Wall).

Global Range

This association is currently only known from El Malpais National Monument in New Mexico. Additional range information will be added as it becomes available.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 10 field plots from 2006: 06JC255, 06JC313, 06JC319, 06JC322, 06JC328, 06JC330, 06JC331, 06JC333, 06JC337, and 06YC019.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Pinus ponderosa / Poa fendleriana **Woodland**

Ponderosa Pine / Muttongrass Woodland

CODE	CEGL005507
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (G228)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

This woodland association is currently known from El Malpais National Monument in New Mexico, Grand Canyon-Parashant National Monument, Lake Mead National Recreation Area and Grand Canyon National Park in Arizona. This association occurs between 1900 and 2537 m (6250-8323 feet) in elevation on moderately steep slopes of volcanic cinder cones, plateaus, and gentle sideslopes across all aspects. The ground surface is dominated by pumice gravels and scattered grasses and litter at El Malpais and predominantly litter in Arizona. These open-canopied (10-25% cover) tall woodlands are dominated by *Pinus ponderosa* with short-statured conifers such as *Juniperus scopulorum* or *Pinus edulis* sometimes present in the subcanopy. Shrubs are few and sparse, although *Quercus gambelii*, *Mahonia repens*, and *Ceanothus fendleri* are common, and the understory is characterized by scattered bunch grasses. *Poa fendleriana* is the dominant and can be well-represented to abundant, and *Koeleria macrantha* is common along with deer sedges (e.g., *Carex geophila* and *Carex rossii*). Forbs are scattered and variable and may include *Achillea millefolium*, *Allium cernuum*, *Antennaria parvifolia*, *Artemisia dracunculus*, *Artemisia ludoviciana*, *Bahia dissecta*, *Glandularia bipinnatifida*, *Hymenopappus filifolius*, *Hymenoxys richardsonii*, Lactuca serriola, *Lithospermum multiflorum*, and *Mentzelia* multiflora var. integra.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2225 and 2270 m (7350-7475 feet) in elevation on moderately steep slopes of volcanic cinder cones in the northwestern portion of the monument. The ground surface is dominated by pumice gravels and scattered grasses and litter.

Global Environment

This association occurs between 1900 and 2537 m (6250-8323 feet) in elevation on moderately steep slopes of volcanic cinder cones, plateaus, and gentle sideslopes across all aspects. The ground surface is dominated by pumice gravels and scattered grasses and litter at El Malpais and predominantly litter in Arizona. Soils are composed of cinder, silt clays, silt loams, and sandy or silty loams.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

These open-canopied (10-25% cover) tall woodlands are dominated by *Pinus ponderosa* with short-statured conifers such as *Juniperus scopulorum* or *Pinus edulis* sometimes present in the subcanopy. Shrubs are few and sparse, and the understory is characterized by scattered bunch grasses. *Poa fendleriana* is the dominant and can be well-represented to abundant, and *Koeleria macrantha* is common along with deer sedges (e.g., *Carex geophila* and *Carex rossii*). Forbs are scattered and variable and may include *Achillea millefolium*, *Allium cernuum*, *Antennaria parvifolia*, *Artemisia dracunculus*, *Artemisia ludoviciana*, *Bahia dissecta*, *Glandularia bipinnatifida*, *Hymenopappus filifolius*, *Hymenoxys richardsonii*, Lactuca serriola, *Lithospermum multiflorum*, and *Mentzelia* multiflora var. integra.

Global Vegetation

These open-canopied (10-25% cover) tall woodlands are dominated by *Pinus ponderosa* with short-statured conifers such as *Juniperus scopulorum* or *Pinus edulis* sometimes present in the subcanopy. Subcanopy cover may be quite high (up to 40%) in the absence of fire. This association generally lacks a shrub layer, although *Quercus gambelii*, *Mahonia repens*, and *Ceanothus fendleri* are common, and the understory is characterized by scattered bunch grasses. *Poa fendleriana* is the dominant and can be well-represented to abundant, and *Koeleria macrantha* is common along with deer sedges (e.g., *Carex geophila* and *Carex rossii*). Forbs are scattered and variable and may include *Achillea millefolium*, *Allium cernuum*, *Antennaria parvifolia*, *Artemisia dracunculus*, *Artemisia ludoviciana*, *Bahia dissecta*, *Glandularia bipinnatifida*, *Hymenopappus filifolius*, *Hymenoxys richardsonii*, Lactuca serriola, *Lithospermum multiflorum*, and *Mentzelia* multiflora var. integra.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Poa fendleriana*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Poa fendleriana*

CHARACTERISTIC SPECIES

El Malpais National Monument

Koeleria macrantha, Pinus ponderosa, Poa fendleriana

Global

Pinus ponderosa, Poa fendleriana

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (15-Jan-2010).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the El Calderon area.

Global Range

This association is currently documented from El Malpais National Monument, Grand Canyon National Park, Grand Canyon-Parashant National Monument, and Lake Mead National Recreation Area, but is likely widespread throughout similar environments in the Southwest.

Nations: US

States/Provinces: AZ, NM

Federal Lands: NPS (El Malpais, Grand Canyon, Grand Canyon-Parashant)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots: 06AB218, 06JC257,06JC342, 06JC343, and 06JC344.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: E. Muldavin and A. Kennedy, mod. M.E. Hall

REFERENCES

Western Ecology Working Group n.d.

Pinus ponderosa / Quercus × pauciloba Woodland

Ponderosa Pine / Wavyleaf Oak Woodland

CODE	CEGL000874
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (G228)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648)

ELEMENT CONCEPT

Global Summary

This ponderosa pine woodland occurs at mid-elevations in the southern Rocky Mountains of southern Colorado and northern New Mexico on sites with moderate to high solar exposure on all aspects. Sites vary from gentle slopes on rolling mesatops, lava plateaus and shoulders (5-20% slope) to steep canyon slopes and rock outcrops (up 60% slope). Elevation ranges between 1995 and 2500 m (6550-8200 feet). Soils range from sandy to loamy, including well-developed Mollisols derived from pumice slope alluvium or rhyolitic colluvium, or occasionally as fine-textured Alfisols, or rock outcrop. Sites are often rocky or boulder-strewn with accumulations of litter in between. This tall conifer association ranges from open woodland where tree canopies are as low as 10% cover to closed-canopied forest with over 60% cover. *Pinus ponderosa* dominates the tree canopy, with *Juniperus monosperma* and *Pinus edulis* sometimes well-represented in the subcanopy. Stand understories are distinctively shrubby, dominated by the hybrid scrub oak *Quercus* × *pauciloba* with *Fallugia paradoxa* as a frequent associate. Other common shrub associates may include *Cercocarpus montanus* and *Robinia neomexicana*. *Quercus gambelii* is poorly represented or absent. The herbaceous layer is generally less than 5% cover but diverse. Dominant graminoid species may include *Bouteloua gracilis*, *Bouteloua hirsuta*, *Muhlenbergia montana*, *Poa fendleriana*, and *Schizachyrium scoparium*. While forbs are diverse, composition is variable from stand to stand and total forb cover is usually less than 5%.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between around 2090 and 2200 m (6840-7240 feet) elevation on very gently rolling lava plateaus (Bandera and McCarty's flows). Typically, ground surface cover is dominated by rock with occasional soil development. Gravel and coarse woody debris are common; cryptogamic cover is poorly represented or scarce.

Global Environment

This association occurs at mid-elevation in the southern Rocky Mountains of southern Colorado and northern New Mexico on sites with moderate to high solar exposure on all aspects. Sites vary from gentle on rolling mesatops, lava plateaus and shoulders (5-20% slope) to steep canyon slopes and rock outcrops (up 60% slope). Elevation ranges between 1995 and 2500 m (6550-8200 feet). Soils range from sandy to loamy, including well-developed Mollisols derived from pumice slope alluvium or rhyolitic colluvium, or occasionally as fine-textured Alfisols, or rock outcrop (Hibner 2009). Sites are often rocky or boulder-strewn with accumulations of litter in between.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this *Pinus ponderosa*-dominated association are open (25-40%), with *Juniperus monosperma* and *Pinus edulis* well-represented in the subcanopy. Shrubs are well-represented and dominated by the diagnostic species *Quercus* × *pauciloba* with *Fallugia paradoxa* as a frequent associate. Herbaceous species in this lava type are well-represented, typically with graminoids predominant. *Bouteloua gracilis* is the most common graminoid, followed by *Bouteloua curtipendula* and *Bouteloua hirsuta*. *Heterotheca villosa* is the most frequently represented forb. *Artemisia carruthii* and *Echinocereus coccineus* occur frequently, though cover is typically low.

Global Vegetation

This is a tall conifer association ranges from open woodland where tree canopies are as low as 10% cover to closed-canopied forest with over 60% cover. *Pinus ponderosa* dominates the canopy. Other conifers may be uncommon to codominant, including *Pinus edulis*, *Juniperus scopulorum*, *Juniperus monosperma*, and *Juniperus deppeana*. Stand understories are distinctively shrubby, dominated by the hybrid scrub oak *Quercus* × *pauciloba* with *Fallugia paradoxa* as a frequent associate. Other common shrub associates may include *Cercocarpus montanus* and *Robinia neomexicana*. *Quercus gambelii* is poorly represented or absent. The herbaceous layer generally has less than 5% cover but is diverse. Dominant graminoid species may include *Bouteloua curtipendula*, *Bouteloua gracilis*, *Bouteloua hirsuta*, *Muhlenbergia montana*, *Poa fendleriana*, and *Schizachyrium scoparium*. *Andropogon gerardii*, *Carex inops* ssp. *heliophila*, and other deer sedges (*Carex geophila*, *Carex occidentalis*, and *Carex rossii*) may also be present but not dominant. While forbs are diverse, composition is variable from stand to stand and total forb cover is usually less than 5%. The most frequent and abundant forb species may include *Artemisia ludoviciana*, *Bahia dissecta*, *Brickellia brachyphylla*, and *Heterotheca villosa*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Quercus* × *pauciloba*
Herb (field)	Graminoid	*Bouteloua gracilis*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Quercus* × *pauciloba*
Herb (field)	Graminoid	*Festuca thurberi, Muhlenbergia montana, Schizachyrium scoparium*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, Pinus ponderosa, Quercus × *pauciloba*

Global

Festuca thurberi, Muhlenbergia montana, Pinus ponderosa, Quercus × *pauciloba, Schizachyrium scoparium*

CONSERVATION STATUS RANK

Global Rank & Reasons: G5 (15-Oct-1996).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Global Related Concepts

- *Pinus ponderosa* / *Quercus undulata* [× *pauciloba*] Cover Type (Balice et al. 1997) =
- *Pinus ponderosa*/*Quercus* × *pauciloba* (Bourgeron and Engelking 1994) =

- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Zuni-Acoma Trail and the Bandera flow north of Hole-In-The-Wall.

Global Range

This association occurs at mid-elevations in the southern Rocky Mountains of southern Colorado and northern New Mexico. It is also reported from Wyoming.

Nations: US

States/Provinces: CO:S1S2, NM:S5, WY

Federal Lands: NPS (Bandelier, El Malpais); USFS (Lincoln)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots from 2005, 2006, and 2007: 05MA010, 06JC268, 06JC292, 06JC394, and 07AB031.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

Global Description Authors: A. Browder and E. Muldavin, mod. K.S. King and M.E. Hall

REFERENCES

Alexander et al. 1984a, Balice et al. 1997, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, DeVelice et al. 1986, Driscoll et al. 1984, Hibner 2009, Rogers 1953, Western Ecology Working Group n.d.

Pinus ponderosa / Quercus gambelii **Woodland**

Ponderosa Pine / Gambel Oak Woodland

CODE	CEGL000870
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (G228)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648)

ELEMENT CONCEPT

Global Summary

This major ponderosa pine woodland is widespread and has been reported from foothills, mountains and plateaus from Colorado to Texas, west to Arizona and Nevada. Elevation ranges from 1830-2800 m (6000-9200 feet). Stands often occur along drainages, on lower and middle slopes and benches on all aspects. Soils are typically shallow and rocky, ranging from sandy loams to clay loams. At El Malpais National Monument in western New Mexico, it generally occurs on rolling lava plateaus, steep sideslopes of volcano craters, on gentle toeslopes of low cinder hills, or on sandstone outcrops. Substrates are derived from basalt or sandstone, with rock, gravel, and occasional patches of sandy soil. Litter is often abundant in patches. *Pinus ponderosa* dominates or sometimes codominates the sparse to moderately dense tree canopy with *Pinus edulis* and *Juniperus* spp. *Pseudotsuga menziesii* is accidental and *Abies concolor* is not present. *Quercus gambelii* dominates both the subcanopy (tree form, if present) and the typically moderately dense tall-shrub layer consisting of dense clumps of oak. *Quercus gambelii* must have at least 5% cover, but there is frequently over 25%. At higher elevations, the *Quercus gambelii* are more treelike, and *Symphoricarpos oreophilus* will be present with significant cover in the short-shrub layer. At lower elevations, scattered *Artemisia tridentata* ssp. *vaseyana*, *Pinus edulis*, and *Juniperus osteosperma* are often present. At El Malpais, *Forestiera pubescens* is the most commonly occurring shrub, along with occasional *Ribes cereum*. Other common shrub species may include *Amelanchier* spp., *Mahonia repens*, and *Rosa woodsii*. The herbaceous layer is generally sparse and composed of mostly graminoids and scattered forbs.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2160 and 2420 m (7080-7940 feet) in elevation on gently rolling lava plateaus, steep sideslopes of volcano craters, on gentle toeslopes of low cinder hills, or on sandstone outcrops (McCarty's and Bandera flows, Bandera Crater and Twin Craters cinder cones). Substrates are derived from basalt or sandstone, with rock, gravel, and occasional patches of sandy soil. Litter is often abundant in patches.

Global Environment

This woodland association is widespread and has been reported from foothills, mountains and plateaus from Colorado to Trans-Pecos Texas, west to Arizona and Nevada. Elevation ranges from 1830-2800 m (6000-9200 feet). Stands often occur along drainages, on lower and middle slopes and benches on all aspects. Slopes are typically gentle or moderate, but may also be steep (>45%). Soils are typically shallow and rocky ranging from sandy loams to clay loams. Parent materials are commonly sandstones, but fractured limestone, basalt, andesite, and alluvium are also reported. At El Malpais National Monument in western New Mexico, it gently occurs on rolling lava plateaus, steep sideslopes of volcano craters, on gentle toeslopes of low cinder hills, or on sandstone outcrops. Substrates are derived from basalt or sandstone, with rock, gravel, and occasional patches of sandy soil. High litter cover (70-90%) about 5 cm deep is common in many stands. Rock outcrops (about 10%) and some bare soil are not uncommon. This conifer woodland transitions to *Quercus gambelii* shrubland in drier sites and at lower elevations. This community is the highest elevation *Pinus ponderosa* / oak woodland present in Trans-Pecos Texas. It typically grades downslope to *Pinus ponderosa* / *Quercus hypoleucoides* Woodland (CEGL000872).

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this association range from very open (30%) to moderately closed and are dominated by *Pinus ponderosa* along with *Juniperus scopulorum*. *Pseudotsuga menziesii* is found scattered through some areas, and *Pinus edulis* also occurs occasionally. *Quercus gambelii* is found frequently in dense patches. In the understory, perhaps because of the presence of dense stands of *Quercus gambelii* in the subcanopy, there are few species of shrubs and their cover is low. *Forestiera pubescens* is the most commonly occurring shrub, along with occasional *Ribes cereum*. In the herbaceous stratum, graminoids are the predominant group. *Muhlenbergia montana* is the most abundant and frequently occurring species. Perhaps due to the presence of sandy soils in some areas, the forbs are represented by a rich mix of xeric and moist-xeric woodland species, including *Artemisia campestris*, *Chenopodium graveolens*, *Penstemon barbatus*, *Heterotheca villosa*, and *Solidago wrightii*.

Global Vegetation

This broadly defined coniferous woodland is widespread and is characterized by a sparse to moderately closed evergreen needle-leaved tree canopy dominated by *Pinus ponderosa*, or sometimes codominated by *Pinus edulis* and scattered *Juniperus scopulorum*, *Juniperus monosperma*, or *Juniperus osteosperma*. In southern stands *Juniperus deppeana* and *Pinus strobiformis* may be present to codominant. *Pseudotsuga menziesii* is accidental and *Abies concolor* is not present. *Quercus gambelii* dominates both the subcanopy (tree form, if present) and the typically moderately dense tall-shrub layer, which consists of dense clumps of oak. This community must have at least 5% cover of *Quercus gambelii*, but there is frequently over 25%. At higher elevations, the *Quercus gambelii* are more tree-like, and *Symphoricarpos oreophilus* will be present with significant cover in a short-shrub layer. At lower elevations, scattered *Artemisia tridentata* ssp. *vaseyana*, *Pinus edulis*, and *Juniperus osteosperma* are often present. At El Malpais, *Forestiera pubescens* is the most commonly occurring shrub, along with occasional *Ribes cereum*. Other common shrub species may include *Arctostaphylos patula*, *Amelanchier* spp., *Cercocarpus montanus*, *Juniperus communis*, *Mahonia repens*, *Robinia neomexicana*, *Rosa woodsii*, and *Shepherdia rotundifolia*. The herbaceous layer is generally sparse (<10% cover) but may equal the shrub cover. It is composed of mostly graminoids, such as *Bouteloua gracilis*, *Elymus elymoides*, *Festuca arizonica*, *Koeleria macrantha*, *Muhlenbergia longiligula*, *Muhlenbergia montana*, *Poa fendleriana*, *Schizachyrium scoparium*, and *Carex* spp., especially *Carex geyeri* and *Carex rossii*. Scattered forbs include *Artemisia ludoviciana*, *Balsamorhiza sagittata*, *Eriogonum* spp., *Erigeron* spp., *Hymenoxys* spp., *Lithospermum multiflorum*, *Packera multilobata*, and *Wyethia amplexicaulis*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus scopulorum, Pinus ponderosa*
Tree canopy	Broad-leaved deciduous tree	*Quercus gambelii*
Herb (field)	Graminoid	*Muhlenbergia montana*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Tall shrub/sapling	Broad-leaved deciduous tree	*Quercus gambelii*

CHARACTERISTIC SPECIES

El Malpais National Monument

Juniperus scopulorum, Muhlenbergia montana, Pinus ponderosa, Quercus gambelii

Global

Pinus ponderosa, Quercus gambelii

CONSERVATION STATUS RANK

Global Rank & Reasons: G5 (1-Feb-1996).

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

Global Comments

This ponderosa pine woodland is a broadly defined plant association. Stuever and Hayden (1997b) report seven phases for this plant association: the *Quercus gambelii*, *Festuca arizonica*, *Muhlenbergia longiligula*, *Pinus edulis*, *Muhlenbergia montana*, *Bouteloua gracilis*, and *Robinia neomexicana* phases. More classification review is needed to further define the relationships between these phases and other similar plant associations.

Global Similar Associations

- *Abies concolor - (Pseudotsuga menziesii) / Quercus gambelii / Carex* rossii Forest (CEGL005351)
- *Abies concolor - (Pseudotsuga menziesii) / Quercus gambelii / Thalictrum fendleri* Forest (CEGL005352)
- *Abies concolor / Quercus gambelii* Forest (CEGL000261)
- *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland (CEGL000791)
- *Pinus monophylla - Juniperus osteosperma - Quercus gambelii / Artemisia tridentata* Woodland (CEGL000837)
- *Pinus monophylla - Quercus gambelii / Artemisia tridentata* Woodland (CEGL000838)
- *Pseudotsuga menziesii / Quercus gambelii* Forest (CEGL000452)

Global Related Concepts

- *Pinus ponderosa / Poa fendleriana* Community Type (Hanks et al. 1983) =
- *Pinus ponderosa / Quercus gambelii / Carex geyeri* Habitat Type (Hess and Wasser 1982) =
- *Pinus ponderosa / Quercus gambelii / Carex geyeri* Habitat Type (Wasser and Hess 1982) =
- *Pinus ponderosa / Quercus gambelii* Community (Blackburn et al. 1969a) =
- *Pinus ponderosa / Quercus gambelii* Habitat Type (Alexander et al. 1987) =
- *Pinus ponderosa / Quercus gambelii* Habitat Type (Youngblood and Mauk 1985) =
- *Pinus ponderosa / Quercus gambelii* Habitat Type (Muldavin et al. 1996) =
- *Pinus ponderosa / Quercus gambelii* Habitat Type (Fitzhugh et al. 1987) =
- *Pinus ponderosa / Quercus gambelii* Habitat Type (DeVelice et al. 1986) =
- *Pinus ponderosa / Quercus gambelii* Habitat Type (Alexander et al. 1984a) =
- *Pinus ponderosa / Quercus gambelii* Plant Association (Johnston 1987) =
- *Pinus ponderosa / Quercus gambelii* Plant Association (Larson and Moir 1987) =
- *Pinus ponderosa / Quercus gambelii* Plant Association (Stuever and Hayden 1997b) =
- *Pinus ponderosa / Quercus gambelii* Plant Community (Roberts et al. 1992) =
- *Pinus ponderosa/Quercus gambelii* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B
- Ponderosa Pine Series (Diamond 1993) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Bandera Crater, El Calderon, Lava Crater, Cerritos de Jaspe, and The Narrows.

Global Range

This ponderosa pine woodland association is widespread in the southern Rocky Mountains and southwestern U.S. and occurs in foothills, mountains and plateaus from Colorado to Trans-Pecos Texas, west to Arizona and Nevada.

Nations: US

States/Provinces: AZ:S3?, CO:S4, NM:S5, NV, TX:S3, UT:S5, WY

Federal Lands: NPS (Bryce Canyon, Canyon de Chelly, Capitol Reef, Curecanti, El Malpais, Grand Canyon, Grand Canyon-Parashant, Guadalupe Mountains, Sunset Crater Volcano, Walnut Canyon, Zion); USFS (Apache-Sitgreaves, Arapaho-Roosevelt, Cibola, Gila, Lincoln, San Juan, White River NF)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 standard plots from 2005 and 2006: 05MA014, 06AB214, 06JC375, 06JC384, and 06YC009.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.A. Schulz, mod. J. Coles and M.E. Hall

REFERENCES

Alexander et al. 1984a, Alexander et al. 1987, Bader 1932, Blackburn et al. 1969a, Blackburn et al. 1969b, Bourgeron and Engelking 1994, Bradley et al. 1992, Bunin 1975, CONHP unpubl. data 2003, Clary 1992, Cogan et al. 2004, DeVelice et al. 1986, Diamond 1993, Dixon 1935, Donart et al. 1978, Driscoll et al. 1984, Fitzhugh et al. 1987, Hanks et al. 1983, Hansen et al. 2004c, Hansen et al. 2004d, Hanson and Ball 1928, Harmon 1980, Helm 1977, Hess and Wasser 1982, Johnston 1987, Johnston and Hendzel 1985, Larson and Moir 1987, Madany and West 1980, Marr et al. 1973, Muldavin et al. 1996, Nixon 1967, Peet 1975, Peet 1981, Roberts et al. 1992, Savage and Swetnam 1990, Schmoll 1935, Somers et al. 1980, Steinhoff 1978, Stuever and Hayden 1997b, Terwilliger et al. 1979b, USFS 1983a, Wasser and Hess 1982, Western Ecology Working Group n.d., Wright et al. 1973, Youngblood and Mauk 1985

Pinus ponderosa / Bouteloua gracilis Woodland

Ponderosa Pine / Blue Grama Woodland

CODE	CEGL000848
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Savanna Group (G229)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648), Southern Rocky Mountain Ponderosa Pine Savanna (CES306.649)

ELEMENT CONCEPT

Global Summary

This widespread woodland occurs at foothill and lower montane elevations from the southern Rocky Mountains, extending east onto southern Great Plains escarpments, south to the mountains of western Texas, and west to the Colorado Plateau and Mogollon Rim of New Mexico, Arizona and Utah. Sites occur on dry, gentle to steep slopes of all aspects, but are more common on southern and western aspects, especially at higher elevations, which range from 1740-2610 m (5700-8550 feet). Substrates are quite variable and include shallow sandy loam soils derived from granitic parent materials, coarse cinder soils, and clayey soil with or without high coarse fragment content. The ground surface is typically characterized by scattered grass patches and litter amid exposed soil. The vegetation is characterized by an open to moderately dense evergreen, needle-leaved tree canopy 10-30 m tall that is typically dominated by *Pinus ponderosa*. Some stands may be codominated by *Pinus edulis*. *Juniperus* spp. may be important subdominants. The shrub canopy is variable and usually low in cover. *Ericameria nauseosa*, *Fallugia paradoxa*, and *Gutierrezia sarothrae* are the most common shrub elements. The typically moderately dense herbaceous layer has greater cover than the shrub layer and is dominated by graminoids. The warm-season, sod-forming shortgrass *Bouteloua gracilis* dominates the herbaceous layer; *Poa* *fendleriana*, *Elymus elymoides*, and *Muhlenbergia montana* are all frequent associates but subordinate. Forb cover is typically sparse to well-represented and most commonly includes semi-arid woodland and plains grassland species such as *Artemisia carruthii*, *Sphaeralcea coccinea*, *Bahia dissecta*, *Hymenoxys richardsonii*, *Glandularia bipinnatifida*, *Lotus wrightii*, and *Heterotheca villosa*.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2100 and 2360 m (6875-7750 feet) elevation on basalt lavaflows (Bandera, Twin Craters, and Hoya flows, and on the surrounding old basalt plains and kipukas) with a veneer of eolian-deposited soils, and occasionally on sandstone-based hillslopes. The ground surface is characterized by scattered bunch grasses intermixed with litter, bare soil deposits, and exposed lava rock or sandstone.

Global Environment

This widespread woodland occurs at foothill and lower montane elevations from the southern Rocky Mountains, extending east onto southern Great Plains escarpments, south to the mountains of western Texas, and west to the Colorado Plateau and Mogollon Rim of New Mexico, Arizona and Utah. Elevation ranges from 1740-2610 m (5700-8550 feet). Sites occur on dry, gentle to steep slopes of all aspects, but are more common on southern and western aspects, especially at higher elevations. Substrates are quite variable and include shallow sandy loam soils derived from granitic parent materials, coarse cinder soils, and clayey soil with or without high coarse fragment content.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

These open-canopied (10-40% cover) tall woodlands are dominated by *Pinus ponderosa* with short-statured conifers such as *Juniperus scopulorum* or *Pinus edulis* sometimes present in the subcanopy. The shrub canopy is variable and usually low in cover. *Ericameria nauseosa*, *Fallugia paradoxa*, and *Gutierrezia sarothrae* are the most common shrub elements. The association is characterized by a rich herbaceous layer dominated by graminoids. *Bouteloua gracilis* is well-represented to abundant and diagnostic. *Poa fendleriana*, *Elymus elymoides*, and *Muhlenbergia montana* are all frequent associates but subordinate. Overall species richness is moderately high with 24 graminoids and 64 forbs identified for the association. Forbs can be well-represented and most commonly include semi-arid woodland and plains grassland species such *Artemisia carruthii*, *Sphaeralcea coccinea*, *Bahia dissecta*, *Hymenoxys richardsonii*, *Glandularia bipinnatifida*, *Lotus wrightii*, and *Heterotheca villosa*.

Global Vegetation

This plant association is characterized by an open to moderately dense evergreen, needle-leaved tree canopy 10-30 m tall that is typically dominated by *Pinus ponderosa*. Some stands may be codominated by *Pinus edulis*. *Juniperus monosperma*, *Juniperus osteosperma*, *Juniperus deppeana*, or *Juniperus scopulorum* may be important subdominants. The shrub canopy is variable and usually low in cover. *Ericameria nauseosa*, *Fallugia paradoxa*, and *Gutierrezia sarothrae* are the most common shrub elements. Other shrubs may include scattered *Artemisia tridentata*, *Ceanothus fendleri*, *Cercocarpus montanus*, *Chrysothamnus viscidiflorus*, *Purshia tridentata*, *Quercus grisea*, *Rhus trilobata*, and *Tetradymia canescens*. The typically moderately dense herbaceous layer has greater cover than the shrub layer and is dominated by graminoids. The warm-season, sod-forming shortgrass *Bouteloua gracilis* dominates the herbaceous layer. Common graminoid associates include *Aristida* spp., *Bouteloua hirsuta*, *Carex geophila*, *Elymus elymoides*, *Hesperostipa comata*, *Koeleria macrantha*, *Muhlenbergia montana*, *Poa fendleriana*, or *Schizachyrium scoparium*. *Quercus gambelii* may be present in the sparse shrub layer (<10% cover) with low cover (<5%). Forb cover is typically sparse and may include species such as *Antennaria* spp., *Artemisia ludoviciana*, *Artemisia carruthii*, *Sphaeralcea coccinea*, *Bahia dissecta*, *Hymenoxys richardsonii*, *Glandularia bipinnatifida*, *Lotus wrightii*, *Heterotheca villosa*, *Erigeron* spp., *Eriogonum racemosum*, *Chaetopappa ericoides*, *Packera neomexicana*, and *Penstemon* spp.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Bouteloua gracilis*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia carruthii, Bouteloua gracilis, Elymus elymoides, Heterotheca villosa, Muhlenbergia montana, Pinus edulis, Pinus ponderosa, Poa fendleriana

Global

Bouteloua gracilis, Pinus ponderosa

CONSERVATION STATUS RANK

Global Rank & Reasons: G4 (1-Feb-1996).

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

Global Comments

This ponderosa pine woodland is a broadly defined plant association. Stuever and Hayden (1997b) report 6 phases: the *Bouteloua gracilis*, *Schizachyrium scoparium*, *Andropogon hallii*, *Artemisia tridentata*, *Quercus grisea*, and *Quercus gambelii* phases. Hanks et al. (1983) described 4 phases of the *Pinus ponderosa* / *Bouteloua gracilis* Habitat Type from northern Arizona. More classification review is needed to further define the relationships between these phases and other similar plant associations. Alexander et al. (1987), DeVelice et al. (1986), and Muldavin et al. (1996) also described phases of this Habitat Type that need further review and cross-walking to the USNVC. Youngblood and Mauk (1985) included stands of this association in their broadly defined *Pinus ponderosa* / *Muhlenbergia montana* Habitat Type.

Global Similar Associations

- *Pinus ponderosa* / *Muhlenbergia montana* Woodland (CEGL000862)

Global Related Concepts

- *Pinus edulis - P. ponderosa* / *Bouteloua gracilis - Carex* spp. Plant Community (Francis 1986) =
- *Pinus ponderosa - Juniperus* / *Bouteloua gracilis* Plant Association (Johnston 1987) =
- *Pinus ponderosa* / *Bouteloua gracilis* Habitat Type (Fitzhugh et al. 1987) =
- *Pinus ponderosa* / *Bouteloua gracilis* Habitat Type (Alexander et al. 1987) =

- *Pinus ponderosa / Bouteloua gracilis* Habitat Type, *Bouteloua gracilis* Phase (DeVelice et al. 1986) =
- *Pinus ponderosa / Bouteloua gracilis* Habitat Type, *Bouteloua gracilis* Phase (Muldavin et al. 1996) =
- *Pinus ponderosa / Bouteloua gracilis* Habitat Type, *Pinus edulis* Phase (Hanks et al. 1983) =
- *Pinus ponderosa / Bouteloua gracilis* Plant Association (Johnston 1987) =
- *Pinus ponderosa / Bouteloua gracilis* Plant Association (Stuever and Hayden 1997b) =
- *Pinus ponderosa / Bouteloua gracilis* Plant Association (Larson and Moir 1987) =
- *Pinus ponderosa / Carex* spp. - *Bouteloua gracilis* Plant Community (Francis 1986) =
- *Pinus ponderosa / Muhlenbergia montana* Habitat Type (Youngblood and Mauk 1985) =
- *Pinus ponderosa /Bouteloua gracilis* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B
- Ponderosa Pine Series (Diamond 1993) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Bandera, Cerro Rendija, Cerritos de Jaspe, Zuni-Acoma Trail, Little Hole-In-The-Wall and the Hoya flow to the south, Hole-In-The-Wall and the Bandera flow to the north, and the McCarty's flow west of the Lava Falls Area.

Global Range

This ponderosa pine woodland occurs in the southern Rocky Mountains, extending east on southern Great Plains escarpments as far as Oklahoma, south to the mountains of western Texas, west to the Colorado Plateau and Mogollon Rim of New Mexico, Arizona, and southern Utah.

Nations: US

States/Provinces: AZ:S4, CO:S4, NM:S4, OK, TX:S3, UT, WY

Federal Lands: NPS (Bandelier, Canyon de Chelly, El Malpais, Grand Canyon, Sunset Crater Volcano, Walnut Canyon); USFS (Cibola)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 26 field plots from 2006 and 2007: 06AB203, 06AB222, 06JC222, 06JC223, 06JC235, 06JC285, 06JC287, 06JC291, 06JC295, 06JC296, 06JC326, 06JC335, 06YC001, 06YC034, 06YC036, 06YC060, 06YC063, 06YC087, 06YC098, 06YC100, 06YC105, 06YC149, 07AB010, 07AB015, 07AB016, and 07AB018.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.A. Schulz, mod. K.S. King and M.E. Hall

REFERENCES

Alexander et al. 1987, Bourgeron and Engelking 1994, Bradley et al. 1992, Bruner 1931, CONHP unpubl. data 2003, DeVelice et al. 1986, Diamond 1993, Driscoll et al. 1984, Fitzhugh et al. 1987, Francis 1986, Hanks et al. 1983, Hansen et al. 2004c, Hansen et al. 2004d, Hibner 2009, Hoagland 2000, Johnston 1987, Larson and Moir 1987, Madany and West 1980, Muldavin et al. 1996, Savage and Swetnam 1990, Stuever and Hayden 1997b, Western Ecology Working Group n.d., Wright and Bailey 1980, Youngblood and Mauk 1985

Pinus ponderosa / Festuca arizonica Woodland

Ponderosa Pine / Arizona Fescue Woodland

CODE	CEGL000856
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Savanna Group (G229)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648), Southern Rocky Mountain Ponderosa Pine Savanna (CES306.649)

ELEMENT CONCEPT

Global Summary

This ponderosa pine woodland association is known from mountains in Colorado, New Mexico, Arizona and the Trans-Pecos (Mt. Livermore in the Davis Mountains) of Texas. It occurs on all aspects and landscape positions within an elevational range of 2195-2900 m (7200-9500 feet). Slopes are gentle to very steep. This association is the coolest and wettest of grassy *Pinus ponderosa* types, and soils are typically deeper than other related *Pinus* types. This woodland has an open parklike character with scattered trees (not more then 50% cover) and an abundant herbaceous understory. *Pinus ponderosa* is the dominant tree and the climax overstory species. In the southern portion of its range, other species may be present in the canopy, including *Pinus edulis*, *Pinus cembroides*, and *Pinus strobiformis*. *Pseudotsuga menziesii* and *Juniperus deppeana* are occasionally present. Shrubs are scarce but are often present; species vary with latitude and include *Quercus gambelii*, *Artemisia tridentata*, *Chrysothamnus depressus*, *Ribes cereum*, *Ceanothus fendleri*, *Symphoricarpos oreophilus*, and *Mahonia repens*. Dominance by grasses and sometimes forbs is diagnostic for this type. *Festuca arizonica* and *Muhlenbergia montana* are consistently present. *Bouteloua gracilis* and *Danthonia parryi* can be very abundant in relatively dry or wet stands, respectively.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association is found on the cinder slopes of Cerro Bandera. The surface is covered with rocks and some gravel, along with a substantial amount of litter (20% of total cover) and a small amount of wood.

Global Environment

This association occurs on all aspects and landscape positions within an elevational range of 2195-2900 m (7200-9500 feet). Slopes are gentle to very steep. Soils are predominantly Borolls, with low coarse fragments. The habitat is the coolest and wettest of grassy *Pinus ponderosa* types, and soils are typically deeper than other related *Pinus* types.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

In this open woodland savanna, mature *Pinus ponderosa* trees are the primary component of the tree canopy, along with occasional young *Pinus edulis* and mature *Juniperus deppeana*. Shrubs are very few in this association, but the herbaceous layer is abundant. In the inter-tree spaces, the bunchgrass *Festuca arizonica* dominates along with scattered forbs such as *Antennaria marginata* and *Lithospermum multiflorum*.

Global Vegetation

Pinus ponderosa is the dominant tree and the climax overstory species. *Pseudotsuga menziesii* and *Juniperus deppeana* are occasionally present. Dominance by grasses and sometimes forbs is diagnostic for this type. Shrubs, when present never exceed 5% cover. *Festuca arizonica* and *Muhlenbergia montana* are consistently present. *Bouteloua gracilis* and *Danthonia parryi* can be very abundant in relatively dry or wet stands, respectively. At high elevations in the Trans-Pecos mountains of Texas and on sky islands of Arizona, other species may be present in the canopy, including *Pinus edulis*, *Pinus cembroides*, and *Pinus strobiformis*. Shrubs are scarce but are often present; species vary with latitude and include *Quercus gambelii*, *Artemisia tridentata*, *Chrysothamnus depressus*, *Ribes cereum*, *Ceanothus fendleri*, *Symphoricarpos oreophilus*, and *Mahonia repens*. The understory is densely grassy with medium-tall grasses, including *Festuca arizonica*, *Bouteloua gracilis*, *Danthonia parryi*, *Piptochaetium fimbriatum*, *Piptochaetium pringlei*, *Achnatherum lobatum* (= *Stipa lobata*), *Bothriochloa barbinodis* (= var. *barbinodis*), *Schizachyrium scoparium* var. *scoparium* (= *Schizachyrium scoparium* ssp. *neomexicanum*), *Muhlenbergia rigida*, *Muhlenbergia montana*, *Elymus elymoides*, and *Panicum bulbosum*. Other species include *Allium cernuum*, *Campanula rotundifolia*, *Silene laciniata*, and *Ageratina rothrockii* (= *Eupatorium rothrockii*).

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Festuca arizonica*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Festuca arizonica, Muhlenbergia montana*

CHARACTERISTIC SPECIES

El Malpais National Monument

Achillea millefolium, Antennaria marginata, Festuca arizonica, Hymenoxys richardsonii, Ipomopsis aggregata, Juniperus deppeana, Koeleria macrantha, Lithospermum multiflorum, Pinus edulis, *Pinus ponderosa*

Global

Festuca arizonica, *Muhlenbergia montana*, *Pinus ponderosa*

CONSERVATION STATUS RANK

Global Rank & Reasons: G4 (1-Feb-1996).

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

Global Related Concepts

- *Pinus ponderosa/Festuca arizonica* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B
- Ponderosa Pine Series (Diamond 1993) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Bandera.

Global Range

This association is known from mountains in Colorado, New Mexico, Arizona and the Trans-Pecos Mountains (Mt. Livermore in the Davis Mountains) of Texas.

Nations: US

States/Provinces: AZ:S4, CO:S4, NM:S4, TX:S3, WY

Federal Lands: NPS (El Malpais, Florissant Fossil Beds, Great Sand Dunes); USFS (Cibola)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 1 field plot from 2006: 06JC347.

Local Description Authors: E. Muldavin and A. Cully

Global Description Authors: G. Kittel, mod. M.E. Hall

REFERENCES

Alexander et al. 1987, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Clary 1978, Clary and Pearson 1969, Costello 1944, Costello 1954, Costello and Schwan 1946, DeVelice 1983, DeVelice and Ludwig 1983, DeVelice et al. 1986, Diamond 1993, Driscoll et al. 1984, Fitzhugh et al. 1987, Hanks et al. 1983, Johnson 1945, Johnson 1953, Johnson 1956, Johnson and Klipple 1946, Johnson and Niederhof 1941, Johnson and Reid 1958, Johnson and Reid 1964, Johnston 1987, Komarkova et al. 1988b, Larson and Moir 1987, Merkle 1962, Moir and Ludwig 1979, Nichol 1937, Shepherd 1975, Smith 1967, Swift 1974, USFS 1983a, Western Ecology Working Group n.d.

***Pinus ponderosa / Muhlenbergia montana* Woodland**

Ponderosa Pine / Mountain Muhly Woodland

CODE	CEGL000862
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Savanna Group (G229)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648)

ELEMENT CONCEPT

Global Summary

This widespread woodland occurs at foothill and lower montane elevations in the southern Rocky Mountains, extending south to the mountains of western Texas, and west to the Mogollon Rim and Colorado Plateau of New Mexico, Arizona and Utah. Elevation ranges from 1890 to 2870 m (6190-9400 feet). Stands occur on bottomlands, elevated plains, cinder cones, piedmont slopes, mesas, foothills, and mountains. Sites include gentle to steep slopes on all aspects, but are more common on southern and western aspects, especially at higher elevations. Substrates are variable but are typically shallow, rocky, coarse-textured soils derived from granitic or cinder parent materials. There is considerable cover of bare soil and exposed bedrock. The vegetation is characterized by an open to moderately dense evergreen, needle-leaved tree canopy to 10-30 m tall that is dominated or codominated by *Pinus ponderosa*. Associated tree species vary geographically. *Pinus edulis*, *Pinus discolor*, and *Juniperus* spp. may be important in the tree canopy. *Pseudotsuga menziesii*, *Pinus flexilis*, and *Populus tremuloides* may also be present but are considered accidental. *Quercus gambelii* may be present with low cover (to 5%) in the sparse shrub layer (<10% cover). Other scattered shrubs may include *Artemisia tridentata*, *Ceanothus fendleri*, *Cercocarpus montanus*, *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, *Juniperus communis*, *Purshia tridentata*, *Rhus trilobata*, *Ribes cereum*, or *Yucca baccata*. The typically moderately dense herbaceous layer has greater cover than the shrub layer and is dominated by graminoids. *Muhlenbergia montana*, a warm-season, medium-tall perennial, typically dominates the herbaceous layer and is diagnostic of this association. Common graminoid associates include *Aristida* spp., *Blepharoneuron tricholepis*, *Bouteloua gracilis*, *Carex geophila*, *Carex rossii*, *Elymus elymoides*, *Koeleria macrantha*, *Poa fendleriana*, and *Schizachyrium scoparium*. *Festuca arizonica*, *Muhlenbergia virescens*, *Muhlenbergia dubia*, *Muhlenbergia emersleyi*, and *Hesperostipa* spp. are typically absent. Forb cover is typically sparse and highly variable.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2090 and 2490 m (6870-8180 feet) elevation on a variety of aspects and landforms including very gently rolling lava plateaus (Bandera, Hoya de Cibola, Twin Craters, and Old Basalt flows), gentle to very steep slopes of volcano cones (Bandera Crater and Twin Craters), and gentle to very steep sideslopes of low sandstone hills. Substrates are typically derived from volcanic basalt or scoria, though occasionally from limestone or sandstone. Ground surface cover is commonly dominated by rock or litter, and gravel may be well-represented or uncommon. Soil is occasionally well-developed, although usually sparse. Coarse woody debris cover is low to common, and cryptogamic cover is low. There is evidence of past fires, both older (40-50 years ago) and within the last several years.

Global Environment

This widespread woodland occurs at foothill and lower montane elevations in the southern Rocky Mountains, extending south to the mountains of western Texas, and west to the Mogollon Rim and Colorado Plateau. Elevation ranges from 1890-2870 m (6190-9400 feet). Stands occur on bottomlands, elevated plains, cinder cones, piedmont slopes, mesas, foothills, and mountains. Sites include gentle to steep slopes on all aspects, but are more common on southern and western aspects, especially at higher elevations. Substrates are variable, but are typically shallow, rocky, coarse-textured soils derived from granitic or cinder parent materials. There is considerable cover of bare soil and exposed bedrock.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Pinus ponderosa dominates the tree canopies of this association, which range from open savanna (10%) to very closed (85%). The trees are typically mature, although regeneration occurs occasionally and there are a few areas with slender (=<1 cm diameter), dense saplings. Sometimes *Pseudotsuga menziesii* occurs with the ponderosa pine, as well as *Juniperus scopulorum* and *Pinus edulis*. The shrub canopy is variable, ranging from low to moderate in cover; *Ribes cereum* is the most frequently occurring shrub, with scattered individuals of other species such as *Fallugia paradoxa*, *Rhus trilobata*, and *Quercus* × *pauciloba* recorded in plots of this association. The herbaceous layer is also variable; relative cover is usually low (probably due primarily to the lack of soil development in many areas) but occasionally abundant. Overall species richness is very high, with around 28 graminoids and 112 forbs identified. *Muhlenbergia montana* occurs throughout the association and is the dominant graminoid (and herbaceous) species. *Bouteloua gracilis*, *Poa fendleriana*, and *Schizachyrium scoparium* occur less frequently and are lower in cover. *Heterotheca villosa* is the most frequently found forb in plots, followed by *Artemisia carruthii* and *Bahia dissecta*.

Global Vegetation

This association is characterized by an open to moderately dense evergreen, needle-leaved tree canopy to 10-30 m tall that is dominated or codominated by *Pinus ponderosa*. Associated tree species vary geographically. *Pinus edulis*, *Pinus discolor*, *Juniperus monosperma*, *Juniperus osteosperma*, *Juniperus deppeana*, and *Juniperus scopulorum* may be important in the tree canopy. *Pseudotsuga menziesii*, *Pinus flexilis*, and *Populus tremuloides* may also be present, but are considered accidental. *Quercus gambelii* may be present with low cover (to 5%) in the sparse shrub layer (<10% cover). Other scattered shrubs may include *Artemisia tridentata*, *Brickellia californica*, *Ceanothus fendleri*, *Cercocarpus montanus*, *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, *Fallugia paradoxa*, *Mahonia* spp., *Purshia tridentata*, *Quercus grisea*, *Rhus trilobata*, *Tetradymia canescens*, or *Yucca baccata*. The typically moderately dense herbaceous layer has greater cover than the shrub layer, and is dominated by graminoids. *Muhlenbergia montana*, a warm-season, medium-tall perennial, typically dominates the herbaceous layer and is diagnostic of this association. Common graminoid associates include *Aristida* spp., *Blepharoneuron tricholepis*, *Bouteloua gracilis*, *Carex geophila*, *Carex rossii*, *Elymus elymoides*, *Koeleria macrantha*, *Poa fendleriana*, and *Schizachyrium scoparium*. *Festuca arizonica*, *Muhlenbergia virescens*, *Muhlenbergia dubia*, *Muhlenbergia emersleyi*, and *Hesperostipa* spp. are typically absent. Forb cover is typically sparse and may include species such as *Antennaria* spp., *Artemisia ludoviciana*, *Erigeron* spp., *Eriogonum racemosum*, *Chaetopappa ericoides*, *Lotus wrightii*, *Oxytropis lambertii*, *Packera neomexicana*, and *Penstemon* spp.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Muhlenbergia montana*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus edulis, Pinus ponderosa*
Herb (field)	Graminoid	*Muhlenbergia montana*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, *Heterotheca villosa*, *Muhlenbergia montana*, *Pinus ponderosa*, *Poa fendleriana*, *Schizachyrium scoparium*

Global

Muhlenbergia montana, *Pinus ponderosa*

CONSERVATION STATUS RANK

Global Rank & Reasons: G4G5 (1-Feb-1996).

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

El Malpais National Monument Comments

A *Poa fendleriana* phase occurs in stands where there is a strong component of cool-season grasses which can also include *Elymus elymoides*, *Koeleria macrantha*, or *Carex* spp.

Global Comments

This ponderosa pine woodland is a broadly defined plant association. Stuever and Hayden (1997b) suggested the xeric upland and mesic bottomland stands be put into different phases. Fitzhugh et al. (1987) suggested it be divided into regional phases.

Global Similar Associations

- *Pinus ponderosa* / *Bouteloua gracilis* Woodland (CEGL000848)
- *Pseudotsuga menziesii* / *Muhlenbergia montana* Forest (CEGL000443)

Global Related Concepts

- *Pinus ponderosa - Pseudotsuga menziesii* / *Muhlenbergia montana* Habitat Type (Johnston 1987) ?
- *Pinus ponderosa* / *Muhlenbergia montana* Cover Type (Balice et al. 1997) ?
- *Pinus ponderosa* / *Muhlenbergia montana* Habitat Type (Wasser and Hess 1982) =
- *Pinus ponderosa* / *Muhlenbergia montana* Habitat Type (Youngblood and Mauk 1985) =
- *Pinus ponderosa* / *Muhlenbergia montana* Habitat Type (Hess and Alexander 1986) =
- *Pinus ponderosa* / *Muhlenbergia montana* Habitat Type (Alexander et al. 1987) =
- *Pinus ponderosa* / *Muhlenbergia montana* Habitat Type (Fitzhugh et al. 1987) =
- *Pinus ponderosa* / *Muhlenbergia montana* Habitat Type (Muldavin et al. 1996) =
- *Pinus ponderosa* / *Muhlenbergia montana* Habitat Type (Hess 1981) =
- *Pinus ponderosa* / *Muhlenbergia montana* Habitat Type (DeVelice et al. 1986) =
- *Pinus ponderosa* / *Muhlenbergia montana* Plant Association (Stuever and Hayden 1997b) =
- *Pinus ponderosa* / *Muhlenbergia montana* Plant Association (Larson and Moir 1987) =
- *Pinus ponderosa* / *Muhlenbergia montana* Plant Association (Baker 1984) =
- *Pinus ponderosa* / *Muhlenbergia montana* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B
- Ponderosa Pine Series (Diamond 1993) B
- Xeric Foothill Woodland (A3) (Peet 1981) I
- Xeric Montane Woodland (A5) (Peet 1981) I

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This widespread association is known from Cerro Bandera, Bandera Crater and along the Chain of Craters Backcountry Byway to the south, Twin Craters, Lava Crater, El Calderon, Cerritos de Jaspe, Cerro Rendija, Little Hole-In-The-Wall and the Hoya de Cibola flow to the south, Mesita Blanca, Hole-In-The-Wall and the Bandera flow to the north, and the McCarty's flow to the north of the Pilares Windmill.

Global Range

This widespread woodland occurs at foothill and lower montane elevations in the southern Rocky Mountains, extending south to the mountains of western Texas, and west to the Mogollon Rim and Colorado Plateau of New Mexico, Arizona and Utah.

Nations: US

States/Provinces: AZ:S4, CO:S2S3, NM:S4, TX:S3, UT:S4S5, WY

Federal Lands: NPS (Bandelier, El Malpais, Great Sand Dunes, Guadalupe Mountains, Rocky Mountain, Sunset Crater Volcano, Walnut Canyon); USFS (Arapaho-Roosevelt, Cibola)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 73 field plots from 2005, 2006, and 2007: 05MA003, 05MA013, 06AB208, 06AB215, 06AB221, 06AB226, 06JC218, 06JC221, 06JC225, 06JC227, 06JC243, 06JC245, 06JC248, 06JC266, 06JC289, 06JC293, 06JC294, 06JC300, 06JC302, 06JC303, 06JC306, 06JC307, 06JC308, 06JC310, 06JC311, 06JC312, 06JC314, 06JC315, 06JC318, 06JC323, 06JC332, 06JC339, 06JC341, 06JC345, 06JC349, 06YC003, 06YC010, 06YC014, 06YC015, 06YC016, 06YC044, 06YC045, 06YC047, 06YC048, 06YC052, 06YC053, 06YC054, 06YC055, 06YC058, 06YC062, 06YC064, 06YC066, 06YC068, 06YC070, 06YC073, 06YC079, 06YC088, 06YC090, 06YC091, 06YC092, 06YC093, 06YC095, 06YC102, 06YC103, 06YC104, 07AB002, 07AB003, 07AB004, 07AB005, 07AB025, 07AB026, 07AB027, and 07AB028.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.A. Schulz

REFERENCES

Alexander et al. 1987, Baker 1984, Balice et al. 1997, Bourgeron and Engelking 1994, Bradley et al. 1992, CONHP unpubl. data 2003, DeVelice 1983, DeVelice and Ludwig 1983, DeVelice et al. 1986, Diamond 1993, Driscoll et al. 1984, Fischer and Bradley 1987, Fitzhugh et al. 1987, Hanks et al. 1983, Hansen et al. 2004c, Hansen et al. 2004d, Hess 1981, Hess and Alexander 1986, Hibner 2009, Johnston 1987, Larson and Moir 1987, Madany and West 1980, Muldavin et al. 1996, Peet 1975, Peet 1981, Savage and Swetnam 1990, Stuever and Hayden 1997a, Stuever and Hayden 1997b, Terwilliger et al. 1979b, Wasser and Hess 1982, Western Ecology Working Group n.d., Youngblood and Mauk 1985

***Pinus ponderosa / Schizachyrium scoparium* Woodland**

Ponderosa Pine / Little Bluestem Woodland

CODE	CEGL000201
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain Ponderosa Pine Savanna Group (G229)

ECOLOGICAL SYSTEM(S)

Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna (CES303.650), Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648)

ELEMENT CONCEPT

Global Summary

This ponderosa pine / little bluestem association is a dry woodland found in the Great Plains of the United States extending west to the mountains of New Mexico, Colorado and Wyoming. In the Great Plains, it usually occurs on south- and west-facing slopes of hills, rocky breaks, and watercourses. In the western portion of its range, this association occurs at mid-elevation, ranging from 1780 and 2430 m (5840-7970 feet), on sites with low to high solar exposure that increases with elevation. Stands occur on gentle slopes of mesatops and shoulders (5-10%) and occasionally on steep (40%) upper canyon slopes. Soils are primarily mapped as well-developed Mollisols derived from pumice slope alluvium, or occasionally as fine-textured Alfisols derived from mixed eolian, and rarely, Aridisols derived from colluvial basalts. At El Malpais National Monument in western New Mexico, it occurs on collapse features and on the tops of very gently rolling lava plateaus. The topography varies from fractured basalt and rocky mounds to flatter areas with some soil development. Substrates are derived from volcanic basalt, and ground surface is typically dominated by rock with litter well-represented. Elsewhere, the ground surface is typically characterized by scattered bunch grasses amid pumice gravel and litter. In the Great Plains, the overstory is dominated by *Pinus ponderosa*. *Juniperus scopulorum* may often be present, but typically only as scattered individuals. The shrub layer is composed of species such as *Juniperus scopulorum*, *Rhus trilobata*, and *Symphoricarpos* spp. *Schizachyrium scoparium* is the most abundant graminoid, often accompanied by *Andropogon gerardii*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Carex inops* ssp. *heliophila*, *Carex siccata* (= *Carex foenea*), *Hesperostipa comata* (= *Stipa comata*), *Pascopyrum smithii*, and *Poa pratensis*. Common forbs include *Achillea millefolium*, *Phlox hoodii*, and *Allium* spp. In New Mexico, this open woodland / savanna is dominated by *Pinus ponderosa* with canopies that range from 10-30% cover with other tree species (*Pinus edulis*, *Pseudotsuga menziesii*, *Quercus gambelii*) rare or incidental. *Pinus ponderosa* seedling and sapling reproduction is typically present. *Juniperus monosperma* and *Pinus edulis* saplings are also occasionally present in the subcanopy. Shrubs are usually poorly represented (occasionally *Robinia neomexicana* or *Ribes cereum* are well-represented). Stands are distinctively grassy (cover can reach 30%). Dominant graminoids include prairie species *Schizachyrium scoparium* along with *Muhlenbergia montana*, *Poa fendleriana*, and *Elymus elymoides*. *Bouteloua gracilis*, while often present, is clearly subdominant. Numerous forb species may be common to well-represented and are variable from stand to stand.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between around 2200 and 2330 m (7230-7700 feet) elevation in collapse features and on the tops of very gently rolling lava plateaus (Bandera Crater, Twin Craters, Hoya de Cibola flows, and Hoya de Cibola shield volcano). The topography varies from fractured basalt and rocky mounds to flatter areas with some soil development. Substrates are derived from volcanic basalt, and ground surface is typically dominated by rock with litter well-represented. There is evidence of previous fires and logging in some areas.

Global Environment

This community is usually found on south-facing slopes and in rocky breaks. The soils are derived from limestone and sandstone (Johnston 1987, McAdams et al. 1998). Slopes are usually moderately inclined. In the Great Plains, it usually occurs on south- and west-facing slopes of hills, rocky breaks, and watercourses. In the western portion of its range, this association occurs at mid-elevation, ranging from 1780 and 2430 m (5840-7970 feet), on sites with low to high solar exposure that increases with elevation. Stands occur on gentle slopes of mesatops and shoulders (5-10%) and occasionally on steep (40%) upper canyon slopes. Soils are primarily mapped as well-developed Mollisols derived from pumice slope alluvium, or occasionally as fine-textured Alfisols derived from mixed eolian, and rarely, Aridisols derived from colluvial basalts (Hibner 2009). At El Malpais National Monument in western New Mexico, it occurs on collapse features and on the tops of very gently rolling lava plateaus. The topography varies from fractured basalt and rocky mounds to flatter areas with some soil development. Substrates are derived from volcanic basalt, and ground surface is typically dominated by rock with litter well-represented. Elsewhere, the ground surface is typically characterized by scattered bunch grasses amid pumice gravel and litter.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this association are very open (25-35%) and are dominated by *Pinus ponderosa* with other tree species (*Pinus edulis*, *Pseudotsuga menziesii*, *Quercus gambelii*) rare or incidental. Sapling ponderosa pine are poorly represented or absent. The shrub canopy is variable, ranging from scarce to well-represented, with *Ribes cereum* most commonly found. Herbaceous species in this association vary from common to well-represented, and graminoids predominate. The diagnostic species *Schizachyrium scoparium* is dominant or codominant, and *Poa fendleriana* is the most common associate. Forbs are scarce to well-represented and most frequently include the xeric woodland species *Artemisia carruthii*, *Bahia dissecta*, and *Heterotheca villosa*.

Global Vegetation

This community is dominated by *Pinus ponderosa* in the overstory and dry prairie graminoids in the understory. *Juniperus scopulorum* may be present as a tall shrub or small tree, but typically only as scattered individuals. Other shrubs that are typically found are *Rhus aromatica*, *Symphoricarpos* spp., and *Yucca glauca*. *Schizachyrium scoparium* is the most abundant graminoid, often accompanied by *Pascopyrum smithii*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Hesperostipa comata* (= *Stipa comata*), *Poa pratensis*, *Andropogon gerardii*, and *Carex siccata* (= *Carex foenea*). Common forbs include *Achillea millefolium*, *Phlox hoodii*, and *Allium* spp. In the Great Plains, the overstory is dominated by *Pinus ponderosa*. *Juniperus scopulorum* may often be present, but typically only as scattered individuals. The shrub layer is composed of species such as *Juniperus scopulorum*, *Rhus trilobata*, and *Symphoricarpos* spp. *Schizachyrium scoparium* is the most abundant graminoid, often accompanied by *Andropogon gerardii*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Carex inops* ssp. *heliophila*, *Carex siccata*, *Hesperostipa*, *Pascopyrum smithii*, and *Poa pratensis*. In New Mexico, this open woodland / savanna is dominated by *Pinus ponderosa* with canopies that range from 10-30% cover with other tree species (*Pinus edulis*, *Pseudotsuga menziesii*, *Quercus gambelii*) rare or incidental. *Pinus ponderosa* seedling and sapling reproduction is typically present. *Juniperus monosperma* and *Pinus edulis* saplings are also occasionally present in the subcanopy. Shrubs are usually poorly represented (occasionally *Robinia neomexicana* or *Ribes cereum* are well-represented). Stands are distinctively grassy (cover can reach 30%). Dominant graminoids include *Elymus elymoides*, *Muhlenbergia montana*, *Poa fendleriana*, and *Schizachyrium scoparium*. *Bouteloua gracilis* is often present but not dominant. Numerous forb species may be common to well-represented and are variable from stand to stand. The most frequent and abundant forbs include *Bahia dissecta*, *Heterotheca villosa*, *Liatris punctata*, and *Lithospermum multiflorum*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Schizachyrium scoparium*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus scopulorum, Pinus ponderosa*
Herb (field)	Graminoid	*Schizachyrium scoparium*

CONSERVATION STATUS RANK

Global Rank & Reasons: G3G4 (24-May-2010). There are probably more than 100 occurrences of this community rangewide. It is reported from Nebraska (where it is ranked S3S4, and is common in much of the

Wildcat Hills and Pine Ridge), South Dakota, Wyoming (S2?), Colorado (S1), New Mexico, and Montana (S2?); it may also occur in Oklahoma. Historical acreage and trends are unknown, but its persistence is dependent on a combination of drought and fires.

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

El Malpais National Monument Comments

A *Poa fendleriana* phase was identified from this association in stands where there is a strong component of cool-season grasses which can also include *Elymus elymoides*, *Koeleria macrantha*, or *Muhlenbergia montana*.

Global Comments

Steinauer and Rolfsmeier (2000) suggest that, in Nebraska, stands dominated by *Schizachyrium scoparium* are more savanna-like. The savanna structure (10-25% tree canopy) cover was formerly treated as a separate type (CEGL002019), but is now treated as a savanna phase of this woodland type, which typically has 25-60% canopy cover. Nebraska's woodland stands may best fit with *Pinus ponderosa* / *Carex inops* ssp. *heliophila* Woodland (CEGL000849).

Global Similar Associations

- *Pinus ponderosa* / (*Andropogon gerardii, Schizachyrium scoparium*) Woodland (CEGL000841)--Should be archived, same as this type.
- *Pinus ponderosa* / *Carex inops* ssp. *heliophila* Woodland (CEGL000849)--Some similarity exists, with *Pinus ponderosa* / *Schizachyrium scoparium* dominant under more open tree canopies.
- *Pinus ponderosa* / *Pascopyrum smithii* Woodland (CEGL000188)--More mesic graminoids, and lower slopes.
- *Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia* Herbaceous Vegetation (CEGL001681)

Global Related Concepts

- *Pinus ponderosa - Schizachyrium scoparium - Elytrigia smithii* Plant Association (Johnston 1987) ?
- *Pinus ponderosa - Schizachyrium scoparium* Community (Jones 1992) =
- *Pinus ponderosa* / *Andropogon scoparius* Habitat Type (Pfister et al. 1977) =
- *Pinus ponderosa* / *Andropogon scoparius* Habitat Unit (Thilenius 1970) =
- *Pinus ponderosa* / *Bouteloua gracilis* Cover Type (Balice et al. 1997) B
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerritos de Jaspe, the Hoya de Cibola flow south of Little Hole-In-The-Wall, and the Bandera flow northeast of Hole-In-The-Wall.

Global Range

This ponderosa pine / little bluestem dry woodland is found in the Great Plains of Nebraska and South Dakota, extending west to the mountains of New Mexico, Colorado, Montana and Wyoming. It may also be found in Oklahoma.

Nations: US

States/Provinces: CO:S1, MT:S2?, NE:S3S4, NM, OK?, SD, WY:S2?

Federal Lands: NPS (Bandelier, Devils Tower, El Malpais, Fort Laramie, Jewel Cave, Mount Rushmore, Scotts Bluff, Wind Cave)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots from 2006: 06JC254, 06JC288, 06JC290, 06JC301, and 06YC061.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

Global Description Authors: J. Drake, mod. K.S. King and M.E. Hall

REFERENCES

Balice et al. 1997, Bruner 1931, CONHP unpubl. data 2003, Diamond 1993, Driscoll et al. 1984, Hibner 2009, Hoagland 2000, Hoffman and Alexander 1987, Johnston 1987, Jones 1992, MTNHP 2002, Marriott and Faber-Langendoen 2000, McAdams et al. unpubl. data 1998, Midwestern Ecology Working Group n.d., Pfister et al. 1977, Steinauer and Rolfsmeier 2000, Terwilliger et al. 1979b, Thilenius 1970, Thilenius 1971, Thilenius 1972, Wasser and Hess 1982

***Pseudotsuga menziesii / Muhlenbergia montana* Forest**

Douglas-fir / Mountain Muhly Forest

CODE	CEGL000443
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain White Fir - Douglas-fir Dry Forest Group (G226)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823)

ELEMENT CONCEPT

Global Summary

This forested plant association occurs on mountains and plateaus in Trans-Pecos Texas, New Mexico, Arizona, and possibly Colorado. Sites are variable and include rocky ridgetops, gentle to steep slopes, streamsides, broken lavaflows and cinder cones. Elevation ranges from 2655-2970 m (8700-9750 feet) on steep south- and west-facing slopes, and down to 2290 m (7500 feet) on cool, northerly slopes. Substrates are generally dry, shallow, well-drained, gravelly or cobbly, coarse-textured soils. Lower elevation soils may be deep sand or cinder. The vegetation is characterized by an open to nearly closed evergreen tree canopy dominated or codominated by *Pseudotsuga menziesii* with a *Muhlenbergia montana*-dominated graminoid layer. Other tree species may include large *Pinus ponderosa* (often codominant) and scattered *Pinus strobiformis*, *Pinus flexilis*, *Pinus edulis*, or *Juniperus* spp. (especially on drier sites). *Abies concolor* is not present or accidental. *Quercus gambelii* may be present in the subcanopy (tree form) or tall-shrub layer, but with less than 5% cover. Shrub cover is typically sparse (<10% cover) and consists of scattered *Ceanothus fendleri*, *Cercocarpus montanus*, *Holodiscus dumosus*, *Mahonia repens*, *Quercus grisea*, or *Ribes cereum*. The herbaceous layer is dominated by graminoids and is moderately dense and diverse. *Muhlenbergia montana* is the most consistent graminoid species and typically dominates. Forb cover is sparse.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association is found on rough and broken lavaflows and cinder cones from 2330 to 2390 m (7630-7830 feet) in elevation. The substrate is mainly rock (about 27% of the total ground cover) followed by gravel, with minor components of soil as well as litter (10% and 14%, respectively).

Global Environment

This forested plant association occurs on mountains and plateaus in Trans-Pecos Texas, New Mexico, Arizona, and possibly Colorado. Sites are variable and include rocky ridgetops, gentle to steep slopes, streamsides, broken lavaflows and cinder cones. Elevation ranges from 2650-2970 m (8700-9750 feet) on steep south- and west-facing slopes, and down to 2245 m (7500 feet) on cool, northerly slopes. Substrates are generally dry, shallow, well-drained, gravelly or cobbly, coarse-textured soils. Lower elevation soils maybe deep sands or cinder.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

This forest association ranges from an open to nearly closed canopy and is dominated by *Pseudotsuga menziesii*, with *Pinus ponderosa* as a codominant. The subcanopy is well-developed, and depending on location, may include *Juniperus scopulorum*, *Juniperus deppeana*, *Pinus edulis*, *Prunus virginiana*, *Populus tremuloides*, or *Quercus gambelii*. Shrubs are not abundant in this association, and are typically less than 5% of the total cover. *Ribes cereum* is the most frequent followed by *Yucca baccata* and *Holodiscus dumosus*. The herbaceous layer is somewhat more developed, can have over 10% cover, and is dominated by grasses such as *Muhlenbergia montana* and *Poa fendleriana*. Forbs are common but variable, and among the 15 species recorded, *Artemisia carruthii* is the most frequent.

Global Vegetation

This plant association is characterized by an open to nearly closed evergreen tree canopy dominated or codominated by *Pseudotsuga menziesii* with a *Muhlenbergia montana*-dominated graminoid layer. Other tree species may include large *Pinus ponderosa* (often codominant) and scattered *Pinus flexilis* (northern stands), *Pinus strobiformis*, *Pinus edulis*, *Juniperus deppeana*, or *Juniperus scopulorum* (especially on drier sites and southern stands). *Abies concolor* is not present or accidental. *Quercus gambelii* may be present in the subcanopy (tree form) or tall-shrub layer, but with less than 5% cover. Shrub cover is typically sparse (<10% cover) and consists of scattered *Ceanothus fendleri*, *Cercocarpus montanus*, *Holodiscus dumosus*, *Mahonia repens*, *Quercus grisea*, or *Ribes cereum*. The herbaceous layer is dominated by graminoids and is moderately dense and diverse. *Muhlenbergia montana* is the most consistent graminoid species and typically dominates. Other graminoids include *Blepharoneuron tricholepis*, *Bromus* spp., *Carex rossii*, *Elymus elymoides*, *Koeleria macrantha*, *Poa fendleriana*, but not *Festuca arizonica* or *Muhlenbergia virescens*. The forb cover is sparse. Common species are *Artemisia ludoviciana*, *Geranium caespitosum*, *Lithospermum multiflorum*, *Packera neomexicana*, *Pseudocymopterus montanus*, and *Thalictrum fendleri* (Alexander et al. 1987, Fitzhugh et al. 1987, Muldavin et al. 1996, Stuever and Hayden 1997b). The graminoid layer has greater than or equal cover as shrub.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa, Pseudotsuga menziesii*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Ribes cereum*
Herb (field)	Graminoid	*Muhlenbergia montana*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa, Pseudotsuga menziesii*
Herb (field)	Graminoid	*Muhlenbergia montana*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia carruthii, *Holodiscus dumosus*, *Juniperus deppeana*, *Juniperus scopulorum*, *Muhlenbergia montana*, *Pinus edulis*, *Pinus ponderosa*, *Pseudotsuga menziesii*, *Ribes cereum*, *Yucca baccata*

Global

Muhlenbergia montana, *Pseudotsuga menziesii*

CONSERVATION STATUS RANK

Global Rank & Reasons: G4 (1-Feb-1996).

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

Global Comments

Two phases of this association are described by Stuever and Hayden (1997b). The limber pine (*Pinus flexilis*) phase is described from higher elevation stands in northern New Mexico (Muldavin et al. 1996) and the two-needle pinyon (*Pinus edulis*) phase from more southern latitudes where *Pinus edulis*, *Pinus strobiformis*, *Juniperus deppeana*, and *Juniperus scopulorum* are common seral species. (Stuever and Hayden 1997b).

Global Similar Associations

- *Abies concolor - Pseudotsuga menziesii* / *Carex rossii* Forest (CEGL000431)
- *Pinus ponderosa* / *Muhlenbergia montana* Woodland (CEGL000862)
- *Pseudotsuga menziesii* / *Festuca arizonica* Forest (CEGL000433)
- *Pseudotsuga menziesii* / *Holodiscus discolor* / *Carex geyeri* Forest (CEGL000437)
- *Pseudotsuga menziesii* / *Mahonia repens* Forest (CEGL000442)
- *Pseudotsuga menziesii* / *Muhlenbergia virescens* Forest (CEGL000444)
- *Pseudotsuga menziesii* / *Quercus gambelii* Forest (CEGL000452)

Global Related Concepts

- *Pseudotsuga menziesii* / *Muhlenbergia montana* (Bourgeron and Engelking 1994) =

- *Pseudotsuga menziesii / Muhlenbergia montana* Habitat Type (Fitzhugh et al. 1987) ?
- *Pseudotsuga menziesii / Muhlenbergia montana* Habitat Type (Muldavin et al. 1996) ?
- *Pseudotsuga menziesii / Muhlenbergia montana* Habitat Type (Alexander et al. 1987) ?
- *Pseudotsuga menziesii / Muhlenbergia montana* Plant Association (Larson and Moir 1987) ?
- *Pseudotsuga menziesii / Muhlenbergia montana* Plant Association (Stuever and Hayden 1997b) ?
- DRISCOLL FORMATION CODE:I.A.9.c. (Driscoll et al. 1984) B
- Douglas Fir-Pine Series (Diamond 1993) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the vicinity of Braided Caves, Twin Crater, and Cerro Candelaria.

Global Range

This forest association occurs on mountains and plateaus in Trans-Pecos Texas, New Mexico, Arizona, and possibly Colorado.

Nations: US

States/Provinces: AZ, CO?, NM:S4, TX:S1

Federal Lands: NPS (El Malpais, Sunset Crater Volcano?); USFS (Cibola)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 4 field plots from 2006: 06AB207, 06JC232, 06JC234, 06JC299.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.A. Schulz

REFERENCES

Alexander et al. 1987, Bourgeron and Engelking 1994, Diamond 1993, Driscoll et al. 1984, Fischer and Bradley 1987, Fitzhugh et al. 1987, Hansen et al. 2004c, Larson and Moir 1987, Muldavin et al. 1996, Stuever and Hayden 1997b, Western Ecology Working Group n.d., Wright et al. 1979

Pseudotsuga menziesii / Quercus gambelii Forest

Douglas-fir / Gambel Oak Forest

CODE	CEGL000452
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Rocky Mountain Cool Temperate Forest (1.B.2.Nb)
MACROGROUP	Southern Rocky Mountain Lower Montane Forest (M022)
GROUP	Southern Rocky Mountain White Fir - Douglas-fir Dry Forest Group (G226)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland (CES306.823), Southern

Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland (CES306.825)

ELEMENT CONCEPT

Global Summary

This forest association occurs on mountains and plateaus from Colorado to Trans-Pecos Texas, west into New Mexico, Arizona and Utah. Elevation ranges from 1229 to 2870 m (4030-9400 feet). Stands are found along drainages, lower and middle slopes, steep upper slopes and gentle to rolling tops of mesas and ridges. Aspects are variable. This forest occurs as both a non-obligate riparian community on the outer margins of riparian areas in desert canyons and steep draws, and as an upland forest forming extensive stands on typically north-facing hillslopes (southern aspects at higher elevations). Soils vary but are often shallow and rocky, ranging from sand to clay, often derived from sandstone. The vegetation is characterized by a relatively sparse to dense evergreen tree canopy dominated by *Pseudotsuga menziesii*, sometimes with *Quercus gambelii* well-represented in the understory. Scattered large *Pinus ponderosa*, *Pinus strobiformis*, *Pinus flexilis*, *Pinus edulis*, or *Juniperus* spp. (especially on drier sites) may be present in the tree canopy or subcanopy. *Abies concolor* is typically not present. *Quercus gambelii* dominates both the subcanopy (tree form, if present) and the moderately dense tall-shrub layer that consists of dense clumps of oak. *Quercus gambelii* must have at least 5% cover, but there is frequently well over 25%. At higher elevations, *Quercus gambelii* are more treelike and *Symphoricarpos oreophilus* will be present with significant cover in the short-shrub layer. At lower elevations, scattered *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus deppeana* are often present. The presence of *Chrysothamnus depressus* in some stands reflects the presence of fairly well-developed soils. The herbaceous layer is generally sparse and composed of mostly graminoids with scattered forbs, but it can be moderately dense and diverse. Many other species are associated, such as *Amelanchier* spp., *Holodiscus dumosus*, *Fendlera rupicola*, *Fraxinus anomal*a, *Mahonia repens*, *Paxistima myrsinites*, *Quercus* × *pauciloba*, *Robinia neomexicana*, *Rosa woodsii*, *Carex* spp., *Festuca arizonica*, *Koeleria macrantha*, *Muhlenbergia virescens*, *Poa fendleriana*, *Lathyrus lanszwertii* var. *leucanthus*, *Thalictrum fendleri*, and *Vicia americana*. The shrub layer has equal or greater cover than graminoids.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2415 and 2445 m (7920-8020 feet) elevation on moderate to steep sideslopes of low, controlled hills with substrates (primarily rock and some soil) derived from sandstone (Glorieta sandstone) and Yeso Formation (Lower Permian). Litter and coarse woody debris are relatively low in abundance.

Global Environment

This forest association occurs on mountains and plateaus at elevations ranging from 1229 to 2870 m (4030-9400 feet). Stands are found along drainages, gentle to moderate lower and middle slopes, steep upper slopes and gentle to rolling tops of mesas and ridges. Aspects are variable. This forest occurs as both a non-obligate riparian community on the outer margins of riparian areas in desert canyons and steep draws, and as an upland forest forming extensive stands on typically north-facing hillslopes, canyon sideslopes and mesa escarpments (southern aspects at higher elevations). Soils vary but are often shallow and rocky, ranging from sand to clay, often derived from sandstone. The surface is generally largely covered with a thin layer of litter. Parent materials are variable and include recent alluvium, fractured limestone, sandstone, metamorphic/granitic rocks, basalt, andesite, volcanic tuff, eroded Claron Formation (Pink Member), and even slickrock. Occasionally, talus to large blocks of rock and bedrock dominate the surface of sites on colluvial slopes / landslide deposits.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this association are nearly closed (60-90%) and are codominated by *Pseudotsuga menziesii* and *Pinus ponderosa*. In the subcanopy, *Juniperus deppeana* and *Juniperus scopulorum* also occur, along with thick clumps of *Quercus gambelii*. Probably due to the dense canopy of *Pseudotsuga menziesii* and its associates, the shrub stratum is poorly developed. The presence of *Chrysothamnus depressus* reflects the presence of fairly well-developed soils. In the herbaceous layer of this association, the presence of cool-season grasses such as *Koeleria macrantha* reflect the cooler, moist conditions of this association. Forbs include a mix of mesic, woodland species such as *Helianthella parryi*, *Artemisia ludoviciana*, and *Erigeron formosissimus*.

Global Vegetation

This forest is characterized by a relatively sparse to moderately dense evergreen tree canopy dominated by *Pseudotsuga menziesii*, with *Quercus gambelii* well-represented in the understory. Scattered large *Pinus ponderosa*, *Pinus strobiformis*, *Pinus flexilis*, *Pinus edulis*, or *Juniperus* spp. (especially on drier sites) may be present in the tree canopy or subcanopy. *Abies concolor* is typically not present. *Quercus gambelii* typically dominates both the subcanopy (tree form, if present) and the open to moderately dense tall-shrub layer that often consists of dense clumps of oak. *Quercus gambelii* must have at least 5% cover, but there is frequently well over 25%. At higher elevations, *Quercus gambelii* are more treelike, and *Symphoricarpos oreophilus* will be present with significant cover in the short-shrub layer. At lower elevations, scattered *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus deppeana* are often present. The presence of *Chrysothamnus depressus* in some stands reflects the presence of fairly well-developed soils. Other common shrub species, depending on geographic location, may include *Acer glabrum*, *Arctostaphylos patula*, *Amelanchier* spp., *Brickellia longifolia*, *Cercocarpus montanus*, *Fendlera rupicola*, *Fraxinus anomala*, *Holodiscus dumosus*, *Mahonia repens*, *Paxistima myrsinites*, *Prunus virginiana*, *Purshia tridentata*, *Quercus* × *pauciloba*, *Rhus trilobata*, *Ribes cereum*, *Robinia neomexicana*, *Rosa woodsii*, *Shepherdia rotundifolia*, and *Yucca* spp. The generally sparse herbaceous layer is composed of mostly graminoids with scattered forbs but ranges to moderately dense and diverse. Species vary greatly by site characteristics and location. Associated graminoids may include *Achnatherum hymenoides*, *Bromus* spp., *Carex geyeri*, *Carex rossii*, *Elymus elymoides*, *Festuca arizonica*, *Koeleria macrantha*, *Muhlenbergia montana*, *Muhlenbergia virescens*, *Piptatherum micranthum*, and *Poa fendleriana*. Common forbs include *Achillea millefolium* var. *occidentalis*, *Cryptantha* sp., *Galium coloradoense*, *Gilia stenothyrsa*, *Lathyrus lanszwertii* var. *leucanthus*, *Lepidium montanum*, *Machaeranthera grindelioides*, *Maianthemum stellatum*, *Packera multilobata*, *Packera neomexicana*, *Physaria acutifolia*, *Thalictrum fendleri*, *Solidago* spp., and *Vicia americana*. The shrub layer generally has equal or greater cover than graminoids. Post-burn stands may have relatively low cover of *Quercus gambelii* temporarily, as these shrubs resprout and grow. This open conifer forest transitions to *Quercus gambelii* woodlands in drier sites and at lower elevations.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*
Tree subcanopy	Broad-leaved deciduous tree	*Quercus gambeli*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa, Pseudotsuga menziesii*
Tall shrub/sapling	Broad-leaved deciduous tree	*Quercus gambelii*

CHARACTERISTIC SPECIES

El Malpais National Monument

Pseudotsuga menziesii, *Quercus gambelii*

Global

Pseudotsuga menziesii, *Quercus gambelii*

OTHER NOTEWORTHY SPECIES

Global

Vulnerable: *Gilia stenothyrsa* (globally imperiled, G3)

CONSERVATION STATUS RANK

Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

El Malpais National Monument Comments

A *Muhlenbergia montana* phase was identified from this association where it is well-represented.

Global Comments

This is a broadly defined association characterized by dominance or codominance of two widespread species, *Pseudotsuga menziesii* and *Quercus gambelii*. Within the literature on habitat type, there are four phases mentioned: *Festuca arizonica* phase, *Holodiscus dumosus* phase, *Muhlenbergia virescens* phase (all defined by having at least 5% cover of both *Quercus gambelii* and the nominal species), and *Quercus gambelii* (typic) phase by a undeveloped herbaceous layer (Alexander et al. 1984b, DeVelice et al. 1986, Alexander et al. 1987, Fitzhugh et al. 1987, Johnston 1987, Larson and Moir 1987, Muldavin et al. 1996, Stuever and Hayden 1997b). There are three similar *Pseudotsuga menziesii* associations in the USNVC that use these phase species as nominal species. These phases represent "intermediate" vegetation. Review of these associations is needed to clarify relationships among associations and possibly subdivide this broadly defined association into types based on herbaceous layer and habitat.

Global Similar Associations

- *Abies concolor - (Pseudotsuga menziesii) / Quercus gambelii / Carex rossii* Forest (CEGL005351)
- *Abies concolor - (Pseudotsuga menziesii) / Quercus gambelii / Thalictrum fendleri* Forest (CEGL005352)
- *Abies concolor / Quercus gambelii* Forest (CEGL000261)
- *Pinus ponderosa / Quercus gambelii* Woodland (CEGL000870)
- *Pseudotsuga menziesii / Festuca arizonica* Forest (CEGL000433)
- *Pseudotsuga menziesii / Holodiscus discolor / Carex geyeri* Forest (CEGL000437)
- *Pseudotsuga menziesii / Muhlenbergia montana* Forest (CEGL000443)
- *Pseudotsuga menziesii / Muhlenbergia virescens* Forest (CEGL000444)

Global Related Concepts

- *Pseudotsuga menziesii / Quercus gambelii* Association (Bourgeron et al. 1995) =
- *Pseudotsuga menziesii / Quercus gambelii* Forest Association (Bourgeron et al. 1993) =
- *Pseudotsuga menziesii / Quercus gambeli*i Forest Association (Kittel et al. 1994) =
- *Pseudotsuga menziesii / Quercus gambeli*i Forest Association (Kittel et al. 1999) =
- *Pseudotsuga menziesii / Quercus gambelii* Habitat Type (Fitzhugh et al. 1987) =
- *Pseudotsuga menziesii / Quercus gambelii* Habitat Type (Alexander et al. 1987) =

- *Pseudotsuga menziesii* / *Quercus gambelii* Habitat Type (DeVelice et al. 1986) =
- *Pseudotsuga menziesii* / *Quercus gambelii* Habitat Type (Youngblood and Mauk 1985) =
- *Pseudotsuga menziesii* / *Quercus gambelii* Habitat Type (Muldavin et al. 1996) =
- *Pseudotsuga menziesii* / *Quercus gambelii* Habitat Type (Alexander et al. 1984b) =
- *Pseudotsuga menziesii* / *Quercus gambelii* Plant Association (Larson and Moir 1987) =
- *Pseudotsuga menziesii* / *Quercus gambelii* Plant Association (Stuever and Hayden 1997b) =
- *Pseudotsuga menziesii* / *Quercus gambelii* Plant Association (Johnston 1987) =
- *Pseudotsuga menziesii* / *Symphoricarpos oreophilus* Habitat Type (Komarkova et al. 1988a) I
- *Pseudotsuga menziesii* / *Quercus gambelii* (Kittel et al. 1999) =
- *Pseudotsuga menziesii* / *Quercus gambelii* (Bourgeron and Engelking 1994) =
- Barn Canyon Conifer (Blackhawk Coal Company 1981) =
- Douglas Fir-Pine Series (Diamond 1993) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known only from near the top of Cerritos de Jaspe.

Global Range

This *Pseudotsuga menziesii* forest association occurs in the southern Rocky Mountains and southwestern U.S. and is found on foothills, mountains and plateaus from Colorado to Trans-Pecos Texas, west to Arizona and Utah.

Nations: US

States/Provinces: AZ, CO:S4, NM:S5, TX:S1, UT:S3?, WY

Federal Lands: NPS (Bandelier, Black Canyon of the Gunnison, Bryce Canyon, Canyon de Chelly, Canyonlands, Capitol Reef, Colorado, Curecanti, El Malpais, Mesa Verde, Natural Bridges, Walnut Canyon, Zion); USFS (Apache-Sitgreaves, Arapaho-Roosevelt, Cibola, Gila, Gunnison, Uncompahgre, White River NF)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 2 field plots from 2006: 06JC262 and 06JC263.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.A. Schulz, mod. J. Drake

REFERENCES

Alexander et al. 1984b, Alexander et al. 1987, Bader 1932, Blackhawk Coal Company 1981, Bourgeron and Engelking 1994, Bourgeron et al. 1993, Bourgeron et al. 1995, CONHP unpubl. data 2003, Cogan et al. 2004, DeVelice et al. 1986, Diamond 1993, Fitzhugh et al. 1987, Freeman and Dick-Peddie 1970, Hansen et al. 2004d, Hess and Wasser 1982, Johnston 1987, Keammerer 1974, Kittel et al. 1994, Kittel et al. 1999, Komarkova et al. 1988a, Komarkova et al. 1988b, Larson and Moir 1987, Muldavin et al. 1996, Stuever and Hayden 1997b, Tiedemann and Terwilliger 1978, Western Ecology Working Group n.d., Youngblood and Mauk 1985

Juniperus monosperma / Bouteloua gracilis Woodland

One-seed Juniper / Blue Grama Woodland

CODE	CEGL000710
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Western North American Cool Temperate Woodland & Scrub (1.B.2.Nc)
MACROGROUP	Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027)
GROUP	Southern Rocky Mountain Juniper Woodland & Savanna Group (G252)

ECOLOGICAL SYSTEM(S)

Colorado Plateau Pinyon-Juniper Woodland (CES304.767), Inter-Mountain Basins Juniper Savanna (CES304.782), Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835), Southern Rocky Mountain Juniper Woodland and Savanna (CES306.834), Southwestern Great Plains Canyon (CES303.664)

ELEMENT CONCEPT

Global Summary

This Southern Rocky Mountains woodland occur on foothills in south-central Colorado and northern New Mexico and extends out into the southwestern Great Plains where it is largely restricted to areas near hills and escarpments. It also extends westward into the southeastern portion of the Colorado Plateau and southward into south-central New Mexico where it is a major association on desert mountains and mesas. Elevation ranges from 1372-2290 m (4500-7500 feet). Sites include gently rolling slopes, including weathered lava plateaus, gentle to steep footslopes and shoulder slopes of low sandstone hills or beneath sandstone bluffs, and steep upper sideslopes of low hills and volcano craters, on a variety of aspects with a tendency of increasing southerly slopes with increasing elevation. Further south it is generally cool (northwest to west), even at higher elevations. Substrates are variable but are frequently finer-textured Mollisols and Aridisols derived from limestone and sandstone, often with piedmont alluvial and slope colluvial deposits. The ground surface is characterized by scattered grass patches and litter amid an equal amount of exposed soil, gravel or rock. Vegetation is characterized by an open to very open tree canopy (10-40% cover) of mature *Juniperus monosperma* forming a generally open woodland or savanna with the grassy inter-tree spaces dominated by *Bouteloua gracilis*. Occasionally mature individuals, seedlings or saplings of *Pinus edulis* can be present. The dwarf-shrub *Gutierrezia sarothrae* is usually present and scattered throughout sites. Other shrubs are poorly represented or absent; succulents such as *Opuntia imbricata* (= *Cylindropuntia imbricata*) and *Opuntia phaeacantha* are the most frequent. The herbaceous layer is characteristically grassy and dominated by abundant *Bouteloua gracilis* with ruderal *Muhlenbergia torreyi* and *Aristida purpurea* often well-represented along with *Pleuraphis jamesii*, *Sporobolus cryptandrus*, and *Sporobolus airoides* as common subordinate associates. *Bouteloua curtipendula* may be present but is clearly not dominant. Forbs may be diverse but variable, and cover is generally low and may include *Artemisia dracunculus*, *Astragalus* spp., *Erigeron divergens*, *Heterotheca villosa*, *Ipomopsis longiflora*, *Ipomopsis multiflora*, *Penstemon* spp., *Townsendia* spp., and *Thelesperma megapotamicum*.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between approximately 2030 and 2290 m (6660-7500 feet) in elevation at a variety of aspects. Slopes and landforms are variable and include gently rolling weathered lava plateaus, gentle to steep footslopes and shoulder slopes of low sandstone hills or beneath sandstone bluffs, and steep upper sideslopes of low hills and volcano craters. The patchy substrates of soil that support this type are typically derived from Mancos shale, Hoya de Cibola flow, or Twin Craters flow, but can occasionally be derived from El Calderon flow, alluvium, Dakota sandstone, or Zuni sandstone. Ground cover is variable and may be dominated by soil, gravel, or rock. Litter is occasionally abundant, while coarse woody debris (primarily in the form of dead and downed trees) and cryptogamic cover occur in patches in some areas.

Global Environment

This widespread open woodland / savanna association occurs on valleys, plains, piedmont alluvial fans, mesas and foothills between 1372 and 2290 m (4500-7500 feet) in elevation. It typically is found on gently rolling slopes, including weathered lava plateaus, gentle to steep footslopes and shoulder slopes of low sandstone hills or beneath sandstone bluffs, and steep upper sideslopes of low hills and volcano craters, on a variety of aspects with a tendency of increasing southerly aspects with increasing elevation. Further south it is generally cool (northwest to west), even at higher elevations. Soils are composed of a variety of substrates including eolian material, alluvium, or colluvium derived from rhyolitic tuff or pumice, sandstones and limestones. The ground surface is characterized by scattered grass patches and litter amid an equal amount of exposed soil, gravel or rock.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Juniperus monosperma occurs in all the sample plots of this vegetation type, often accompanied by *Pinus edulis*. Canopy cover varies from more sparse savanna (10%) to moderately open woodland (55%). Seedlings and saplings of both species occur in a few of the areas, although in others, there is evidence of tree mortality without regeneration. The shrub layer is variable, and most frequently includes the cacti *Opuntia phaeacantha* and *Opuntia imbricata*, though cover is typically low. *Ericameria nauseosa* and *Gutierrezia sarothrae*, although more abundant in terms of cover, occur less frequently than the cacti. Graminoids predominate in the herbaceous layer, with the diagnostic species *Bouteloua gracilis* the most frequent and abundant and *Sporobolus cryptandrus* occurring as frequently but in lower abundance. Forbs are low in abundance and individual species occur infrequently from plot to plot; however, the overall species richness is high with 31 graminoids and 78 forbs identified in plots from this association.

Global Vegetation

Vegetation within this open woodland consists of an overstory (10-40% tree cover) dominated by *Juniperus monosperma*. *Pinus edulis* may also be present in microsites. The grassy inter-tree spaces are dominated by *Bouteloua gracilis*. *Bouteloua curtipendula* is occasionally well-represented, but it is not normally a codominant. Diversity can be high (>150 species). The subshrub *Gutierrezia sarothrae* is usually present and scattered throughout many sites (Muldavin, Chauvin, et al. 2000). Shrubs species are poorly represented or absent; the ruderal subshrub *Gutierrezia sarothrae* and succulents such as *Opuntia imbricata* (= *Cylindropuntia imbricata*) and *Opuntia phaeacantha* are the most frequent. The herbaceous layer is characteristically grassy and dominated by abundant *Bouteloua gracilis* with ruderal *Muhlenbergia torreyi* and *Aristida purpurea* often well-represented along with *Piptatherum micranthum*, *Pleuraphis jamesii*, *Sporobolus cryptandrus*, and *Sporobolus airoides* as common subordinate associates. Forbs are diverse but variable. *Artemisia dracunculus*, *Artemisia ludoviciana*, *Astragalus brandegeei*, *Cordylanthus wrightii*, *Erigeron divergens*, *Eriogonum jamesii*, *Heterotheca villosa*, *Hymenopappus filifolius*, *Ipomopsis longiflora*, *Ipomopsis multiflora*, *Menodora scabra*, *Mirabilis multiflora*, *Penstemon virgatus*, *Schoenocrambe linearifolia*, *Townsendia annua*, and *Thelesperma megapotamicum* are the most frequent species, but cover is generally low.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Herb (field)	Graminoid	*Bouteloua gracilis*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, *Chenopodium graveolens*, *Juniperus monosperma*, *Opuntia imbricata*, *Opuntia phaeacantha*, *Portulaca oleracea*, *Sporobolus cryptandrus*

CONSERVATION STATUS RANK

Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

El Malpais National Monument Comments

Three phases were identified from this association. The *Artemisia frigida* and the *Bouteloua eriopoda* phases occur where these species are well-represented, exceeding 15% total cover. A *Quercus* × *pauciloba* phase occurs where it is well-represented, exceeding 5% total cover.

Global Comments

In northern New Mexico, mature *Pinus edulis* was present in many stands prior to a die-off during the drought of 2002-03, but it is now represented only by seedlings and samplings. Some of these stands may have represented *Pinus edulis* - (*Juniperus monosperma*, *Juniperus deppeana*) / *Bouteloua gracilis* Woodland (CEGL002151) before the pinyon die-off. Both associations are established types that have been well-documented elsewhere in New Mexico.

Global Related Concepts

- *Juniperus monosperma/Bouteloua gracilis* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerritos de Jaspe, the Zuni-Acoma trailheads, the Hoya de Cibola flow west of Las Ventanas Windmill, the Dakota sandstone bluffs near the Natural Arch, the Hoya de Cibola flow near Los Pilares, The Narrows, and the Dakota sandstone formations south of the Malpais Windmill.

Global Range

This Southern Rocky Mountains woodland occur in foothills in south-central Colorado and northern New Mexico and extends out into the southwestern Great Plains where it is largely restricted to areas near breaks and escarpments. It also extends southward into central New Mexico and westward into the southeastern Colorado Plateau. Specific locations include the San Isabel National Forest in south-central Colorado, Comanche National Grassland in southeastern Colorado, the Upper Rio Puerco watershed in northwestern New Mexico, Bandelier National Monument, Salinas Pueblo Missions National Monument in central New Mexico, and White Sands Missile Range in south-central New Mexico where it is also a major association of the Oscura and San Andres mountains and of the Chupadera Mesa - Red Rio area.

Nations: US

States/Provinces: AZ:S4, CO:S3S4, NM:S5, WY

Federal Lands: DOD (White Sands Missile Range); NPS (Bandelier, El Malpais, Salinas Pueblo Missions)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 29 field plots from 2005, 2006, and 2007: 05MA006, 05MA018, 06AB227, 06AB234, 06JC282, 06JC397, 06JC401, 06JC405, 06JC418, 06YC032, 06YC039, 06YC042, 06YC136, 06YC143, 06YC145, 06YC146, 06YC150, 06YC151, 06YC154, 06YC168, 06YC169, 06YC170, 06YC171, 06YC172, 06YC173, 07AB030, 07AB033, 07AB034, and 07AB035.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.S. King, mod. K.A. Schulz

REFERENCES

Barnes 1983; Baxter 1977; Bourgeron and Engelking 1994; CONHP unpubl. data 2003; Dick-Peddie 1986; Dick-Peddie 1987; Dick-Peddie et al. 1984; Donart et al. 1978; Driscoll et al. 1984; Dwyer and Pieper 1967; Fischer and Bradley 1987; Francis 1986; Hendricks 1934; Hibner 2009; Johnsen 1962; Johnston 1987; Larson and Moir 1986; Larson and Moir 1987; Moir and Carleton 1987; Muldavin and Mehlhop 1992; Muldavin, Chauvin, et al. 2000; Nelson and Redders 1982; Pieper et al. 1971; Rippel et al. 1983; Shaw et al. 1989; Stuever and Hayden 1997a; Terwilliger et al. 1979b; USFS 1983b; USFS 1985b; USFS 1985a; Western Ecology Working Group n.d.; Wright et al. 1973; Wright et al. 1979

Juniperus monosperma / Fallugia paradoxa Woodland

One-seed Juniper / Apache Plume Woodland

CODE	CEGL000716
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Western North American Cool Temperate Woodland & Scrub (1.B.2.Nc)
MACROGROUP	Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027)
GROUP	Southern Rocky Mountain Juniper Woodland & Savanna Group (G252)

ECOLOGICAL SYSTEM(S)

Colorado Plateau Pinyon-Juniper Woodland (CES304.767), Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

This woodland association is known from El Malpais National Monument and Carson National Forest in New Mexico. Additional information will be added as it becomes available. In El Malpais, this association occurs between approximately 2010 and 2290 m (6600-7500 feet) elevation on very gently rolling basalt lava plateaus (Bandera, Hoya de Cibola, and McCarty's flow). Ground surface is rough and broken, and dominated by relatively unweathered lava rock. *Juniperus monosperma* is the dominant species in the sparse, savanna-like tree canopies of this lava association; *Pinus edulis* occurs infrequently. There is no apparent regeneration of either species. The open canopies allow for a relatively abundant shrub layer dominated by *Fallugia paradoxa*. *Rhus trilobata* and the cacti *Echinocereus coccineus*, *Opuntia phaeacantha*, and *Opuntia polyacantha* are frequent associates, though they are poorly represented. Graminoids (including *Elymus elymoides*, *Schizachyrium scoparium*, and *Bouteloua curtipendula*) are the most abundant in terms of herbaceous species cover. *Heterotheca villosa* is the most common and abundant forb. Overall species richness is low, with 13 graminoids and 17 forbs found from plots attributed to this association.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between approximately 2010 and 2290 m (6600-7500 feet) elevation on very gently rolling basalt lava plateaus (Bandera, Hoya de Cibola, and McCarty's flow). Ground surface is rough and broken, and dominated by relatively unweathered lava rock.

Global Environment

The only comprehensive data for this association are from El Malpais National Monument, therefore global information is not currently available.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Juniperus monosperma is the dominant species in the sparse, savanna-like tree canopies of this lava association; *Pinus edulis* occurs infrequently. There is no apparent regeneration of either species. The open canopies allow for a relatively abundant shrub layer dominated by *Fallugia paradoxa*. *Rhus trilobata* and the cacti *Echinocereus coccineus*, *Opuntia phaeacantha*, and *Opuntia polyacantha* are frequent associates, though they are poorly represented. Graminoids (including *Elymus elymoides*, *Schizachyrium scoparium*, and *Bouteloua curtipendula*) are the most abundant in terms of herbaceous species cover. *Heterotheca villosa* is the most common and abundant forb. Overall species richness is low, with 13 graminoids and 17 forbs found from this association.

Global Vegetation

The only comprehensive data for this association are from El Malpais National Monument, therefore global information is not currently available.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Fallugia paradoxa*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Fallugia paradoxa*

CHARACTERISTIC SPECIES

El Malpais National Monument

Fallugia paradoxa, *Juniperus monosperma*

Global

Fallugia paradoxa, *Juniperus monosperma*

OTHER NOTEWORTHY SPECIES

Global

Vulnerable: *Xanthoparmelia neoconspersa* (G1G3)

CONSERVATION STATUS RANK

Global Rank & Reasons: G4 (23-Feb-1994).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Global Related Concepts

- *Juniperus monosperma / Fallugia paradoxa/Parmelia conspersa* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the McCarty's flow west of the Las Ventanas Windmill, from the Bandera flow east of Little Hole-In-The-Wall, and the older basalt flows (including Hoya) north of Four Corners Windmill.

Global Range

This association is currently only known from El Malpais National Monument and Carson National Forest in New Mexico. Additional range information will be added as it becomes available.

Nations: US

States/Provinces: NM:S4

Federal Lands: NPS (El Malpais); USFS (Carson)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 3 standard field plots from 2005 and 2006: 05MA020,05MA023, and 06JC416.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: E. Muldavin and A. Kennedy, mod. M.E. Hall

REFERENCES

Bourgeron and Engelking 1994, Driscoll et al. 1984, Lindsey 1951, Moir and Carleton 1987, Western Ecology Working Group n.d.

Juniperus monosperma / Quercus × pauciloba Woodland

One-seed Juniper / Wavyleaf Oak Woodland

CODE	CEGL000721
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Western North American Cool Temperate Woodland & Scrub (1.B.2.Nc)
MACROGROUP	Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027)
GROUP	Southern Rocky Mountain Juniper Woodland & Savanna Group (G252)

ECOLOGICAL SYSTEM(S)

Colorado Plateau Pinyon-Juniper Woodland (CES304.767), Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

This woodland is known to occur in the Rocky Mountains in central New Mexico, and locally in northern New Mexico on gentle to moderate (15-40%) rocky slopes. It intergrades to scarp woodland with increasing steepness and rocky outcrop terrain. Elevations range from 1830 to 2120 m (6000-6960 feet). In central New Mexico, stands occur on soils derived from limestones of the Permian San Andres Formation. At El Malpais National Monument, it typically occurs on very gently rolling, but rough and broken lava plateaus and occasionally on gentle, upper dipslopes of hills derived from Dakota sandstone. The ground surface is characterized by exposed soil and gravel with widely scattered grass patches and litter. This woodland/savanna is characterized by an open canopy of mature *Juniperus monosperma* trees with scattered saplings or seedlings. *Pinus edulis* may co-occur as seedlings, saplings, or mature individuals, and *Pinus ponderosa* is found occasionally. In the shrub layer, *Quercus × pauciloba* is well-represented in the intercanopy spaces. Additional shrub species may be present, including *Atriplex canescens*, *Cercocarpus montanus* var. *paucidentatus*, *Dalea formosa*, *Ephedra viridis*, *Fallugia paradoxa*, *Lycium pallidum*, *Nolina microcarpa*, *Opuntia* spp., *Quercus turbinella*, and *Yucca* spp. In the herbaceous layer, graminoids can be well-represented with dominant species including *Bouteloua gracilis* along with *Bouteloua eriopoda* and *Schizachyrium scoparium*. Additional graminoids may include *Bouteloua curtipendula*, *Elymus elymoides*, *Eragrostis intermedia*, *Muhlenbergia* spp., and *Achnatherum* and *Hesperostipa* spp. (= *Stipa* spp.). Forbs are scarce.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2040 and 2120 m (6690-6960 feet) elevation, typically on very gently rolling, but rough and broken lava plateaus (Bandera and McCarty's flows), and occasionally on gentle, upper dipslopes of hills derived from Dakota sandstone.

Global Environment

This woodland is known to occur in the Rocky Mountains in central New Mexico, and locally in northern New Mexico on gentle to moderate (15-40%) rocky slopes. It intergrades to scarp woodland with increasing steepness and rocky outcrop terrain. Elevations range from 1830 to 2120 m (6000-6960 feet). In central New Mexico, stands occur on soils derived from limestones of the Permian San Andres Formation. At El Malpais National Monument, it typically occurs on very gently rolling, but rough and broken lava plateaus and occasionally on gentle, upper dipslopes of hills derived from Dakota sandstone. The ground surface is characterized by exposed soil and gravel with widely scattered grass patches and litter.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of these woodlands vary from sparse (around 10% cover) to very open (30% cover) and are dominated by *Juniperus monosperma*. Regeneration of this species is occurring in some areas. *Pinus edulis* may co-occur as seedlings, saplings, or mature individuals, and *Pinus ponderosa* is found occasionally. In some places, there are standing snags and downed dead *Pinus edulis* and *Pinus ponderosa*. The open canopies allow light to penetrate, and often there is an abundant shrub layer dominated by *Quercus* × *pauciloba*. *Echinocereus coccineus* and *Yucca baccata* are frequent associates, though they are scattered. Graminoids dominate the herbaceous cover and frequently include *Bouteloua curtipendula* and *Bouteloua gracilis*. Forbs are represented by xeric woodland species such as *Artemisia carruthii* and *Heterotheca villosa*.

Global Vegetation

This woodland/savanna is characterized by an open canopy of mature *Juniperus monosperma* trees with scattered saplings or seedlings. *Pinus edulis* may co-occur as seedlings, saplings, or mature individuals, and *Pinus ponderosa* is found occasionally. In the shrub layer, *Quercus* × *pauciloba* is well-represented in the intercanopy spaces. Additional shrub species may be present, including *Atriplex canescens*, *Cercocarpus montanus* var. *paucidentatus*, *Dalea formosa*, *Ephedra viridis*, *Fallugia paradoxa*, *Lycium pallidum*, *Nolina microcarpa*, *Opuntia* spp., *Quercus turbinella*, and *Yucca* spp. In the herbaceous layer, graminoids can be well-represented with dominant species including *Bouteloua gracilis* along with *Bouteloua eriopoda* and *Schizachyrium scoparium*. Additional graminoids may include *Bouteloua curtipendula*, *Elymus elymoides*, *Eragrostis intermedia*, *Muhlenbergia* spp., and *Achnatherum* and *Hesperostipa* spp. (= *Stipa* spp.). Forbs are scarce.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Quercus* × *pauciloba*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Quercus* × *pauciloba*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Juniperus monosperma, *Quercus* × *pauciloba*

CONSERVATION STATUS RANK

Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Global Related Concepts

- *Juniperus monosperma/Quercus undulata* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Bandera flow south of Loma Montosa, the McCarty's flow along the Acoma-Zuni Trail, and the Sandstone Bluffs Overlook.

Global Range

This woodland association is known to occur in the Rocky Mountains in central New Mexico, and locally in northern New Mexico.

Nations: US

States/Provinces: NM:S5

Federal Lands: NPS (El Malpais, Salinas Pueblo Missions)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 4 field plots from 2005, and 2006: 05MA016, 06JC275, 06JC393, and 06JC404.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.S. King, mod. M.E. Hall

REFERENCES

Bourgeron and Engelking 1994, Driscoll et al. 1984, Dwyer and Pieper 1967, Fischer and Bradley 1987, Larson and Moir 1986, Moir and Carleton 1987, Pettit et al. 1980, Stuever and Hayden 1997a, USFS 1981, Western Ecology Working Group n.d., Wright et al. 1979

Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland

Two-needle Pinyon - (One-seed Juniper, Alligator Juniper) / Blue Grama Woodland

CODE	CEGL002151
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Western North American Cool Temperate Woodland & Scrub (1.B.2.Nc)
MACROGROUP	Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027)
GROUP	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)

ECOLOGICAL SYSTEM(S)

Colorado Plateau Pinyon-Juniper Woodland (CES304.767), Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

This widespread woodland association occurs in Colorado, Oklahoma, New Mexico, and possibly Texas and east-central Arizona. It is known from the foothills and mountains of the southern Colorado Front Range, New Mexico, and the hills, canyons, escarpments and other breaks in the southwestern Great Plains. Elevations range from 1525-2445 m (5000-8000 feet), but may be higher in stands in southern New Mexico. Stands occur on gently sloping low hills and plains, on flat to moderate slopes along drainages and on mesa tops, and on moderate to steep rocky slopes of foothills, mountains and canyons. The soils are variable but are typically shallow, gravelly calcareous, finer-textured soils (clay loam or silty clay) with a caliche layer or bedrock outcrops not uncommon. Parent materials include limestone, sandstone, and basalt. The ground surface is may be characterized by scattered grass patches and litter amid an equal amount of exposed soil and gravel. The vegetation is characterized by an open to moderately dense tree canopy (10-60% cover) codominated by *Pinus edulis* and *Juniperus monosperma* with a grassy understory dominated by *Bouteloua gracilis*. *Pinus edulis* may be present with relatively small cover in some stands. *Juniperus deppeana* or *Juniperus coahuilensis* may replace *Juniperus monosperma* in southern stands. Other species of *Juniperus* such as *Juniperus scopulorum* may be present at upper elevations. The shrub canopy ranges from low to high cover. If *Quercus gambelii* is present, it has less than 5% cover. Scattered *Agave* spp., *Cercocarpus montanus*, *Dasylirion wheeleri*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Opuntia* spp., *Tetradymia canescens*, or *Yucca* spp. may be present. The herbaceous layer is moderately dense to dense and is dominated by the warm-season, perennial short grass *Bouteloua gracilis*. Associated graminoids include *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Elymus elymoides*, *Koeleria macrantha*, *Hesperostipa comata* (= *Stipa comata*), *Hesperostipa neomexicana* (= *Stipa neomexicana*), *Muhlenbergia torreyi*, and *Pleuraphis jamesii* (= *Hilaria jamesii*). *Muhlenbergia montana* is absent or scarce (<1% cover). Forb cover is typically low, but may be moderately diverse. Species such as *Cryptantha cinerea* var. *jamesii* (= *Cryptantha jamesii*), *Eriogonum jamesii*, *Hymenopappus filifolius*, and *Mentzelia* spp. are common.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2030 and 2435 m (6660-7990 feet) in elevation, typically on sideslopes, on gentle slopes or shoulder slopes of low hills, though occasionally on upland valleys or cinder cones. Slopes vary from gentle to steep and represent a variety of aspects. Substrates are typically derived from weathered lava

(El Calderon, Hoya de Cibola, Old Basalt flows); cinders; alluvium; Glorieta, Dakota, Tres Hermanos, Zuni, or Yeso formation sandstones; Mancos shale; and occasionally from San Andres and Abó limestone. The ground cover is variable and can be dominated by soil, gravel, rock, or litter, with patches of coarse woody debris and cryptogamic cover.

Global Environment

This widespread woodland association occurs in Colorado, Oklahoma, New Mexico, and possibly Texas and east-central Arizona. It is known from the foothills and mountains of the southern Colorado Front Range, New Mexico, and the hills, canyons, escarpments and other breaks in the southwestern Great Plains. Elevations range from 1525-2444 m (5000-8000 feet), but may be higher in stands in southern New Mexico. Stands occur on gently sloping low hills and plains, on flat to moderate slopes along drainages and on mesa tops, and on moderate to steep rocky slopes of foothills, mountains and canyons. The soils are variable but are typically shallow, gravelly calcareous, finer-textured soils (clay loam, silty clay) with a caliche layer or bedrock outcrops not uncommon. Parent materials include limestone, sandstone, and basalt. The ground surface may be characterized by scattered grass patches and litter amid an equal amount of exposed soil and gravel.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this association vary from sparse savanna (10%) to closed woodland (65%) and are codominated by *Pinus edulis* and either *Juniperus monosperma* or *Juniperus scopulorum*, and sometimes *Juniperus deppeana*, with seedlings and saplings of these species occurring in some areas. The shrub canopy ranges from low to high cover, and frequently includes *Gutierrezia sarothrae*, *Ericameria nauseosa*, *Yucca baccata*, *Opuntia phaeacantha*, and *Tetradymia canescens*. In contrast, the herbaceous layer is often abundant and very rich in species. Grasses are dominant in the herbaceous layer, with *Bouteloua gracilis* the diagnostic species of this woodland association forming most of the cover. Forbs are occasionally abundant and include xeric woodland species such as *Eriogonum jamesii* and *Bahia dissecta*.

Global Vegetation

This plant association is characterized by an open to moderately dense tree canopy (10-60% cover) codominated by *Pinus edulis* and *Juniperus monosperma* with a grassy understory dominated by *Bouteloua gracilis*. *Pinus edulis* may be present with relatively small cover in some stands. *Juniperus deppeana* or *Juniperus coahuilensis* may replace *Juniperus monosperma* in southern stands. Other species of *Juniperus* such as *Juniperus scopulorum* may be present at upper elevations. The shrub canopy ranges from low to high cover. If *Quercus gambelii* is present, it has less than 5% cover. Scattered *Agave* spp., *Cercocarpus montanus*, *Dasylirion wheeleri*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Opuntia* spp., *Tetradymia canescens*, or *Yucca* spp. may be present. The herbaceous layer is moderately dense to dense and is dominated by the warm-season, perennial short grass *Bouteloua gracilis*. Associated graminoids include *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Elymus elymoides*, *Koeleria macrantha*, *Hesperostipa comata* (= *Stipa comata*), *Hesperostipa neomexicana* (= *Stipa neomexicana*), *Muhlenbergia torreyi*, and *Pleuraphis jamesii* (= *Hilaria jamesii*). *Muhlenbergia montana* is absent or scarce (<1% cover). Forb cover is typically low, but may be moderately diverse. Species such as *Cryptantha cinerea* var. *jamesii* (= *Cryptantha jamesii*), *Eriogonum jamesii*, *Hymenopappus filifolius*, and *Mentzelia* spp. are common. Other forbs may include *Ipomopsis multiflora*, *Astragalus* sp., and *Erigeron divergens*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma, Juniperus scopulorum, Pinus edulis*
Herb (field)	Graminoid	*Bouteloua gracilis*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus deppeana, Juniperus monosperma, Juniperus scopulorum, Pinus edulis*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Juniperus monosperma*, *Juniperus scopulorum*, *Pinus edulis*, *Tetradymia canescens*

Global

Bouteloua gracilis, *Juniperus monosperma*, *Pinus edulis*

CONSERVATION STATUS RANK

Global Rank & Reasons: G5? (15-Dec-1994).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

El Malpais National Monument Comments

Three phases were identified from this association including a *Poa fendleriana* phase occurring in stands where there is a strong component of cool-season grasses which can also include *Elymus elymoides*, *Koeleria macrantha*, or *Muhlenbergia montana*. A *Sporobolus cryptandrus* phase represents stands occurring on sandy soils where it is present. A *Quercus gambelii* phase occurs where it is common, exceeding 2% total cover.

Global Comments

The two *Pinus edulis* / *Bouteloua gracilis* plant associations are treated as phases in Stuever and Hayden (1997a). In the USNVC we are including stands with southern Great Plains, Chihuahua Desert floristic affinities in *Pinus edulis* - (*Juniperus monosperma*, *Juniperus deppeana*) / *Bouteloua gracilis* Woodland (CEGL002151), and stands with the Colorado Plateau and Great Basin floristic affinities in *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland (CEGL000778). Both of these associations may include stands codominated by *Juniperus deppeana* in their southern extent. Stuever and Hayden (1997a) also described a *Juniperus deppeana* phase (recognized by the its dominance in the stand) and hillslope phase, which occurs on slopes >15% and may have low cover of grasses (<5% cover). More survey is needed to fully understand the distribution and ecological relationships between these 3 species of *Juniperus*.

Global Similar Associations

- *Pinus edulis - (Juniperus osteosperma) / Bouteloua gracilis* Woodland (CEGL000778)

Global Related Concepts

- *Juniperus monosperma / Oryzopsis micrantha* Plant Community (Shaw et al. 1989) ?
- *Pinus edulis-Juniperus deppeana / Bouteloua gracilis* Habitat Type (Kennedy 1983a) ?
- *Pinus edulis-Juniperus deppeana /Bouteloua gracilis* Vegetation Type (Dick-Peddie 1993) ?
- *Pinus edulis-Juniperus monosperma / Bouteloua gracilis* Plant Association (Bourgeron and Engelking 1994) ?
- *Pinus edulis-Juniperus monosperma / Bouteloua gracilis* Plant Community (Francis 1986) ?
- *Pinus edulis-Juniperus monosperma / Bouteloua gracilis* Vegetation Type (Dick-Peddie 1993) ?
- *Pinus edulis / Bouteloua gracilis* - Eriogonum spp. Plant Community (Francis 1986) ?
- *Pinus edulis / Bouteloua gracilis* Plant Association (Muldavin et al. 1994) ?
- *Pinus edulis / Bouteloua gracilis* Plant Association (Muldavin, Chauvin, et al. 2000) ?
- *Pinus edulis / Bouteloua gracilis* Plant Association (Larson and Moir 1987) ?
- *Pinus edulis / Bouteloua gracilis* Plant Association (Stuever and Hayden 1997a) ?

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Hoya and the older flows to the south, Cerritos de Jaspe, the Twin Craters and Hoya de Cibola flows south of Loma Montosa, flows south of Cerro Hueco, Cerro Bandera, Cerro Encierro, Cerro Rendija, Sandstone Bluffs Overlook, The Narrows, North Pasture and the sandstone formations to the north, Malpais Windmill, the Visitor Center, Mesita Blanca, and the alluvial flats north of the Lava Falls Area.

Global Range

This widespread woodland association occurs in Wyoming, southern Colorado, western Oklahoma, New Mexico, and possibly Texas and east-central Arizona.

Nations: US

States/Provinces: AZ?, CO, NM, OK, TX?, WY

Federal Lands: DOD (White Sands Missile Range); NPS (El Malpais, Great Sand Dunes, Salinas Pueblo Missions)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 46 field plots from 2005, 2006, and 2007: 05MA002, 05MA015, 05MA024, 06AB205, 06AB206, 06AB224, 06AB225, 06AB232, 06AB232, 06JC236, 06JC240, 06JC241, 06JC250, 06JC252, 06JC297, 06JC340, 06JC351, 06JC372, 06JC376, 06JC377, 06JC399, 06JC419, 06YC002, 06YC004, 06YC006, 06YC018, 06YC022, 06YC029, 06YC056, 06YC071, 06YC085, 06YC086, 06YC089, 06YC101, 06YC114, 06YC115, 06YC116, 06YC117, 06YC118, 06YC121, 06YC127, 06YC128, 06YC129, 06YC130, 06YC133, and 07AB023

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.A. Schulz, mod. K.S. King

REFERENCES

Barnes 1987; Blair and Hubbell 1938; Bourgeron and Engelking 1994; Bruner 1931; CONHP unpubl. data 2003; Caire 1989; Dick-Peddie 1993; Duck and Fletcher 1945; Dwyer and Pieper 1967; Francis 1986; Hoagland 2000; Jameson 1962; Kennedy 1983a; Ladyman and Muldavin 1996; Larson and Moir 1987; Little 1987; Moir and

Carleton 1987; Muldavin and Mehlhop 1992; Muldavin et al. 1994; Muldavin, Archer, et al. 1998; Muldavin, Chauvin, et al. 2000 ; Powell 1988; Rogers 1949; Rogers 1953; Rogers 1954; Shaw et al. 1989; Stuever and Hayden 1997a; Western Ecology Working Group n.d.; Wright et al. 1979

Pinus edulis - Juniperus spp*. / Fallugia paradoxa* Woodland

Two-needle Pinyon - Juniper species / Apache Plume Woodland

CODE	CEGL002188
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Western North American Cool Temperate Woodland & Scrub (1.B.2.Nc)
MACROGROUP	Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027)
GROUP	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)

ECOLOGICAL SYSTEM(S)

Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

This woodland association is currently only known from El Malpais National Monument in New Mexico. Additional information will be added as it becomes available. This association occurs between about 2025 and 2400 m (6620-7880 feet) elevation in on gentle slopes, gently rolling lava plateaus, and steep, moderately warm, southeasterly or northwesterly backslopes of cinder cones. Substrates of this lava-related association are derived from Bandera or McCarty's flows and cinders, and ground surface is predominantly lava rock and occasionally gravel. Tree canopies of this association range from very sparse (10% cover) to very open woodland (30% cover). Trees are often low and stunted. In a few areas, *Pinus edulis* is the only species found in sparse, savanna-like tree canopies of this association, but most areas are codominated by *Pinus edulis* and either *Juniperus monosperma* or *Juniperus scopulorum*. Saplings of *Juniperus* species are common; *Pinus edulis* saplings are uncommon or absent. In some locations, mature and sapling *Pinus ponderosa* are present, but never exceed 10% in total cover. The shrub layer ranges from absent to about 13%, with the diagnostic species *Fallugia paradoxa* dominant. Mesic shrubs such as *Forestiera pubescens*, *Holodiscus dumosus*, and *Rhus trilobata* are frequent associates, though cover is low. Herbaceous species cover is low (up to about 9%), either evenly divided between graminoids and forbs or with forbs dominant. Typically *Schizachyrium scoparium* dominates the graminoids, while *Heterotheca villosa* dominates the forbs.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between about 2025 and 2400 m (6620-7880 feet) elevation on gentle slopes, gently rolling lava plateaus, and steep, moderately warm, southeasterly or northwesterly backslopes of cinder cones. Substrates of this lava-related association are derived from Bandera or McCarty's flows and cinders. Ground surface is dominated by lava rock and occasionally gravel.

Global Environment

This association is only known from El Malpais National Monument, therefore no global information is available.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this association range from very sparse savanna (10% cover) to very open woodland (30% cover). Trees are often low and stunted. In a few areas, *Pinus edulis* is the only species found in sparse, savanna-like tree canopies of this association, but most areas are codominated by *Pinus edulis* and either *Juniperus monosperma* or *Juniperus scopulorum*. Saplings of *Juniperus* species are common; *Pinus edulis* saplings are uncommon or absent. In some locations, mature and sapling *Pinus ponderosa* are present, but never exceed 10% in total cover. The shrub layer ranges from absent to about 13%, with the diagnostic species *Fallugia paradoxa* dominant. Mesic shrubs such as *Forestiera pubescens*, *Holodiscus dumosus*, and *Rhus trilobata* are frequent associates, though cover is low. Herbaceous species cover is low (up to about 9%), either evenly divided between graminoids and forbs or with forbs dominant. Typically *Schizachyrium scoparium* dominates the graminoids, while *Heterotheca villosa* dominates the forbs.

Global Vegetation

This association is only known from El Malpais National Monument, therefore no global information is available.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma, Juniperus scopulorum, Pinus edulis*
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Fallugia paradoxa*

CHARACTERISTIC SPECIES

El Malpais National Monument

Echinocereus coccineus, *Fallugia paradoxa*, *Forestiera pubescens*, *Heterotheca villosa*, *Juniperus monosperma*, *Juniperus scopulorum*, *Opuntia polyacantha*, *Pinus edulis*, *Rhus trilobata*, *Schizachyrium scoparium*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (9-Apr-2010).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Rendija, Lava Crater, Twin Craters, the Acoma-Zuni trailhead, The Narrows, the McCarty's lava flow north of North Windmill and the south end of the park, and Malpais Windmill.

Global Range

This association is currently only known from El Malpais National Monument in New Mexico. Additional range information will be added as it becomes available.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 20 field plots from 2005, 2006, and 2007: 05MA007, 06JC230, 06JC237, 06JC321, 06JC361, 06JC368, 06JC369, 06JC370, 06JC373, 06JC374, 06JC378, 06JC379, 06JC383, 06JC385, 06JC390, 06JC396, 06JC414, 06YC148, 06YC159, 07AB011.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland

Two-needle Pinyon - Rocky Mountain Juniper / Rockspirea Woodland

CODE	CEGL002802
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Western North American Cool Temperate Woodland & Scrub (1.B.2.Nc)
MACROGROUP	Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027)
GROUP	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)

ECOLOGICAL SYSTEM(S)

Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

ELEMENT CONCEPT

Global Summary

This woodland association is currently known from Black Canyon of the Gunnison, Curecanti National Recreation Area and Great Sand Dunes in Colorado and El Malpais National Monument in New Mexico. More survey and classification work are needed to fully characterize this type. The sampled Colorado stand occurs on a steep (100%), southwest-facing midslope on a ridge at 2303 m elevation. The unvegetated surface has moderate cover of litter and bedrock, large rocks, and small rocks. Downed wood is common. Substrate is a rapidly drained loamy sand soil derived from Black Canyon schist (mica schist). At El Malpais, this association occurs between about 2240 and 2390 m (7340-7850 feet) elevation on very gently rolling lava plateaus and collapse features, to steep slopes of cinder cones. Substrates are derived from basalt lava rock and cinders from cinder cone flows. Ground surface is made up of lava rock with abundant litter and occasional soil and coarse woody debris present. The vegetation is characterized by an open to moderately closed (30-60% cover) tree canopy 2-5 m tall codominated by *Pinus edulis* and *Juniperus scopulorum* with a short-shrub layer dominated by *Holodiscus dumosus*. The shrub layer is diverse in terms of species composition and provides low to moderate cover. Associated shrub species include *Cercocarpus montanus*, *Quercus gambelii*, *Artemisia tridentata*, *Philadelphus microphyllus*, *Pinus edulis* saplings, and *Artemisia frigida*. In New Mexico, *Ribes cereum* is common, and the cacti *Echinocereus coccineus* and *Opuntia polyacantha* are frequent associates, though cover is low. The herbaceous layer is low in species diversity and provides sparse to low cover. Species include *Achnatherum hymenoides*, *Arabis crandallii*, *Artemisia carruthii*, *Bouteloua gracilis*, *Descurainia incana*, *Poa fendleriana*, and *Senecio integerrimus*. Lichens and mosses can each provide low cover, up to 5%.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between about 2240 and 2390 m (7340-7850 feet) elevation on very gently rolling lava plateaus and collapse features, to steep slopes of cinder cones. Substrates are derived from basalt lava rock (Bandera flows) and cinders from cinder cone flows (Twin Craters). Ground surface is made up of lava rock with abundant litter and occasional soil and coarse woody debris present.

Global Environment

This woodland association occurs midslope on an extremely steep site with 100% slope at Black Canyon and on gently rolling lava plateaus, collapse features and steep slopes of cinder cones at El Malpais from 2240-2390 m elevation. Parent materials include mica schist, basalt and cinders. Unvegetated surfaces include bedrock, large rocks, small rocks with moderate to abundant litter and downed wood.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this association are very open (12%) to moderately closed (60%), and are codominated by *Pinus edulis* and *Juniperus scopulorum*. Seedlings and saplings of both species occur frequently in the understory. Other conifer species such as *Pinus ponderosa* and *Pseudotsuga menziesii* are rare or incidental. The shrub layer of this association is characteristically abundant (up to 30% cover) with the diagnostic species *Holodiscus dumosus* dominant. *Ribes cereum* is common, and the cacti *Echinocereus coccineus* and *Opuntia polyacantha* are frequent associates, though cover is low. The herbaceous canopy of this association is variable, ranging from sparse (0.1%) to abundant (30%). Graminoids make up most of the herbaceous cover and are most frequently represented by *Poa fendleriana* and *Bouteloua gracilis*. Forb species are few (11 species), occur sporadically, and are low in abundance (up to 5% cover); the most commonly occurring species is *Artemisia carruthii*.

Global Vegetation

Vegetation of this association is characterized by a open to moderately closed (30-60%) canopy codominated by *Pinus edulis* and *Juniperus scopulorum* with a short-shrub layer of *Holodiscus dumosus*. Other coniferous species such as *Pinus ponderosa* or *Pseudotsuga menziesii* may be present but incidental. Shrub cover varies from low to abundant (up to 30%). Associated shrubs include *Cercocarpus montanus*, *Quercus gambelii*, *Artemisia tridentata*, *Philadelphus microphyllus*, *Artemisia frigida*, *Ribes cereum*, and cacti including *Echinocereus coccineus* and *Opuntia polyacantha*. Herbaceous diversity is low. At Black Canyon, the only documented graminoid is *Achnatherum hymenoides*, whereas at El Malpais, *Poa fendleriana* and *Bouteloua gracilis* are the most abundant, but do not exceed 5% cover. Forbs are sparse and sporadic and may include, but are not limited to, *Arabis crandallii*, *Artemisia carruthii*, *Descurainia incana* ssp. *incisa*, and *Senecio integerrimus*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus scopulorum, Pinus edulis*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Holodiscus dumosus*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus scopulorum, Pinus edulis*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Holodiscus dumosus*

CHARACTERISTIC SPECIES

El Malpais National Monument

Holodiscus dumosus, *Juniperus scopulorum*, *Pinus edulis*

Global

Holodiscus dumosus, *Juniperus scopulorum*, *Pinus edulis*

OTHER NOTEWORTHY SPECIES

Global

Vulnerable: *Arabis crandallii* (globally imperiled, G2)

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (23-Jun-2005).

CLASSIFICATION

Status: Standard

Classification Confidence: 3 - Weak

Global Comments

This association has only been sampled from one location in Curecanti National Recreation Area in western Colorado. More surveys and classification work are needed to change the provisional status of this association.

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Bandera Crater, Cerro Bandera, Cerro Rendija, El Calderon, and the Ice Caves.

Global Range

This woodland association is currently known from Black Canyon of the Gunnison, Curecanti National Recreation Area and Great Sand Dunes in Colorado and El Malpais National Monument in New Mexico. More survey work is needed to fully document its global range.

Nations: US

States/Provinces: CO, NM

Federal Lands: NPS (Black Canyon of the Gunnison, Curecanti, El Malpais, Great Sand Dunes)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 8 field plots from 2005 and 2006: 05MA025, 06JC229, 06JC244, 06JC336, 06JC352, 06YC017, 06YC023, and 06YC106.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.A. Schulz, mod. M.E. Hall

REFERENCES

Western Ecology Working Group n.d.

***Pinus edulis - Juniperus monosperma / Quercus × pauciloba* Woodland**

Two-needle Pinyon - One-seed Juniper / Wavyleaf Oak Woodland

CODE	CEGL000793
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Western North American Cool Temperate Woodland & Scrub (1.B.2.Nc)
MACROGROUP	Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027)
GROUP	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)

ECOLOGICAL SYSTEM(S)

Colorado Plateau Pinyon-Juniper Woodland (CES304.767), Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

This woodland association is currently only documented from El Malpais National Monument in New Mexico, but has been reported from Colorado as well. At El Malpais, it occurs between around 2085 and 2130 m (6840-7000 feet) in elevation, typically on gently rolling lava plateaus of the Bandera and McCarty's flows, on substrates derived from basalt; it also occurs occasionally on the tops of low hills on Dakota sandstone substrates in the northeast part of the monument. Tree canopies of this woodland association are very open (25-35% cover) and are codominated by *Pinus edulis* and *Juniperus monosperma*. Typically *Pinus ponderosa* is also well-represented in the canopy. The understory of this woodland is characteristically shrubby (up to 15% cover), and is dominated by the diagnostic species *Quercus* × *pauciloba*. *Opuntia polyacantha*, *Echinocereus coccineus*, *Fallugia paradoxa*, and *Opuntia phaeacantha* are all frequent associates in this xeric woodland, though cover is usually low. The herbaceous layer cover is low (up to around 2%) and typically evenly distributed between forbs and graminoids. Xeric woodland species such as *Bouteloua gracilis*, *Bouteloua curtipendula*, *Schizachyrium scoparium*, *Heterotheca villosa*, *Artemisia carruthii*, *Schoenocrambe linearifolia*, and *Glandularia bipinnatifida* are most commonly represented in the herbaceous layer.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between around 2085 and 2130 m (6840-7000 feet) in elevation, typically on gently rolling lava plateaus of the Bandera and McCarty's flows, on substrates derived from basalt; it also occurs occasionally on the tops of low hills on Dakota sandstone substrates in the northeast part of the monument.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this woodland association are very open (25-35% cover) and are codominated by *Pinus edulis* and *Juniperus monosperma*. Typically *Pinus ponderosa* is also well-represented in the canopy. The understory of this woodland is characteristically shrubby (up to 15% cover), and is dominated by the diagnostic species *Quercus* × *pauciloba*. *Opuntia polyacantha*, *Echinocereus coccineus*, *Fallugia paradoxa*, and *Opuntia phaeacantha* are all frequent associates in this xeric woodland, though cover is usually low. The herbaceous layer cover is low (up to around 2%) and typically evenly distributed between forbs and graminoids. Xeric woodland species such as *Bouteloua gracilis*, *Bouteloua curtipendula*, *Schizachyrium scoparium*, *Heterotheca villosa*, *Artemisia carruthii*, *Schoenocrambe linearifolia*, and *Glandularia bipinnatifida* are most commonly represented in the herbaceous layer.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma, Pinus edulis*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Quercus* × *pauciloba*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia carruthii, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Echinocereus coccineus*, *Fallugia paradoxa*, *Glandularia bipinnatifida*, *Heterotheca villosa*, *Juniperus monosperma*, *Opuntia phaeacantha*, *Opuntia polyacantha*, *Pinus edulis*, *Quercus* × *pauciloba*, *Schizachyrium scoparium*, *Schoenocrambe linearifolia*

CONSERVATION STATUS RANK

Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Global Related Concepts

- *Pinus edulis*/*Quercus* × *pauciloba* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Zuni-Acoma Trail, the Sandstone Bluffs Overlook, and the McCarty's flow north of La Vieja.

Global Range

This woodland association is found in New Mexico and Colorado.

Nations: US

States/Provinces: CO:S2, NM:S5

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 3 field plots from 2006: 06JC271, 06JC272, and 06YC147.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: E. Muldavin and A. Kennedy, mod. M.E. Hall

REFERENCES

Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, Larson and Moir 1986, Larson and Moir 1987, Muldavin and Mehlhop 1992, Rogers 1953, Western Ecology Working Group n.d.

Pinus edulis / Achnatherum scribneri Woodland

Two-needle Pinyon / Scribner's Needlegrass Woodland

CODE	CEGL000798
PHYSIOGNOMIC CLASS	Forest to Open Woodland (1)
PHYSIOGNOMIC FORMATION	Cool Temperate Forest (1.B.2)
PHYSIOGNOMIC DIVISION	Western North American Cool Temperate Woodland & Scrub (1.B.2.Nc)
MACROGROUP	Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027)
GROUP	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)

ECOLOGICAL SYSTEM(S)

Colorado Plateau Pinyon-Juniper Woodland (CES304.767), Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

ELEMENT CONCEPT

Global Summary

The center of distribution for this association is the central mountain corridor of New Mexico with outliers in southeastern Colorado. It is specifically known from the Sierra Oscura, San Andres Mountains, and Organ Mountains of the south-central Rio Grande corridor, and likely in the Manzano, Sandia, and Sacramento mountains. This association is typically found at mid to high elevations of 1890-2590 m (6200-8500 feet), on north-facing mountain slopes. Slope positions vary from gentle dipslopes to steep escarpments. The larger stands are particularly evident on the long, gently sloping dipslopes of the major fault block mountains. Soils range from well-developed Mollisols or Alfisols with high nutrient status to drier and more poorly developed Inceptisols. Although gravel and cobble content can be high, water-holding capacity is probably moderate. Secondary calcium carbonate accumulations can occur, including indurated petrocalcic horizons, which can limit root penetration. At El Malpais National Monument in west-central New Mexico, this association occurs between 2135 and 2380 m (7000-7800 feet) in elevation on gently rolling mesatops, gentle footslopes and shoulder slopes of low hills, and steep sideslopes of low hills. Substrates are typically derived from Permian sandstone and occasionally limestone formations. Ground surface cover is variable and can be dominated by gravel, rock or litter. It is characterized by a moderately open to relatively dense and tall overstory of *Pinus edulis* (>9 m [30+ feet]) with *Juniperus monosperma* (or occasionally *Juniperus deppeana*) scattered in the subcanopy. *Pinus edulis* regeneration is usually present, *Juniperus monosperma* less so. A grassy understory of well-represented to abundant *Achnatherum scribneri* (= *Stipa scribneri*) or *Achnatherum lobatum* (= *Stipa lobata*) is diagnostic; *Bouteloua gracilis* often shares the dominance. *Muhlenbergia pauciflora* can be common but is clearly not the dominant. Scattered shrubs occur, but total shrub cover seldom exceeds 5%. *Cercocarpus montanus*, *Yucca baccata*, *Quercus* × *pauciloba* (= *Quercus undulata*), and *Opuntia phaeacantha* are the most conspicuous shrub species. Forb species richness is high (66 species), and cover reaches 5% in some stands. They may commonly include *Hymenoxys richardsonii*, *Tetraneuris argentea*, and *Eriogonum jamesii*.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2135 and 2380 m (7000-7800 feet) in elevation on gently rolling mesatops, gentle footslopes and shoulder slopes of low hills, and steep sideslopes of low hills. Substrates are typically derived from Permian (Yeso, Abó, Glorieta) sandstone and occasionally limestone formations (San Andres). Ground surface cover is variable and can be dominated by gravel, rock, or litter.

Global Environment

This association is typically found at mid to high elevations of 1890-2590 m (6200-8500 feet), on north-facing mountain slopes. Slope positions vary from gentle dipslopes to steep escarpments. The larger stands are particularly evident on the long, gently sloping dipslopes of the major fault block mountains. Soils range from well-developed Mollisols or Alfisols with high nutrient status to drier and more poorly developed Inceptisols. Although gravel and cobble content can be high, water-holding capacity is probably moderate. Secondary calcium carbonate accumulations can occur, including indurated petrocalcic horizons, which can limit root penetration. At El Malpais National Monument in west-central New Mexico, this association occurs between 2135 and 2380 m (7000-7800 feet) in elevation on gently rolling mesatops, gentle footslopes and shoulder slopes of low hills, and steep sideslopes of low hills. Substrates are typically derived from Permian sandstone and occasionally limestone formations. Ground surface cover is variable and can be dominated by gravel, rock, or litter.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this association vary from moderately open (40%) to more closed woodland (65%) and are codominated by *Pinus edulis* and *Juniperus monosperma*. Seedlings and saplings of both species are found, as well as snags. Other conifers such as *Juniperus deppeana* or *Pseudotsuga menziesii* occur occasionally. Shrub species are few and low in abundance, but most frequently include the xeric shrub *Yucca baccata*. In contrast, the herbaceous layer is well-represented and moderately rich in species (17 graminoids and 26 forbs recorded from this association). Grass species predominate; *Achnatherum scribneri*, the diagnostic species of this woodland association, is most abundant. *Bouteloua gracilis* often shares the dominance. Forbs are patchily abundant and most commonly include *Hymenoxys richardsonii*, *Tetraneuris argentea*, and *Eriogonum jamesii*.

Global Vegetation

This association is characterized by a moderately open to relatively dense and tall overstory of *Pinus edulis* with

Juniperus monosperma (or occasionally *Juniperus deppeana*) scattered in the subcanopy. *Pinus edulis* regeneration is usually present, *Juniperus monosperma* less so. A grassy understory of well-represented to abundant *Achnatherum scribneri* (= *Stipa scribneri*) or *Achnatherum lobatum* (= *Stipa lobata*) is diagnostic; *Bouteloua gracilis* often shares the dominance. *Muhlenbergia pauciflora* can be common but is clearly not the dominant. Scattered shrubs occur, but total shrub cover seldom exceeds 5%. *Cercocarpus montanus*, *Yucca baccata*, *Quercus* × *pauciloba* (= *Quercus undulata*), and *Opuntia phaeacantha* are the most conspicuous shrub species. Forb species richness is high (66 species), and cover reaches 5% in some stands.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma, Pinus edulis*
Herb (field)	Graminoid	*Achnatherum scribneri*

Globally

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma, Pinus edulis*
Herb (field)	Graminoid	*Achnatherum lobatum, Achnatherum scribneri*

CHARACTERISTIC SPECIES

El Malpais National Monument

Achnatherum scribneri, *Bouteloua gracilis*, *Gutierrezia sarothrae*, *Hymenoxys richardsonii*, *Juniperus monosperma*, *Opuntia phaeacantha*, *Pinus edulis*, *Poa fendleriana*, *Yucca baccata*

Global

Achnatherum scribneri, *Juniperus monosperma*, *Pinus edulis*

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (1-Dec-2000). This is a restricted Southwest regional endemic community, that has had a long history of human impacts. In this association, *Pinus edulis* achieves its maximum expression with tall trees that can form old-growth, closed-canopy, pygmy forests. The grassy understory composition is also unique among pinyon-juniper types. Stands can be large, but few examples remain that have not been significantly impacted by 300+ years of fuelwood removal and altered fire regimes, leading to increased fragmentation and loss. In addition, the majority of the remaining high-quality occurrences are found in remote areas where livestock impacts are minimal.

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Global Comments

The two-needle pinyon pine / Dore's needlegrass (*Pinus edulis* / *Stipa nelsonii* var. *dorei*) type as defined by Stuever and Hayden (1997a) based on the *Stipa columbiana* type of Kennedy (1983b) may be synonymous with this association; further analysis of the former types is needed. *Stipa columbiana* and *Stipa nelsonii* var. *dorei* are synonyms of *Achnatherum nelsonii* ssp. *dorei* (Kartesz 1999).

Global Related Concepts

- *Pinus edulis/Stipa scribneri* (Bourgeron and Engelking 1994) =
- *Stipa columbiana* type (Kennedy 1983b) ?
- DRISCOLL FORMATION CODE:II.A.2.a. (Driscoll et al. 1984) B
- Two-needle pinyon pine / Dore's needlegrass (*Pinus edulis* / *Stipa nelsonii* var. *dorei*) type (Stuever and Hayden 1997a) ?

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Twin Crater, the vicinity of Junction Cave, Encerrito, Cerritos de Jaspe, the Zuni-Acoma trailhead, and Mesita Blanca.

Global Range

The center of distribution for this association is the central mountain corridor of New Mexico with outliers in southeastern Colorado. It is specifically known from the Sierra Oscura, San Andres Mountains, and Organ Mountains of the south-central Rio Grande corridor, and likely in the Manzano, Sandia, and Sacramento mountains.

Nations: US

States/Provinces: CO:S2, NM:S3, WY

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 8 field plots from 2006: 06AB223, 06EM016, 06JC251, 06JC259, 06JC260, 06JC264, 06YC030, and 06YC067.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: E. Muldavin, mod. M.E. Hall

REFERENCES

Bourgeron and Engelking 1994; CONHP unpubl. data 2003; Clements 1904; Driscoll et al. 1984; Galatowitsch and Bourgeron 1985; Kartesz 1999; Kennedy 1983b; Muldavin and Mehlhop 1992; Muldavin, Chauvin, et al. 2000; Shantz 1906; Soil Conservation Service 1978; Stuever and Hayden 1997a; Stuever and Hayden 1997b; Western Ecology Working Group n.d.

2. Shrubland & Grassland

Fallugia paradoxa - Rhus trilobata Shrubland

Apache Plume - Skunkbush Sumac Shrubland

CODE	CEGL002222
PHYSIOGNOMIC CLASS	Shrubland & Grassland (2)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.B.2)
PHYSIOGNOMIC DIVISION	Western North American Grassland & Shrubland (2.B.2.Na)
MACROGROUP	Southern Rocky Mountain Montane Shrubland (M049)
GROUP	Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group (G276)

ECOLOGICAL SYSTEM(S)

Rocky Mountain Lower Montane-Foothill Shrubland (CES306.822)

ELEMENT CONCEPT

Global Summary

This shrubland association is currently only known from El Malpais National Monument in New Mexico, and the following description is based on occurrences there. Additional information will be added as it becomes available. This association occurs between 2010 and 2325 m (6600-7630 feet) in elevation on gently rolling lava plateaus. Substrates are mainly derived from McCarty's lavaflow, though occasionally from Bandera or Hoya de Cibola flows. Ground cover is dominated by rock with litter or gravel occasionally well-represented. In this shrubland, stunted and depauperate *Pinus edulis* and *Juniperus scopulorum* individuals may be scattered, along with occasional *Pinus ponderosa* and *Juniperus monosperma*. Shrubs are the main component of the association in frequency and abundance (ranging up to 40% cover). *Fallugia paradoxa* is the most frequently occurring and abundant shrub (at all sampling sites); *Rhus trilobata* occurs as frequently but is not as abundant (relative cover about 2%). A strong component of other mesic shrubs such as *Forestiera pubescens*, *Holodiscus dumosus*, and *Ribes cereum* is characteristic of this association. The herbaceous layer is not abundant, with a mean cover of about 6%; forbs usually predominate. *Bouteloua gracilis*, *Bouteloua curtipendula*, *Elymus elymoides*, and *Schizachyrium scoparium* are the most frequently occurring graminoids, though cover of any individual species is low. Forbs can range as high as 20% total cover, with *Heterotheca villosa* the most common species found, followed by *Artemisia carruthii*.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2010 and 2325 m (6600-7630 feet) in elevation on gently rolling lava plateaus. Substrates are mainly derived from McCarty's lavaflow, though occasionally from Bandera or Hoya de Cibola flows. Ground cover is dominated by rock with litter or gravel occasionally well-represented.

Global Environment

This association is only known from El Malpais National Monument, therefore no global information is available.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

In this shrubland, stunted and depauperate *Pinus edulis* and *Juniperus scopulorum* individuals may be scattered, along with an occasional *Pinus ponderosa* and *Juniperus monosperma*. Shrubs are the main component of the association in terms of frequency and abundance (ranging up to 40% cover). *Fallugia paradoxa* is the most frequently occurring and abundant shrub (at all sampling sites); *Rhus trilobata* occurs as frequently but is not as abundant (relative cover about 2%). A strong component of other mesic shrubs such as *Forestiera pubescens*, *Holodiscus dumosus*, and *Ribes cereum* is characteristic of this association. The herbaceous layer is not abundant, with a mean cover of about 6%; forbs usually predominate. *Bouteloua gracilis*, *Bouteloua curtipendula*, *Elymus elymoides*, and *Schizachyrium scoparium* are the most frequently occurring graminoids, though cover of any individual species is low. Forbs can range as high as 20% total cover, with *Heterotheca villosa* the most common species found, followed by *Artemisia carruthii*.

Global Vegetation

This association is only known from El Malpais National Monument, therefore no global information is available.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Rhus trilobata*
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Fallugia paradoxa*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, *Echinocereus coccineus*, *Elymus elymoides*, *Fallugia paradoxa*, *Heterotheca villosa*, *Opuntia polyacantha*, *Pinus edulis*, *Rhus trilobata*, *Schizachyrium scoparium*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (12-Apr-2010).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the McCarty's flow west of Las Ventanas Ridge, the Zuni-Acoma Trail, and north of Sandstone Bluffs Overlook.

Global Range

This association is currently only known from El Malpais National Monument in New Mexico. Additional range information will be added as it becomes available.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 13 field plots from 2005, 2006, and 2007: 05MA019, 06JC228, 06JC338, 06JC364, 06JC365, 06JC391, 06JC408, 06JC409, 06JC410, 06JC417, 06YC160, 07AB014, and 07AB019.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

***Fallugia paradoxa* / Rockland Shrubland**

Apache Plume / Rockland Shrubland

CODE	CEGL002330
PHYSIOGNOMIC CLASS	Shrubland & Grassland (2)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.B.2)
PHYSIOGNOMIC DIVISION	Western North American Grassland & Shrubland (2.B.2.Na)
MACROGROUP	Southern Rocky Mountain Montane Shrubland (M049)
GROUP	Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group (G276)

ECOLOGICAL SYSTEM(S)

Rocky Mountain Lower Montane-Foothill Shrubland (CES306.822)

ELEMENT CONCEPT

Global Summary

This shrubland association is currently only known from El Malpais National Monument in New Mexico, and the following description is based on occurrences there. Additional information will be added as it becomes available. This association occurs between 2030 and 2420 m (6650-7950 feet) in elevation typically on rough and broken, gently rolling lava plateaus, but occasionally on moderate to steep sideslopes of volcano craters. Substrates are typically derived from McCarty's lavaflow, though occasionally from Hoya de Cibola flows, Twin Craters, or older lavaflows. Ground cover is dominated by lava rock or gravel. Trees are rare in this shrubland, and the shrub *Fallugia paradoxa* is the dominant species, occurring in every sampling location with an occasional maximum relative cover of up to 42%. Other shrub species, including *Holodiscus dumosus* and *Ericameria nauseosa*, also occur but less frequently and in less abundance. The herbaceous layer is characteristically sparse (about 2% total cover), though it rarely ranges as high as 20%; it is about equally divided between graminoids and forbs. *Schizachyrium scoparium* and *Elymus elymoides* are the most abundant grasses, although they occur infrequently. The most commonly occurring forb is *Heterotheca villosa*.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2030 and 2420 m (6650-7950 feet) in elevation typically on rough and broken, gently rolling lava plateaus, but occasionally on moderate to steep sideslopes of volcano craters. Substrates are typically derived from McCarty's lavaflow, though occasionally from Hoya de Cibola flows, Twin Craters, or older lavaflows. Ground cover is dominated by rock or gravel.

Global Environment

This association is only known from El Malpais National Monument, therefore no global information is available.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Trees are rare in this shrubland, and the shrub *Fallugia paradoxa* is the dominant species, occurring in every sampling location with an occasional maximum relative cover of up to 42%. Other shrub species, including *Holodiscus dumosus* and *Ericameria nauseosa*, also occur but less frequently and in less abundance. The herbaceous layer is characteristically sparse (about 2% total cover), though it rarely ranges as high as 20%; it is about equally divided between graminoids and forbs. *Schizachyrium scoparium* and *Elymus elymoides* are the most abundant grasses, although they occur infrequently. The most commonly occurring forb is *Heterotheca villosa*. Lava rock and gravel dominate the ground surface of these shrublands.

Global Vegetation

This association is only known from El Malpais National Monument, therefore no global information is available.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Fallugia paradoxa*

Globally

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

CHARACTERISTIC SPECIES

El Malpais National Monument

Fallugia paradoxa

Global

Fallugia paradoxa

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (12-Apr-2010).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Candelaria, Cerro Encierro, the McCarty's flow north of Sandstone Bluffs Overlook, south of Los Medanitos, north of North Windmill, and west of Malpais Windmill.

Global Range

This association is currently only known from El Malpais National Monument in New Mexico. Additional range information will be added as it becomes available.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 9 field plots from 2005, 2006, and 2007: 05MA001, 06AB211, 06JC298, 06JC367, 06JC382, 06JC392, 06JC395, 06JC415, and 07AB007.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Rhus trilobata - Ribes cereum Shrubland

Skunkbush Sumac - Wax Currant Shrubland

CODE	CEGL002333
PHYSIOGNOMIC CLASS	Shrubland & Grassland (2)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.B.2)
PHYSIOGNOMIC DIVISION	Western North American Grassland & Shrubland (2.B.2.Na)
MACROGROUP	Southern Rocky Mountain Montane Shrubland (M049)
GROUP	Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group (G276)

ECOLOGICAL SYSTEM(S)

Rocky Mountain Lower Montane-Foothill Shrubland (CES306.822)

ELEMENT CONCEPT

Global Summary

This shrubland association is currently only known from El Malpais National Monument in New Mexico, and the following description is based on occurrences there. Additional information will be added as it becomes available. This association occurs between 2110-2420 m (6930-7940 feet) in elevation on gently rolling lava plateaus and collapse features. Substrates are typically weathered, rough, and broken lava from Twin Craters and Bandera flows. The ground surface cover is composed of lava rock and gravel, with areas interspersed where finer wind- or water-borne soils have accumulated. A well-developed shrub canopy (mean cover around 13%) is characteristic of this mesic association, with *Rhus trilobata* and *Ribes cereum* the dominant species and *Forestiera pubescens* a frequent associate. Tree species such as *Juniperus monosperma*, *Pinus edulis*, or *Populus tremuloides* are frequently present in these shrublands as saplings or mature individuals, but never exceed 10% total cover. Herbaceous species occur most abundantly in the patches of finer soil and reach about 8% cover, which is typically equally distributed between graminoids and forbs. *Bouteloua gracilis*, *Piptatherum micranthum*, and *Poa fendleriana* are the most frequently occurring graminoids, though individual cover is low. *Artemisia carruthii* is the most frequently occurring amongst the forb species identified from this association.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2110-2420 m (6930-7940 feet) in elevation on gently rolling lava plateaus and collapse features. Substrates are typically weathered, rough, and broken lava from Twin Craters and Bandera flows. The ground surface cover is composed of lava rock and gravel, with areas interspersed where finer wind- or water-borne soils have accumulated.

Global Environment

This association is only known from El Malpais National Monument, therefore no global information is available.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

A well-developed shrub canopy (mean cover around 13%) is characteristic of this mesic association, with *Rhus trilobata* and *Ribes cereum* the dominant species and *Forestiera pubescens* a frequent associate. Tree species such as *Juniperus monosperma*, *Pinus edulis*, or *Populus tremuloides* are frequently present in these shrublands as saplings or mature individuals, but never exceed 10% total cover. Herbaceous species occur most abundantly in the patches of finer soil and reach about 8% cover, which is typically equally distributed between graminoids and forbs. *Bouteloua gracilis*, *Piptatherum micranthum*, and *Poa fendleriana* are the most frequently occurring graminoids, though individual cover is low. *Artemisia carruthii* is the most frequently occurring amongst the forb species identified from this association.

Global Vegetation

This association is only known from El Malpais National Monument, therefore no global information is available.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Rhus trilobata, Ribes cereum*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia carruthii, *Bouteloua gracilis*, *Forestiera pubescens*, *Pinus edulis*, *Piptatherum micranthum*, *Poa fendleriana*, *Populus tremuloides*, *Rhus trilobata*, *Ribes cereum*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (12-Apr-2010).

CLASSIFICATION

Status: Standard

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Bandera Crater, Visitor Center - West, Encerrito West, and Junction Cave.

Global Range

This association is currently only known from El Malpais National Monument in New Mexico. Additional range information will be added as it becomes available.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots from 2006: 06AB212, 06JC219, 06JC220, 06JC256, and 06YC031.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

***Artemisia filifolia / Bouteloua (curtipendula, gracilis)* Shrubland**

Sand Sagebrush / (Sideoats Grama, Blue Grama) Shrubland

CODE	CEGL002176
PHYSIOGNOMIC CLASS	Shrubland & Grassland (2)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.B.2)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.B.2.Nb)
MACROGROUP	Great Plains Sand Grassland & Shrubland (M052)
GROUP	Great Plains Sand Shrubland Group (G069)

ECOLOGICAL SYSTEM(S)

Western Great Plains Sandhill Steppe (CES303.671)

ELEMENT CONCEPT

Global Summary

This sagebrush shrubland is found on sandy rolling hills in the southern Great Plains of the United States, ranging from Kansas south to Texas. It is also known to occur at 1930 m (6325 feet) elevation on gently rolling hills and sandy alluvial plains within the Salinas Pueblo Missions National Monument in New Mexico and between 1960 and 2160 m (6430-7090 feet) on a variety of aspects and landforms, including gently rolling, old lavaflows, gently sloping coppice dunes, or lower dipslopes of low sandstone hills at El Malpais National Monument. Soils are loamy fine sand to sandy, excessively drained, and formed in loamy or sandy eolian sediments. The ground surface is characterized by large patches of exposed soil and scattered areas of grass and litter. The shrub layer is between 0.5 and 1 m tall and dominated by *Artemisia filifolia* with *Chrysothamnus pulchellus* as a frequent associate at some sites. Occasionally *Pinus edulis* or *Pinus ponderosa* are scattered, but typically trees are absent in these sandy shrublands. Short to medium grasses dominate the ground layer, including *Bouteloua curtipendula* and *Bouteloua gracilis*. Other graminoids include *Andropogon hallii*, *Aristida purpurea*, *Cyperus schweinitzii*, *Paspalum setaceum*, *Pascopyrum smithii*, *Schizachyrium scoparium*, and *Sporobolus cryptandrus*, among others. Herbs may include *Erigeron annuus*, *Helianthus petiolaris*, and *Grindelia papposa* (= *Prionopsis ciliata*). Prairie forb species such as *Gaillardia pulchella*, *Linum lewisii*, *Machaeranthera tanacetifolia*, *Melampodium leucanthum*,*Mirabilis linearis*, and*Oenothera pallida* may be common and characteristic.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 1960 and 2160 m (6430-7090 feet) in elevation on a variety of aspects and landforms, including gently rolling, old lavaflows, gently sloping coppice dunes, or lower dipslopes of low sandstone hills. Substrates are derived from sandy alluvium or Dakota sandstone, and ground cover is dominated by soil and litter.

Global Environment

This sagebrush shrubland is found on sandy rolling hills in the southern Great Plains of the United States. It is also known to occur at 1930 m (6325 feet) elevation on gently rolling hills and sandy alluvial plains within the Salinas Pueblo Missions National Monument in New Mexico and between 1960 and 2160 m (6430-7090 feet) on a variety of aspects and landforms, including gently rolling, old lavaflows, gently sloping coppice dunes, or lower dipslopes of low sandstone hills at El Malpais National Monument. Soils are loamy fine sand to sandy, excessively drained, and formed in loamy or sandy eolian sediments. Soils are loamy fine sand to sandy, excessively drained, and formed in loamy or sandy eolian sediments (Lauver et al. 1999). The ground surface is characterized by large patches of exposed soil and scattered areas of grass and litter.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Artemisia filifolia dominates the abundant (up to 50% cover) shrub canopy of this association, with *Chrysothamnus pulchellus* as a frequent associate. Occasionally *Pinus edulis* or *Pinus ponderosa* are scattered, but typically trees are absent in these sandy shrublands. The herbaceous layer of this association is variable, ranging from around 2-25% cover, and graminoids predominate. The diagnostic species *Bouteloua gracilis* is the dominant graminoid species, frequently with *Sporobolus cryptandrus* as a codominant. Forbs are typically low in abundance, though occasionally they can range as high as 10% total cover, and include a mix of xeric grassland species that prefer sandy soils, such as *Dimorphocarpa wislizeni*. Overall herbaceous species richness is 39: 11 graminoids and 28 forbs. This may vary considerably from year to year, depending on changes in precipitation and temperature.

Global Vegetation

The shrub layer is between 0.5 and 1 m tall. The canopy is dominated by *Artemisia filifolia* with *Chrysothamnus pulchellus* as a frequent associate at some sites. Occasionally *Pinus edulis* or *Pinus ponderosa* are scattered, but typically trees are absent in these sandy shrublands. Short to medium grasses dominate the ground layer, including *Bouteloua curtipendula* and *Bouteloua gracilis*. Other graminoids may include *Andropogon hallii*, *Aristida purpurea*, *Cyperus schweinitzii*, *Paspalum setaceum*, *Pascopyrum smithii*, *Schizachyrium scoparium*, and *Sporobolus cryptandrus*, among others. Herbs may include *Erigeron annuus*, *Helianthus petiolaris*, and *Grindelia papposa* (= *Prionopsis ciliata*) (Lauver et al. 1999). Prairie forb species such as *Gaillardia pulchella*, *Linum lewisii*, *Machaeranthera tanacetifolia*, *Melampodium leucanthum*,*Mirabilis linearis*, and*Oenothera pallida* may be common and characteristic.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Bouteloua gracilis*

Globally

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Artemisia filifolia*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia filifolia, *Bouteloua gracilis*, *Chrysothamnus pulchellus*, *Salsola tragus*, *Sporobolus cryptandrus*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (3-Oct-1996).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

El Malpais National Monument Comments

Ericameria nauseosa or *Quercus* × *pauciloba* phases occur in this association where these species exceed 5% total cover.

Global Related Concepts

- Sandsage-Midgrass Series (Diamond 1993) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Northwest New Mexico Visitor Center, the Sandstone Bluffs Overlook, and North Pasture.

Global Range

This community is found in the southern Great Plains of the United States, ranging from Kansas south to Texas. It is also known to occur within the Salinas Pueblo Missions National Monument and El Malpais National Monument in New Mexico.

Nations: US

States/Provinces: KS:SU, NM, OK, TX:S4

Federal Lands: NPS (El Malpais, Lake Meredith, Salinas Pueblo Missions)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots from 2005 and 2006: 05MA017, 06JC427, 06YC126, 06YC167, and 06YC176.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

Global Description Authors: D. Faber-Langendoen, mod. K.S. King and M.E. Hall

REFERENCES

Baalman 1965, Blair and Hubbell 1938, Bruner 1931, Diamond 1993, Duck and Fletcher 1945, Harlan 1957, Hoagland 2000, Jones 1963, Lauver et al. 1999, Osborn 1941, Osborn and Kellogg 1943, Sherwood 1980, Sherwood and Risser 1980, Smith 1998, Southeastern Ecology Working Group n.d., Zanoni et al. 1979

Artemisia frigida / Bouteloua gracilis Dwarf-shrubland [Provisional]

Fringed Sagebrush / Blue Grama Dwarf-shrubland

CODE	CEGL002782
PHYSIOGNOMIC CLASS	Shrubland & Grassland (2)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.B.2)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.B.2.Nb)
MACROGROUP	Great Plains Shortgrass Prairie & Shrubland (M053)
GROUP	Great Plains Shortgrass Prairie Group (G144)

ECOLOGICAL SYSTEM(S)

Rocky Mountain Lower Montane-Foothill Shrubland (CES306.822)

ELEMENT CONCEPT

Global Summary

This dwarf-shrubland is reported from central Colorado, where it is associated with prairie dog towns and heavily grazed pastures in the vicinity of livestock watering ponds. It is located on deeper soils that are typically deposited in drainages, swales (interfluves), and along lower hillslopes. The soil must be of a consistency (silty-clay and clay) that will support burrowing activity in terms of both depth and cohesiveness. Ground cover is typically 60-90% bare soil and small gravel, with the remainder in herbaceous litter. It also occurs at El Malpais National Monument in western New Mexico, primarily in areas of soil formation from deposition and weathering, as well as in kipukas of the oldest lavaflows and occasionally on gentle sideslopes of low hills or on gently rolling plains with alluvium or sandstone substrates. This type is found at elevations ranging from 2100 to 2640 m (6900-8660 feet). The slopes range from 2-7% and are considered moderately well-drained. In prairie dog communities, *Artemisia frigida* is an increaser under livestock grazing regimes and is evidently unpalatable or less palatable to prairie dogs. The age of the colony determines to what extent *Artemisia frigida* dominates the site, and the following description covers sites that have been used by prairie dogs for several years. Prairie dog colonies that are densely occupied typically have vegetative cover values less than 40%. The foliar cover for *Artemisia frigida* ranges from 20-40%, and other dwarf-shrubs (i.e., Ericameria parryi, *Chrysothamnus viscidiflorus*, *Gutierrezia sarothrae*, Rosa acicularis, and *Solidago* sp.) contribute from 5-20% foliar cover on some sites. The most abundant graminoid is *Bouteloua gracilis*, which is an increaser under light to moderate grazing regimes. *Bouteloua gracilis* contributes approximately 5-10% foliar cover on sites that are moderate to heavily-grazed. Other graminoids present on established prairie dog towns include Schedonnardus paniculatus, *Poa fendleriana*, and *Nassella viridula*. They rarely contribute greater than 5% foliar cover, unless it is a less densely populated colony, then the cover values increase for these species. Forbs generally contribute less than 5% to the foliar cover; those species commonly associated with these disturbed sites include Argentina anserina, Melilotus officinalis, and *Achillea millefolium*. At El Malpais, *Bouteloua gracilis* is also the most frequent and abundant species and typically exceeds 25% cover. *Elymus elymoides* occurs nearly as frequently, though cover is lower. The shrub layer is dominated by the low-growing subshrub *Artemisia frigida* with around 10% cover. Taller shrubs such as *Ericameria nauseosa*, *Gutierrezia sarothrae*, and *Tetradymia canescens* are common associates, but their cover seldom exceeds 5%. Forbs make up a small proportion of the total cover, but species richness is high with 43 forb species found from sample plots of these grasslands. *Eriogonum jamesii* and *Sphaeralcea coccinea* are the most frequently occurring forb species observed. Trees can be scattered in these grasslands but typically occur with less than 10% cover and may include *Pinus edulis*, *Pinus ponderosa*, *Juniperus scopulorum*, and *Juniperus monosperma*.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2100 and 2330 m (6900-7660 feet) in elevation, primarily in areas of soil formation from deposition and weathering, as well as in kipukas of the oldest lavaflows. It occurs occasionally on gentle sideslopes of low hills or on gently rolling plains with alluvium or sandstone substrates. Ground cover is dominated by soil, with a large component of rock and some gravel. Litter is abundant in some areas.

Global Environment

This association is known from central Colorado and El Malpais National Monument in New Mexico. In Colorado, this community is associated with prairie dog towns and grazed pastures in the vicinity of livestock watering ponds. It is located on deeper soils that are typically deposited in drainages, swales (interfluves), and along lower hillslopes. It also occurs at El Malpais National Monument in western New Mexico primarily in areas of soil formation from deposition and weathering, as well as in kipukas of the oldest lavaflows and occasionally on gentle sideslopes of low hills or on gently rolling plains with alluvium or sandstone substrates. In both areas this type is found at elevations ranging from 2100 to 2640 m (6900-8660 feet). The slopes range from 2-7% and are considered moderately well-drained.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

In this shortgrass prairie grassland, *Bouteloua gracilis* is the most frequent and abundant species and typically exceeds 25% cover. *Elymus elymoides* occurs nearly as frequently, though cover is lower. The shrub layer in this association is dominated by the low-growing subshrub *Artemisia frigida* with around 10% cover. Taller shrubs such as *Ericameria nauseosa*, *Gutierrezia sarothrae*, and *Tetradymia canescens* are common associates, but their cover seldom exceeds 5%. Forbs make up a small proportion of the total cover (around 1%), but species richness is high with 43 forb species found from these grasslands. *Eriogonum jamesii* and *Sphaeralcea coccinea* are the most frequently occurring forb species observed. Trees can be scattered in these grasslands but typically occur with less than 10% cover and may include *Pinus edulis*, *Pinus ponderosa*, *Juniperus scopulorum*, and *Juniperus monosperma*.

Global Vegetation

In prairie dog colonies, the age of the colony determines to what extent *Artemisia frigida* dominates the site, and the following description covers sites that have been used by prairie dogs for several years. Prairie dog colonies that are densely occupied typically have vegetative cover values less than 40%. The foliar cover for *Artemisia frigida* ranges from 20-40%, and other dwarf-shrubs (i.e., *Ericameria parryi*, *Chrysothamnus viscidiflorus*, *Gutierrezia sarothrae*, *Rosa acicularis*, and *Solidago* sp.) contribute from 5-20% foliar cover on some sites. The most abundant graminoid is *Bouteloua gracilis*, which is an increaser under light to moderate grazing regimes. *Bouteloua gracilis* contributes approximately 5-10% foliar cover on sites that are moderate to heavily-grazed. Other graminoids present on established prairie dog towns include *Schedonnardus paniculatus*, *Poa fendleriana*, and *Nassella viridula*. They rarely contribute greater than 5% foliar cover, unless it is a less densely populated colony, then the cover values increase for these species. Forbs generally contribute less than 5% to the foliar cover; those species commonly associated with these disturbed sites include Argentina anserina, Melilotus officinalis, and *Achillea millefolium*. At El Malpais, *Bouteloua gracilis* is also the most frequent and abundant species and typically exceeds 25% cover. *Elymus elymoides* occurs nearly as frequently, though cover is lower. The shrub layer is dominated by the low-growing subshrub *Artemisia frigida* with around 10% cover. Taller shrubs such as *Ericameria nauseosa*, *Gutierrezia sarothrae*, and *Tetradymia canescens* are common associates, but their cover seldom exceeds 5%. Forbs make up a small proportion of the total cover, but species richness is high with 43 forb species found from sample plots of these grasslands. *Eriogonum jamesii* and *Sphaeralcea coccinea* are the most frequently occurring forb species observed. Trees can be scattered in these grasslands but typically occur with less than 10% cover and may include *Pinus edulis*, *Pinus ponderosa*, *Juniperus scopulorum*, and *Juniperus monosperma*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Dwarf-shrub	*Artemisia frigida*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia frigida, *Bouteloua gracilis*, *Chamaesyce serpyllifolia*, *Elymus elymoides*, *Ericameria nauseosa*, *Eriogonum jamesii*, *Gutierrezia sarothrae*, Monroa squarrosa, *Sphaeralcea coccinea*, *Tetradymia canescens*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (27-Aug-2002).

CLASSIFICATION

Status: Provisional

Classification Confidence: 3 - Weak

El Malpais National Monument Comments

An *Ericameria nauseosa* phase was identified from this association where the species exceeds 5% total cover.

Global Comments

The attribution of the plots from El Malpais to this community are questionable. Clearly in Colorado this type is maintained by disturbance, whereas El Malpais has very little land-use history and no suitable prairie dog habitat.

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Rendija; Little Hole-In-The-Wall and the Bandera flow to the east, and the Hoya de Cibola flow to the south; Mesita Blanca; and Hole-In-The-Wall.

Global Range

This shrubland is reported from central Colorado and western New Mexico at El Malpais National Monument.

Nations: US

States/Provinces: CO, NM

Federal Lands: NPS (El Malpais, Florissant Fossil Beds)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 15 field plots from 2005 and 2006: 05MA004, 06JC284, 06JC286, 06JC327, 06YC043, 06YC046, 06YC051, 06YC057, 06YC069, 06YC074, 06YC075, 06YC076, 06YC078, 06YC084, and 06YC107.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

Global Description Authors: M.E. Hall

REFERENCES

Western Ecology Working Group n.d.

Bouteloua gracilis Herbaceous Vegetation

Blue Grama Herbaceous Vegetation
Blue Grama Shortgrass Prairie

CODE	CEGL001760
PHYSIOGNOMIC CLASS	Shrubland & Grassland (2)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.B.2)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.B.2.Nb)
MACROGROUP	Great Plains Shortgrass Prairie & Shrubland (M053)
GROUP	Great Plains Shortgrass Prairie Group (G144)

ECOLOGICAL SYSTEM(S)

Inter-Mountain Basins Semi-Desert Grassland (CES304.787), Western Great Plains Foothill and Piedmont Grassland (CES303.817), Western Great Plains Shortgrass Prairie (CES303.672)

ELEMENT CONCEPT

Global Summary

This minor plant association is reported from Arizona, Colorado, New Mexico, Utah and Wyoming. Sites are flat to gently sloping and include plains, plateaus and montane meadows at elevations ranging from 1660-2780 m (5420-9115 feet). Substrates are variable and range from coarse-textured soils derived from sand, gravel, old lavaflows, kipukas, alluvium, limestone, sandstone, granite or cinder to silty clay loam prairie soils. The vegetation is characterized by a moderate to dense (25-80% cover) herbaceous layer that is strongly dominated by the warm-season, perennial shortgrass *Bouteloua gracilis*. Associated grasses are *Bouteloua curtipendula*, *Elymus elymoides*, *Muhlenbergia* spp., *Pascopyrum smithii*, *Pleuraphis jamesii* (= *Hilaria jamesii*), *Sporobolus cryptandrus*, and the introduced *annua*l grass *Bromus tectorum*. Forb cover is sparse but may be diverse over the range of the type. Scattered *Ericameria nauseosa*, *Tetradymia canescens*, and *Gutierrezia sarothrae* shrubs and an occasional *Pinus edulis*, *Juniperus* spp., or *Pinus ponderosa* tree (in montane stands) may be present.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2030 and 2360 m (6670-7740 feet) on old lavaflows in areas where weathering and deposition have caused soils to form; it may also occur in kipukas, in valley bottoms in alluvium, and on sandstone and limestone hills. Substrates are derived from lava, alluvium, and sandstone and limestone formations. Surface ground cover is primarily soil, followed by gravel, rock, and litter.

Global Environment

This minor plant association is reported from Arizona, Colorado, New Mexico, Utah and Wyoming. Elevation ranges from 1660-2780 m (5420-9115 feet). Sites are flat to moderately sloping and include plains, old lavaflows, kipukas, valley bottoms, sand and limestone hills, plateaus, and montane meadows and parks. Substrates are variable and range from coarse-textured soils derived from sand, gravel, granite or cinder to silty clay loam prairie soils. Montane *Bouteloua gracilis*-dominated grasslands included in this association are typically the result of heavy grazing by wildlife and/or livestock that select out less grazing-tolerant midgrasses.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

The herbaceous stratum, where cover typically exceed 35%, defines this association. *Bouteloua gracilis* is the dominant species, occurring in abundance in every sampling location (29% mean relative cover). *Elymus elymoides* and *Muhlenbergia torreyi* often occur with *Bouteloua gracilis*, but are less frequent and abundant. Forbs in the herbaceous stratum are diverse; 48 species are known from the sampling locations, although many occur only once. The perennials *Artemisia dracunculus*, *Sphaeralcea coccinea*, *Artemisia carruthii*, and *Eriogonum jamesii*, and the *annua*ls *Portulaca oleracea*, *Bahia dissecta*, and *Salsola tragus* are the most frequently occurring and abundant forb species. Trees are scattered sparsely in this association; young as well as mature *Pinus edulis* and *Juniperus monosperma* occur infrequently, making up less than 1% of the total cover. Shrubs are slightly more abundant (about 2.5% of total cover); *Ericameria nauseosa*, *Tetradymia canescens*, and *Gutierrezia sarothrae* are the most frequent and abundant.

Global Vegetation

This association is characterized by a moderate to dense (10-80% cover) herbaceous layer that is strongly dominated by the warm-season, perennial shortgrass *Bouteloua gracilis*. Associated grasses are *Achnatherum hymenoides*, *Bouteloua curtipendula*, *Elymus elymoides*, *Koeleria macrantha*, *Muhlenbergia montana*, *Muhlenbergia richardsonis*, *Muhlenbergia torreyi*, *Pascopyrum smithii*, *Pleuraphis jamesii* (= *Hilaria jamesii*), *Sporobolus cryptandrus*, and the introduced annual grass *Bromus tectorum*. Forb cover is sparse but may be diverse over the range of the type. Associated forbs include *Artemisia carruthii*, *Artemisia dracunculus*, *Eriogonum* spp., and *Sphaeralcea coccinea*. Scattered *Ericameria nauseosa*, *Tetradymia canescens*, and *Gutierrezia sarothrae* shrubs and an occasional *Juniperus* spp., *Pinus edulis*, or *Pinus ponderosa* tree (in montane stands) may be present.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Bouteloua gracilis*

Globally

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia dracunculus, *Bouteloua gracilis*, *Elymus elymoides*, *Muhlenbergia torreyi*, *Portulaca oleracea*, *Sphaeralcea coccinea*

Global

Bouteloua gracilis

OTHER NOTEWORTHY SPECIES

Global

Exotic/Invasive: *Bromus tectorum* (exotic, High)

CONSERVATION STATUS RANK

Global Rank & Reasons: G4Q (23-Feb-1994).

CLASSIFICATION

Status: Standard

Classification Confidence: 3 - Weak

Global Comments

This is a low-confidence association. There are many other associations in the *Bouteloua gracilis* Herbaceous Alliance (A.1282). This association often represents degraded montane grasslands and *Bouteloua gracilis*-dominated grasslands that lack other diagnostic species. *Bouteloua gracilis* is often able to persist after other species are eliminated because it is an extremely drought- and grazing-tolerant species.

Global Similar Associations

- *Bouteloua eriopoda - Bouteloua gracilis* Herbaceous Vegetation (CEGL001748)
- *Bouteloua gracilis - Bouteloua curtipendula* Herbaceous Vegetation (CEGL001754)
- *Bouteloua gracilis - Bouteloua hirsuta* Herbaceous Vegetation (CEGL001755)
- *Bouteloua gracilis - Buchloe dactyloides* Herbaceous Vegetation (CEGL001756)
- *Bouteloua gracilis - Eragrostis intermedia* Herbaceous Vegetation (CEGL001758)
- *Bouteloua gracilis - Hesperostipa neomexicana* Herbaceous Vegetation (CEGL001763)
- *Bouteloua gracilis - Pleuraphis jamesii* Herbaceous Vegetation (CEGL001759)
- *Bouteloua gracilis - Sporobolus cryptandrus* Herbaceous Vegetation (CEGL001761)
- *Bouteloua gracilis - Sporobolus flexuosus* Herbaceous Vegetation (CEGL001762)
- *Hesperostipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation (CEGL002037)
- *Pleuraphis mutica - Bouteloua gracilis* Herbaceous Vegetation (CEGL001638)

Global Related Concepts

- *Bouteloua gracilis* (Shortgrass Prairie) (Bourgeron and Engelking 1994) =
- *Bouteloua gracilis* / Monotypic Stand Plant Association (Muldavin, Chauvin, et al. 2000) =
- DRISCOLL FORMATION CODE:V.C.5.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Cerritos de Jaspe, Cerro Bandera, Cerro Candelaria, Cerro Encierro, El Calderon, and Junction Cave areas; Hoya de Cibola flow south of La Montosa; Hole-in-the-Wall; Laguna Torrito; La Ventana Natural Arch; Malpais Windmill; Mesita Blanca; and the Zuni-Acoma Trail.

Global Range

This minor plant association occurs in Arizona, Colorado, New Mexico, Utah and Wyoming.

Nations: US

States/Provinces: AZ, CO:S4, NM, UT, WY

Federal Lands: NPS (Canyon de Chelly, El Malpais, Glen Canyon, Grand Canyon, Great Sand Dunes, Mesa Verde, Natural Bridges, Petrified Forest, Rocky Mountain, Sunset Crater Volcano, Walnut Canyon)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 22 field plots from 2005, 2006, and 2007: 05MA022, 06JC253, 06JC258, 06YC011, 06YC021, 06YC027, 06YC038, 06YC049, 06YC050, 06YC065, 06YC094, 06YC096, 06YC097, 06YC109, 06YC112, 06YC125, 06YC144, 06YC162, 07AB017, 07AB020, 07AB024, and 07AB032.

Local Description Authors: E. Muldavin and A. Cully

Global Description Authors: K.A. Schulz, mod. J. Coles and M.E. Hall

REFERENCES

Bourgeron and Engelking 1994; Bradley et al. 1992; CONHP unpubl. data 2003; Driscoll et al. 1984; Dwyer and Pieper 1967; Fisser 1970; Fisser et al. 1965; Hansen et al. 2004a; Hansen et al. 2004c; Hansen et al. 2004d; Muldavin, Chauvin, et al. 2000; Pieper 1968; Western Ecology Working Group n.d.; Williams 1961; Zimmerman 1967

Bouteloua gracilis - Sporobolus cryptandrus **Herbaceous Vegetation**

Blue Grama - Sand Dropseed Herbaceous Vegetation
Blue Grama - Sand Dropseed Shortgrass Prairie

CODE	CEGL001761
PHYSIOGNOMIC CLASS	Shrubland & Grassland (2)
PHYSIOGNOMIC FORMATION	Temperate Grassland, Meadow & Shrubland (2.B.2)
PHYSIOGNOMIC DIVISION	Great Plains Grassland & Shrubland (2.B.2.Nb)
MACROGROUP	Great Plains Shortgrass Prairie & Shrubland (M053)
GROUP	Great Plains Shortgrass Prairie Group (G144)

ECOLOGICAL SYSTEM(S)

No data are available.

ELEMENT CONCEPT

Global Summary

This herbaceous association is currently only known from El Malpais National Monument in New Mexico, and the following description is based on occurrences there. Additional information will be added as it becomes available. This association occurs between 2085 and 2200 m (6840-7230 feet) elevation on a variety of landforms including valley bottoms, gentle shoulders or footslopes of low hills, and occasionally kipukas and depositional areas in lavaflows. Substrates are mainly derived from alluvium or sometimes from volcanics or sandstone formations. Typically, ground surface cover is dominated by soil, with gravel, rock, litter, and coarse woody debris as minor components. In some areas, pocket gopher mounds and kangaroo rat burrows have disturbed the soil. In this shortgrass prairie grassland, graminoids dominate (generally >25% cover) with *Bouteloua gracilis* and *Sporobolus cryptandrus* the most frequent and abundant species. Forbs are scattered and most frequently include *Sphaeralcea coccinea* and *Artemisia carruthii*, along with the non-native *Salsola tragus*. Among trees, *Juniperus monosperma* and *Pinus edulis* are scattered about this grassland association, along with the shrubs *Ericameria nauseosa* and *Gutierrezia sarothrae*, but seldom exceed 1 or 2% cover.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2085 and 2200 m (6840-7230 feet) elevation on a variety of landforms including valley bottoms, gentle shoulders or footslopes of low hills, and occasionally kipukas and depositional areas in lavaflows. Substrates are mainly derived from alluvium or sometimes from volcanics or sandstone formations. Typically, ground surface cover is dominated by soil, with gravel, rock, litter, and coarse woody debris as minor components. In some areas, pocket gopher mounds and kangaroo rat burrows have disturbed the soil.

Global Environment

This association is only known from El Malpais National Monument, therefore no global information is currently available.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

In this shortgrass prairie grassland, graminoids dominate (generally >25% cover) with *Bouteloua gracilis* and *Sporobolus cryptandrus* the most frequent and abundant species. Forbs are scattered and most frequently include *Sphaeralcea coccinea* and *Artemisia carruthii*, along with the non-native *Salsola tragus*. Among trees, *Juniperus monosperma* and *Pinus edulis* are scattered about this grassland association, along with the shrubs *Ericameria nauseosa* and *Gutierrezia sarothrae*, but seldom exceed 1 or 2% cover.

Global Vegetation

This association is only known from El Malpais National Monument, therefore no global information is currently available.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Bouteloua gracilis, Sporobolus cryptandrus*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, *Portulaca oleracea*, *Sporobolus cryptandrus*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNRQ (23-Feb-1994).

CLASSIFICATION

Status: Standard

Classification Confidence: 3 - Weak

El Malpais National Monument Comments

A *Lycurus setosus* phase was identified from this association where that species exceeds 15% total cover.

Global Similar Associations

- *Bouteloua gracilis* Herbaceous Vegetation (CEGL001760)
- *Sporobolus cryptandrus* Great Basin Herbaceous Vegetation (CEGL002691)

Global Related Concepts

- *Bouteloua gracilis-Sporobolus cryptandrus* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:V.C.5.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Zuni-Acoma Trail, the Sandstone Bluffs Overlook, La Ventana Natural Arch, North Windmill, North Pasture, Malpais Windmill, and the Lava Falls area.

Global Range

This association is currently only known from El Malpais National Monument in New Mexico. Additional range information will be added as it becomes available.

Nations: MX?, US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 12 field plots from 2005 and 2006: 05MA012, 06AB229, 06JC276, 06JC386, 06JC388, 06JC402, 06YC041, 06YC119, 06YC132, 06YC134, 06YC137, and 06YC138.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

Global Description Authors: A. Kennedy, E. Muldavin and A. Cully

REFERENCES

Bourgeron and Engelking 1994, Driscoll et al. 1984, Muldavin and Mehlhop 1992, Western Ecology Working Group n.d.

3. Desert & Semi-Desert

Bouteloua gracilis - Pleuraphis jamesii Herbaceous Vegetation

Blue Grama - James' Galleta Herbaceous Vegetation
Blue Grama - Galleta Shortgrass Prairie

CODE	CEGL001759
PHYSIOGNOMIC CLASS	Desert & Semi-Desert (3)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.Ne)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (M171)
GROUP	Intermountain Semi-Desert Grassland Group (G311)

ECOLOGICAL SYSTEM(S)

Inter-Mountain Basins Semi-Desert Grassland (CES304.787), Western Great Plains Shortgrass Prairie (CES303.672)

ELEMENT CONCEPT

Global Summary

These grasslands occur on alluvial flats, mesas and plains in the semi-arid southwestern Great Plains and the Colorado Plateau in southeastern Colorado, New Mexico, northern Arizona and southern Utah. Elevation ranges from 1625-2230 m (5330-6110 feet) in central and western New Mexico and on the Colorado Plateau and extends below 1525 m (5000 feet) in the southwestern Great Plains. Sites are flat to undulating, with shallow to moderately deep, loam to silty clay loam-textured soils. In western New Mexico, it is typically found on gently rolling, weathered, lava plateaus with substrates derived from volcanic basalt, but occasionally on gentle sideslopes of low hills on alluvium derived from sandstone. The ground surface is characterized by scattered bunch grasses intermixed with exposed soil and litter; there may also be a strong component of gravel and rock. Stands are codominated by the graminoids *Bouteloua gracilis* and *Pleuraphis jamesii* (= *Hilaria jamesii*). These short and medium-tall perennial bunch grasses may form a sod-like ground cover with patches of bare ground, especially where grazing by livestock encourages a prostrate growth form. Canopy cover is relatively sparse to moderately dense (20-80% cover). Other grasses include *Buchloe dactyloides*, *Muhlenbergia torreyi*, *Sporobolus cryptandrus*, *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Pascopyrum smithii*, *Hesperostipa comata* (= *Stipa comata*), or *Hesperostipa neomexicana* (= *Stipa neomexicana*). Forb cover is generally sparse but may be diverse. Characteristic species include *Cryptantha* spp., *Grindelia squarrosa*, *Machaeranthera pinnatifid*a, *Ratibida* spp., *Sphaeralcea coccinea*, and *Zinnia grandiflora*. Scattered dwarf-shrubs, shrubs and cacti, such as *Artemisia bigelovii*, *Artemisia frigida*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia imbricata* (= *Cylindropuntia imbricata*), *Opuntia polyacantha*, *Prosopis glandulosa* (southern stands), and *Yucca glauca*, are not uncommon. Codominance of *Bouteloua gracilis* and *Pleuraphis jamesii* distinguishes this vegetation from several closely related grasslands. Seedling and sapling *Juniperus monosperma* and *Pinus edulis*, when present, are scattered in these grasslands, and shrubs are scarce (making up less than 2% of cover) and most commonly represented by *Gutierrezia sarothrae* and *Ericameria nauseosa*.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 1960 and 2230 m (6440-7320 feet) in elevation, typically on gently rolling, weathered, lava plateaus with substrates derived from volcanic basalt, but occasionally on gentle sideslopes of low hills on alluvium derived from sandstone. Ground cover is dominated by soil, with litter abundant in some areas. There is also a strong component of gravel and rock.

Global Environment

These grasslands occur on alluvial flats, mesas and plains in the semi-arid southwestern Great Plains and the Colorado Plateau in southeastern Colorado, New Mexico, northern Arizona and southern Utah. Elevation ranges from 1625-1860 m (5330-6110 feet) in central and western New Mexico and on the Colorado Plateau and extends below 1525 m (5000 feet) in the southwestern Great Plains. Sites are flat to undulating, with shallow to moderately deep, loam to silty clay loam-textured soil. In western New Mexico, it is typically found on gently rolling, weathered, lava plateaus with substrates derived from volcanic basalt, but occasionally on gentle sideslopes of low hills on alluvium derived from sandstone. The ground surface is characterized by scattered bunch grasses intermixed with exposed soil and litter; there may also be a strong component of gravel and rock.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

In this Colorado Plateau grassland, *Bouteloua gracilis* and *Pleuraphis jamesii* codominate, with cover that typically exceeds 25% (15% and 10%, respectively). *Sporobolus cryptandrus* can occur frequently but is low in cover. Seedling and sapling *Juniperus monosperma* and *Pinus edulis* are scattered in these grasslands, and shrubs are scarce (making up less than 2% of cover) and most commonly represented by *Gutierrezia sarothrae* and *Ericameria nauseosa*. Forbs are also scattered and variable and make up less than 2% of the cover; the most frequently occurring and abundant is *Salsola tragus*, a non-native annual species. Natives include desert grassland species such as *Sphaeralcea coccinea* and *Artemisia carruthii*.

Global Vegetation

This association is characterized by an open to moderately dense (20-80% cover) herbaceous layer that is codominated by the graminoids *Bouteloua gracilis* and *Pleuraphis jamesii* (= *Hilaria jamesii*). These short and medium-tall perennial bunch grasses may form a sod-like ground cover with patches of bare ground, especially where grazing by livestock encourages a prostrate growth form. Other grasses include *Buchloe dactyloides*, *Muhlenbergia torreyi*, *Sporobolus cryptandrus*, *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Pascopyrum smithii*, *Hesperostipa comata* (= *Stipa comata*), or *Hesperostipa neomexicana* (= *Stipa neomexicana*). Forb cover is generally sparse but may be diverse. Characteristic species include *Cryptantha* spp., *Grindelia squarrosa*, *Machaeranthera pinnatifid*a, *Ratibida* spp., *Sphaeralcea coccinea*, and *Zinnia grandiflora*. Scattered dwarf-shrubs, shrubs and cacti, such as *Artemisia bigelovii*, *Artemisia frigida*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia imbricata* (= *Cylindropuntia imbricata*), *Opuntia polyacantha*, *Prosopis glandulosa* (southern stands), and *Yucca glauca* are not uncommon. Codominance of *Bouteloua gracilis* and *Pleuraphis jamesii* distinguishes this vegetation from several closely related grasslands. Seedling and sapling *Juniperus monosperma* and *Pinus edulis*, when present, are scattered in these grasslands, and shrubs are scarce (making up less than 2% of cover) and most commonly represented by *Gutierrezia sarothrae* and *Ericameria nauseosa*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Bouteloua gracilis, Pleuraphis jamesii*

Globally

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Bouteloua gracilis, Pleuraphis jamesii*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Juniperus monosperma*, *Pleuraphis jamesii*, *Salsola tragus*

Global

Bouteloua gracilis

CONSERVATION STATUS RANK

Global Rank & Reasons: G2G4 (15-Oct-1999). Historically, most sites supporting this association have been converted to dryland or irrigated cropland in the plains. Overgrazing by livestock has changed some of these grasslands to sparse desert grasslands or desert scrubland. In addition, the reduction of fire frequency, either by livestock grazing the fine fuels that carry fires or by active suppression, has allowed the invasion of trees and shrubs. Loss to urban development has been significant in recent decades. Transformation to pinyon/juniper woodlands or desert grassland/scrubland, and urban development continue the negative trend. More classification and survey work are needed to distinguish this type from closely related grasslands over its relatively broad geographic range, and to inventory its extent and condition.

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

El Malpais National Monument Comments

A *Muhlenbergia torreyi* phase was identified in this association where that species exceeds 5% total cover.

Global Comments

More classification and survey work is needed to distinguish this type from closely related grasslands over its relatively broad geographic range, and to inventory its extent and condition.

Global Similar Associations

- *Bouteloua gracilis* Herbaceous Vegetation (CEGL001760)
- *Pleuraphis jamesii* Herbaceous Vegetation (CEGL001777)

Global Related Concepts

- *Bouteloua gracilis - Hilaria jamesii* Plant Community (Shaw et al. 1989) =
- *Bouteloua gracilis / Hilaria jamesii* Plant Association (Johnston 1987) =
- *Bouteloua gracilis / Hilaria jamesii* Plant Community (Francis 1986) =
- *Bouteloua gracilis-Hilaria jamesii* (Bourgeron and Engelking 1994) =
- *Hilaria jamesii - Bouteloua gracilis* Plant Association (Muldavin, Shore, et al. 1998) =
- DRISCOLL FORMATION CODE:V.C.5.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Northwest New Mexico Visitor Center, El Calderon south of Loma Montosa, Cerritos de Jaspe, the Zuni-Acoma Trail, and North Pasture.

Global Range

These grasslands are found in the southern shortgrass steppe of southeastern Colorado and eastern New Mexico, and alluvial flats and mesas of the Colorado Plateau in New Mexico and Utah, south to Sevilleta National Wildlife Refuge and Salinas Pueblo Missions National Monument in central New Mexico. It is also report from Utah and Wyoming.

Nations: US

States/Provinces: AZ, CO:S3, NM:SU, UT:S2S4, WY

Federal Lands: NPS (Capitol Reef, El Malpais, Petrified Forest, Salinas Pueblo Missions); USFWS (Sevilleta)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 7 field plots from 2006 and 2007: 06AB233, 06YC020, 06YC035, 06YC113, 06YC177, 06YC178, and 07AB029.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

Global Description Authors: K.A. Schulz, mod. K.S. King and M.E. Hall

REFERENCES

Beavis et al. 1982; Bourgeron and Engelking 1994; CONHP unpubl. data 2003; Dick-Peddie 1993; Driscoll et al. 1984; Francis 1986; Johnston 1987; Muldavin, Shore, et al. 1998; Rogers 1953; Shaw et al. 1989; Soil Conservation Service 1978; Terwilliger et al. 1979b; Van Pelt 1978; Western Ecology Working Group n.d.

Sporobolus airoides Monotype Herbaceous Vegetation

Alkali Sacaton Monotype Herbaceous Vegetation
Alkali Sacaton (Mixed Prairie)

CODE	CEGL001688
PHYSIOGNOMIC CLASS	Desert & Semi-Desert (3)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.Ne)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (M171)
GROUP	Intermountain Semi-Desert Grassland Group (G311)

ECOLOGICAL SYSTEM(S)

Inter-Mountain Basins Semi-Desert Grassland (CES304.787), Chihuahuan-Sonoran Desert Bottomland and Swale Grassland (CES302.746), Western Great Plains Saline Depression Wetland (CES303.669)

ELEMENT CONCEPT

Global Summary

This herbaceous association is currently only known from El Malpais National Monument in New Mexico and Great Sand Dunes National Park and Preserve in Colorado, and the following description is based on occurrences there. Additional information will be added as it becomes available. At El Malpais, this association occurs between 1950 and 1960 m (6410-6430 feet) in elevation in swales and broad, shallow drainages in gently rolling, old lava plateaus. A prairie dog colony is present at one location, with the attendant soil disturbance and vegetation cropping. At Great Sand Dunes, it generally occurs on valley floors but can be found on sandsheets and bolsons. Elevations range from 2300 to 2335 m. Terrain is flat and stands can be intermittently flooded. Soils are somewhat to moderately drained silt, sandy loam, or loamy sand and derived from alluvial deposits. Bare soil is the dominant ground surface cover, ranging from 0 -88%. Many of the surveyed stands have experienced heavy grazing by bison, cattle and elk. Total herbaceous vegetation ranges from 35-85% and is dominated by graminoid species. *Sporobolus airoides* is abundant to luxuriant (up to 40% relative cover) and typically the dominant species in these monotypic grasslands. Species richness is moderately high, but few species have significant cover or are found consistently across all surveyed stands. *Juncus balticus* and *Cleome serrulata* are the only two other species that occur in the majority of the stands at Great Sand Dunes, but have low cover. At El Malpais, other species are present, but not abundant; they include *Tamarix ramosissima* and *Opuntia imbricata* (= *Cylindropuntia imbricata*), among others.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 1950 and 1960 m (6410-6430 feet) in elevation in swales and broad, shallow drainages in gently rolling, old lava plateaus. A prairie dog colony is present at one location, with the attendant soil disturbance and vegetation cropping.

Global Environment

At El Malpais National Monument, this association occurs between 1950 and 1960 m (6410-6430 feet) in elevation in swales and broad, shallow drainages in gently rolling, old lava plateaus. A prairie dog colony is present at one location, with the attendant soil disturbance and vegetation cropping. At Great Sand Dunes, this association can be found in palustrine or upland settings on valley floors, but it can be found on sandsheets and bolsons as well. Elevations range from 2300 to 2335 m. Terrain is flat and stands can be intermittently flooded. Soils are somewhat to moderately drained silt, sandy loam, or loamy sand and derived from alluvial deposits. Bare soil is the dominant ground surface cover ranging from 0-88%. Many of the surveyed stands have experienced heavy grazing by bison, cattle and elk.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Sporobolus airoides is abundant to luxuriant (up to 40% relative cover) and typically the dominant species in these monotypic grasslands. Other species are present, but not abundant; they include *Tamarix ramosissima* and *Opuntia imbricata* (= *Cylindropuntia imbricata*), among others.

Global Vegetation

Total herbaceous cover ranges up to 85% cover of *Sporobolus airoides* in this monotypic grassland. Species diversity can be quite high, but at low cover, and is inconsistent across stands. *Juncus balticus*, *Tamarix ramosissima*, *Opuntia imbricata*, and *Cleome serrulata* are four associated species that occur in the majority of the stands, but have low cover.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Sporobolus airoides*

Globally

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Sporobolus airoides*

CHARACTERISTIC SPECIES

El Malpais National Monument

Sporobolus airoides

Global

Sporobolus airoides

CONSERVATION STATUS RANK

Global Rank & Reasons: GUQ (23-Feb-1994).

CLASSIFICATION

Status: Standard

Classification Confidence: 3 - Weak

Global Similar Associations

- *Sporobolus airoides* Southern Plains Herbaceous Vegetation (CEGL001685)

Global Related Concepts

- *Sporobolus airoides* (Mixed Prairie) (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:V.B.4.b. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known only from the Northwest New Mexico Visitor Center.

Global Range

This herbaceous association is currently only known from El Malpais National Monument in New Mexico and Great Sand Dunes National Park and Preserve in Colorado. Additional range information will be added as it becomes available.

Nations: US

States/Provinces: CO, NM:SU

Federal Lands: NPS (El Malpais, Great Sand Dunes); USFWS (Bosque del Apache)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 2 field plots from 2006: 06JC425 and 06YC179.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

Global Description Authors: A. Kennedy, E. Muldavin, A. Cully and K.E. Sabo

REFERENCES

Bourgeron and Engelking 1994, Donnelly et al. 2006, Driscoll et al. 1984, Francis 1986, Western Ecology Working Group n.d.

Ericameria nauseosa / Bouteloua gracilis Shrub Herbaceous Vegetation

Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation

CODE	CEGL003495
PHYSIOGNOMIC CLASS	Desert & Semi-Desert (3)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.Ne)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (M171)
GROUP	Intermountain Semi-Desert Shrubland & Steppe Group (G310)

ECOLOGICAL SYSTEM(S)

Inter-Mountain Basins Semi-Desert Grassland (CES304.787), Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788)

ELEMENT CONCEPT

Global Summary

This shrub herbaceous association occurs on valley floors, swales and alluvial flats in the southern and central part of the Colorado Plateau, southern Rocky Mountains and western New Mexico mountains. Its presence generally indicates disturbance from grazing and/or recent flooding, and it may represent degraded forms of other grassland, shrubland or woodland communities. Stands occupy gentle to moderate slopes (2-13%) between 1635 and 2400 m (5360-7870 feet) elevation. Aspect does not affect the distribution of this association. Litter and bare soil cover most of the unvegetated surface. Parent materials are variable and include sandstones and shale that have eroded and been re-deposited as alluvium or windblown sediments (loess). Soils are well-drained and fine-sandy or silty in texture. Occasionally *Juniperus monosperma* or *Pinus edulis* seedlings, saplings, or mature individuals may be found in these grasslands, but shrubs are the most common woody vegetation. Total vegetation cover ranges from 10 to 65%, roughly equally divided between the shrub and herbaceous layers. The vegetation is characterized by an open short-shrub canopy of *Ericameria nauseosa* that ranges in cover from 5 to 25% and an understory dominated by *Bouteloua gracilis* that ranges in cover from 5 to 35%. Other shrubs may be present with very low cover, including *Tetradymia canescens*, *Atriplex* spp., *Gutierrezia sarothrae*, and *Opuntia polyacantha*. Associated graminoids present include the bunch grasses *Achnatherum hymenoides*, *Aristida purpurea*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Sporobolus airoides*, *Sporobolus cryptandrus*, and *Muhlenbergia pungens*. Only scattered forbs are present but diversity can be high.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2030 and 2400 m (6650-7870 feet) in elevation on gently rolling lava plateaus or in broad, upland valleys. Substrates are typically derived from alluvium, but occasionally, they are derived from older basalt flows or Permian sandstone. Ground cover is dominated primarily by soil, with occasional patches of abundant litter. Much of the area exhibits signs of disturbance from grazing and recent flooding.

Global Environment

This shrub herbaceous association occurs on valley floors, swales and alluvial flats in the central part of the Colorado Plateau, southern Rocky Mountains and western New Mexico mountains. Stands occupy gentle to moderate slopes (2-13%) between 1635 and 2400 m (5360-7870 feet) elevation. Aspect does not control the distribution of this association. Litter and bare soil cover most of the unvegetated surface. Parent materials are variable and include sandstones and shale that have eroded and been re-deposited as alluvium or windblown sediments. Soils are well-drained and fine-sandy or silty in texture.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Occasionally *Juniperus monosperma* or *Pinus edulis* seedlings, saplings, or mature individuals may be found in these grasslands, but shrubs (averaging around 6% cover) are the most common woody vegetation. *Ericameria nauseosa* is the most frequently occurring and abundant species in the shrub layer; *Gutierrezia sarothrae* is a frequent associate. Graminoids predominate in this association and may be abundant (up to 70%). The diagnostic species *Bouteloua gracilis* is the most frequently occurring and abundant graminoid (in every sampling location), with cover sometimes around 63%. Other graminoids occur only infrequently and their cover is less (e.g., *Sporobolus cryptandrus* occurring in 7 of 19 plots, around 8% cover). Forbs are typically low in abundance (averaging around 4% cover) and include the herbaceous perennial *Artemisia dracunculus* and *Sphaeralcea coccinea*, as well as annual species such as *Portulaca oleracea*. Herbaceous species can occasionally range as high as 15% total cover. Overall species richness is high, with 17 graminoids and 60 forbs identified from this association.

Global Vegetation

Occasionally *Juniperus monosperma* or *Pinus edulis* seedlings, saplings, or mature individuals may be found in these grasslands, but shrubs are the most common woody vegetation. The total vegetation cover ranges from 10 to 65%, roughly equally divided between the shrub and herbaceous layers. The vegetation is characterized by a short-shrub canopy of *Ericameria nauseosa* that ranges in cover from 5 to 25% and an understory dominated by *Bouteloua gracilis* that ranges in cover from 5 to 35%. Other shrubs may be present with very low cover, including *Tetradymia canescens*, *Atriplex canescens*, *Atriplex confertifolia*, *Gutierrezia sarothrae*, and *Opuntia polyacantha*. Associated graminoids present include the bunch grasses *Achnatherum hymenoides*, *Aristida purpurea*, *Pascopyrum smithii*, *Sporobolus airoides*, *Sporobolus cryptandrus*, and *Muhlenbergia pungens*. Only scattered forbs are present, such as *Chaetopappa ericoides*, *Ipomopsis longiflora*, and *Senecio spartioides*. Diversity can be high; 17 graminoids and 60 forbs were identified from this association at El Malpais National Monument in western New Mexico.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Short shrub/sapling	Dwarf-shrub	*Ericameria nauseosa*
Herb (field)	Graminoid	*Bouteloua gracilis*

Globally

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Ericameria nauseosa*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Sphaeralcea coccinea*

Global

Bouteloua gracilis, *Ericameria nauseosa*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (14-Apr-2003).

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

El Malpais National Monument Comments

A *Gutierrezia sarothrae* phase was identified from this association where it is well-represented with up to 12% total cover.

Global Comments

Former CEGL001738 and CEGL001739 were lumped into this new association; separation of these two types by ssp. of *Ericameria nauseosa* was not supported by the data in Francis (1986).

Global Similar Associations

- *Ericameria nauseosa / Muhlenbergia pungens - Achnatherum hymenoides* Shrub Herbaceous Vegetation (CEGL002921)

Global Related Concepts

- *Chrysothamnus nauseosus* ssp. *bigelovii* / *Bouteloua gracilis - Agropyron smithii* Phyto-edaphic Community (Francis 1986) F
- *Chrysothamnus nauseosus* ssp. *graveolens* / *Bouteloua gracilis - Agropyron smithii* Phyto-edaphic Community (Francis 1986) F

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Rendija, Bandera Crater, Cerro Encierro, Cerritos de Jaspe, Junction Cave, Hole-In-The-Wall, Sandstone Bluffs Overlook, The Narrows, the older flows east of the Cherry Stem Road, the Information Center, and the Lava Falls Area.

Global Range

This association has been documented from widely scattered sites in southern Utah, northern Arizona, from the upper Rio Puerco watershed in northern New Mexico (Francis 1986), El Malpais National Monument in western New Mexico, Petrified Forest National Park in northeastern Arizona, in Utah, and is likely to occur across the central part of the Colorado Plateau.

Nations: US

States/Provinces: AZ, CO, NM, UT

Federal Lands: NPS (Capitol Reef, El Malpais, Grand Canyon, Great Sand Dunes, Petrified Forest, Walnut Canyon)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 19 field plots from 2005, 2006, and 2007: 05MA021, 06AB204, 06JC226, 06JC238, 06JC246, 06JC247, 06JC249, 06JC267, 06JC371, 06JC387, 06YC005, 06YC012, 06YC108, 06YC122, 06YC152, 06YC157, 07AB001, 07AB021, and 07AB022.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: J. Coles and K.A. Schulz, mod. M.E. Hall

REFERENCES

Francis 1986, Hansen et al. 2004a, Hansen et al. 2004d, Western Ecology Working Group n.d.

Krascheninnikovia lanata / Bouteloua gracilis Dwarf-shrub Herbaceous Vegetation

Winterfat / Blue Grama Dwarf-shrub Herbaceous Vegetation
Winterfat / Blue Grama Shrub Prairie

CODE	CEGL001321
PHYSIOGNOMIC CLASS	Desert & Semi-Desert (3)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.Ne)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (M171)
GROUP	Intermountain Semi-Desert Shrubland & Steppe Group (G310)

ECOLOGICAL SYSTEM(S)

Inter-Mountain Basins Semi-Desert Shrub-Steppe (CES304.788), Central Mixedgrass Prairie (CES303.659)

ELEMENT CONCEPT

Global Summary

This widespread, open dwarf-shrub type is found in the western Great Plains from eastern Wyoming, western Kansas, Colorado, and New Mexico to the Colorado Plateau and semi-desert mountains in the northern Chihuahuan Desert. This shrub herbaceous association occurs on alluvial flats, plains, mesas, and desert mountains. Stands occupy flat to moderate slopes between 1630 and 2130 m (5360-7000 feet) elevation. The sometimes rocky soils are typically shallow, alkaline, calcareous, and loamy or clayey in soil texture and are derived from shale or alluvium; elsewhere sites may have sandy, alluvial soil at the foot of sandstone cliffs. Ground cover ranges from bare soil to scattered bunch grasses and litter with exposed soil and gravel in the intergrass spaces. In Colorado Plateau stands, there is often significant cover of biotic crusts (to 30% cover). This community contains open shrub and graminoid layers dominated by the shrub *Krascheninnikovia lanata* with a sparse to dense herbaceous understory dominated by *Bouteloua gracilis*. Other shrubs may be present with very low cover, including *Artemisia nov*a, *Atriplex* spp., *Chrysothamnus greenei*, *Ephedra viridis*, *Gutierrezia sarothrae*, *Opuntia imbricata*, and *Opuntia polyacantha*. Associated graminoids present may include *Achnatherum hymenoides*, *Aristida purpurea*, *Elymus elymoides*, *Hesperostipa comata*, *Muhlenbergia torreyi*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Sporobolus airoides*, and *Sporobolus cryptandrus*. Forb cover is typically low but may be diverse.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs at 2130 m (7000 feet) elevation in sandy, alluvial soil at the foot of sandstone cliffs.

Global Environment

This widespread, open dwarf-shrub type is found in the western Great Plains from eastern Wyoming, western Kansas, Colorado, and New Mexico semi-desert mountains (Oscura and San Andres mountains in south-central

New Mexico; Salinas Pueblo Missions National Monument in central New Mexico) and the Colorado Plateau. This shrub herbaceous association occurs on alluvial flats, plains, mesas, and desert mountains. Stands occupy flat to moderate slopes between 1630 and 2130 m (5360-7000 feet) elevation. The sometimes rocky soils are typically shallow, alkaline, calcareous, and loamy or clayey in soil texture and are derived from shale or alluvium (Francis 1986; Lauver et al. 1999; Muldavin, Chauvin, et al. 2000), elsewhere sites may have sandy, alluvial soil at the foot of sandstone cliffs. In Kansas, stands occur in areas with sparse vegetation on uplands and flats. Soils are shallow, rocky, and alkaline (Lauver et al. 1999). Ground cover ranges from bare soil to scattered bunch grasses and litter with exposed soil and gravel in the intergrass spaces. In Colorado Plateau stands, there is often significant cover of biotic crusts (to 30% cover).

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

This shrub-steppe is characterized by a grassy herbaceous layer dominated by *Bouteloua gracilis* (typically >25% cover of grasses), along with *Sporobolus cryptandrus* and *Achnatherum hymenoides*. Shrubs can be well-represented but seldom exceed 25% total cover, with *Krascheninnikovia lanata* the dominant and *Chrysothamnus greenei* and *Atriplex canescens* the lesser components.

Global Vegetation

This community contains open shrub and graminoid layers dominated by the shrub *Krascheninnikovia lanata* with a sparse to dense herbaceous understory dominated by *Bouteloua gracilis*. The dwarf-shrub layer is about 0.5 m tall, containing annual stems from a woody rootstock, and microphyllous leaves. Other shrubs may be present with very low cover, including *Artemisia nova*, *Atriplex* spp., *Chrysothamnus greenei*, *Ephedra viridis*, *Gutierrezia sarothrae*, *Opuntia imbricata*, and *Opuntia polyacantha*. Associated graminoids present may include *Achnatherum hymenoides*, *Aristida purpurea*, *Elymus elymoides*, *Hesperostipa comata*, *Muhlenbergia torreyi*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Sporobolus airoides*, and *Sporobolus cryptandrus* (Francis 1986; Muldavin, Chauvin, et al. 2000). Forb cover is typically low but may be diverse. Common species in the Colorado Plateau are *Chaetopappa ericoides*, *Cryptantha crassisepala*, *Gilia leptomeria*, *Helianthus petiolaris*, *Machaeranthera canescens*, *Mentzelia albicaulis*, *Plantago patagonica*, *Senecio spartioides*, and *Sphaeralcea coccinea*; *Glandularia bipinnatifida* is the most constant in mountains of south-central New Mexico. In central New Mexico, *Lycium pallidum* is a common associate, possibly indicating disturbance. Forbs are common but variable; the most abundant are *Erysimum capitatum*, *Physalis hederifolia* var. *fendleri*, *Solanum jamesii*, and *Sphaeralcea incana*. In Kansas, *Stanleya pinnata*, a subshrubby perennial from a woody base, can be over 1 m tall and is often present; *Echinacea angustifolia* and *Liatris punctata* are often codominate with *Bouteloua gracilis* in the herbaceous layer. Exotic annual grass *Bromus tectorum* is frequently present in disturbed stands.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Krascheninnikovia lanata*
Herb (field)	Graminoid	*Bouteloua gracilis*

Globally

Stratum	Lifeform	Species
Short shrub/sapling	Dwarf-shrub	*Krascheninnikovia lanata*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Achnatherum hymenoides, *Atriplex canescens*, *Bouteloua gracilis*, *Chrysothamnus greenei*, *Krascheninnikovia lanata*, *Sporobolus cryptandrus*

Global

Bouteloua gracilis, *Krascheninnikovia lanata*

OTHER NOTEWORTHY SPECIES

Global

Exotic/Invasive: *Bromus tectorum* (exotic, High)

CONSERVATION STATUS RANK

Global Rank & Reasons: G4 (1-Feb-1996).

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

Global Similar Associations

- *Krascheninnikovia lanata / Hesperostipa comata* Dwarf-shrubland (CEGL001327)
- *Krascheninnikovia lanata / Pleuraphis jamesii* Dwarf-shrubland (CEGL001322)
- *Krascheninnikovia lanata / Poa secunda* Dwarf-shrubland (CEGL001326)

Global Related Concepts

- *Bouteloua gracilis / Eurotia lanata* Plant Association (Johnston 1987) ?
- *Bouteloua gracilis / Krascheninnikovia lana*ta Plant Association (Muldavin, Chauvin, et al. 2000) =
- *Bouteloua gracilis / Krascheninnikovia lanata* Plant Association (Muldavin, Shore, et al. 1998) =
- *Ceratoides lanata - Gutierrezia sarothrae / Bouteloua gracilis* Plant Community (Francis 1986) =
- *Ceratoides lanata / Bouteloua gracilis* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:III.C.1.b. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from beneath La Ventana Natural Arch.

Global Range

This widespread, open dwarf-shrub type is found in the western Great Plains from western Kansas and eastern Colorado, to semi-desert mountains (Oscura and San Andres mountains) in south-central New Mexico, within Salinas Pueblo Missions National Monument in central New Mexico and El Malpais National Monument in western New Mexico, and the Colorado Plateau (northern Arizona and southern Utah). It is also reported from Wyoming. This associations is likely more widespread as the dominant/diagnostic species are common in the western U.S.

Nations: US

States/Provinces: AZ, CO, KS:SU, NM:S4, UT, WY

Federal Lands: DOD (White Sands Missile Range); NPS (Canyonlands, El Malpais, Petrified Forest, Salinas Pueblo Missions); USFWS (Sevilleta)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 1 rapid plot from 2006: 06JC421.

Local Description Authors: E. Muldavin and A. Cully

Global Description Authors: K.A. Schulz, mod. K.S. King and M.E. Hall

REFERENCES

BIA 1979; Bourgeron and Engelking 1994; Daubenmire 1970; Driscoll et al. 1984; Francis 1986; Johnston 1987; Lauver et al. 1999; Muldavin and Mehlhop 1992; Muldavin, Shore, et al. 1998; Muldavin, Chauvin, et al. 2000; Rasmussen and Brotherson 1986; Soil Conservation Service 1978; Western Ecology Working Group n.d.

Sarcobatus vermiculatus / Sporobolus airoides **Shrubland**

Greasewood / Alkali Sacaton Shrubland

CODE	CEGL001368
PHYSIOGNOMIC CLASS	Desert & Semi-Desert (3)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.Ne)
MACROGROUP	Great Basin & Intermountain Dry Shrubland & Grassland (M171)
GROUP	Intermountain Semi-Desert Shrubland & Steppe Group (G310)

ECOLOGICAL SYSTEM(S)

Inter-Mountain Basins Greasewood Flat (CES304.780), Inter-Mountain Basins Wash (CES304.781), Inter-Mountain Basins Playa (CES304.786), Central Mixedgrass Prairie (CES303.659)

ELEMENT CONCEPT

Global Summary

This association occurs in the Columbia and Wyoming basins, Colorado Plateau and western Great Plains from eastern Oregon, central and northeastern Wyoming, northwestern and southeastern Colorado, western New Mexico and eastern Utah. Stands of this type usually occur as small, relict patches on level to gently sloping valley floors, on alluvial fans along intermittent washes and streams, and on abandoned stream terraces with fine-textured to sandy, alkaline soils derived from alluvium. The water table rarely reaches the surface, and these sites flood only occasionally. Elevations range from 1180 to 1960 m (3870-6420 feet) in Colorado, New Mexico and Utah. *Sarcobatus vermiculatus* typically dominates the open to moderately dense shrub layer with between 10 and 50% cover and includes sparse and open steppe stands with 5-10% shrub cover. Other shrubs present with low cover may include *Atriplex canescens*, *Ericameria nauseosa*, *Artemisia tridentata* ssp. *wyomingensis*, and *Artemisia tridentata* ssp. *tridentata*. The herbaceous understory is typically dominated by *Sporobolus airoides*, usually with a number of other species present, including *Pascopyrum smithii*, *Hordeum jubatum*, *Hesperostipa comata*, *Bouteloua gracilis*, *Elymus elymoides*, *Elymus lanceolatus* ssp. *lanceolatus*, and *Distichlis spicata*. Forbs generally contribute little cover, although several weedy or exotic forbs may be abundant.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs at 1960 m (6420 feet) on the margins of a broad, sandy wash.

Global Environment

Stands of this type usually occur as small, relict patches on level to gently sloping valley floors and on abandoned stream terraces with fine-textured to sandy, alkaline soils derived from alluvium. Elevations range from 1180 to 1960 m (3870-6420 feet) in Colorado, New Mexico and Utah. The water table is usually within 1 m of the surface for at least part of the growing season, although it may be a perched water table held by a hard pan just below the ground surface.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Sarcobatus vermiculatus is the dominant shrub, comprising about 8% of the vegetative cover; *Ericameria nauseosa* also occurs, but is lower in cover. In the herbaceous layer, *Sporobolus airoides* is about equal in cover to *Sarcobatus vermiculatus*. The presence of the forb *Limonium limbatum* indicates periodic inundation and alkaline conditions in the area. *Salsola tragus*, an invasive species indicative of disturbance, is also present.

Global Vegetation

Sarcobatus vermiculatus dominates the shrub layer with between 10 and 50% cover. Other shrubs present with low cover may include *Atriplex canescens*, *Atriplex confertifolia*, *Allenrolfea occidentalis*, *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, *Suaeda moquinii* (= *Suaeda torreyana*), *Artemisia tridentata* ssp. *wyomingensis*, and *Artemisia tridentata* ssp. *tridentata*. The herbaceous understory contains and is often dominated by *Sporobolus airoides* and usually a number of other species, including *Pascopyrum smithii*, *Hordeum jubatum*, *Bouteloua gracilis*, *Elymus elymoides*, *Elymus lanceolatus* ssp. *lanceolatus*, and *Distichlis spicata*. Forbs generally contribute little cover, although several weedy or exotic forbs may be abundant.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Sarcobatus vermiculatus*
Herb (field)	Graminoid	*Sporobolus airoides*

Globally

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Sarcobatus vermiculatus*
Herb (field)	Graminoid	*Sporobolus airoides*

CHARACTERISTIC SPECIES

El Malpais National Monument

Limonium limbatum, *Sarcobatus vermiculatus*, *Sporobolus airoides*

Global

Sarcobatus vermiculatus, *Sporobolus airoides*

CONSERVATION STATUS RANK

Global Rank & Reasons: G3? (1-Dec-2000). This association has been named from the Thunder Basin National Grassland of northeastern Wyoming, and it apparently also occurs along the North Platte and Sweetwater rivers in central Wyoming. It is ranked G3 because it has been described from a limited geographic range, and many stands seem to contain exotic plants. The lack of detailed descriptions or stand data make the rank questionable. As additional data become available and the full range of the association becomes better understood, this rank should be revisited. It appears that many stands in the Colorado Plateau that historically were this association have been degraded by grazing and water table collapse.

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Global Comments

This association was renamed to a shrubland association and moved from a sparsely vegetated to a shrubland alliance based on literature and plot review that indicated that, although some stands are sparse (<10% total vegetation cover), most are not and some have rather dense cover (50% cover of shrubs). This description is based on information from northeastern Wyoming, northwestern and southeastern Colorado and southern Utah. A general vegetation description and habitat description from central Wyoming are also available. The plant species listed for this association also occur in *Sarcobatus vermiculatus* / *Pascopyrum smithii* - (*Elymus lanceolatus*) Shrub Herbaceous Vegetation (CEGL001508), and this type may also be similar to *Sarcobatus vermiculatus* / *Distichlis spicata* Shrubland (CEGL001363). These three associations apparently are differentiated on the basis of the relative amounts of the various grass species in the undergrowth. Grass dominance varies with soil salinity and aeration, and this association may represent the more saline but well-aerated conditions. Also compare this association with *Sarcobatus vermiculatus* / *Distichlis spicata* - (*Puccinellia nuttalliana*) Shrub Herbaceous Vegetation (CEGL002146).

Global Similar Associations

- *Sarcobatus vermiculatus / Distichlis spicata - (Puccinellia nuttalliana)* Shrub Herbaceous Vegetation (CEGL002146)
- *Sarcobatus vermiculatus / Distichlis spicata* Shrubland (CEGL001363)
- *Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus)* Shrub Herbaceous Vegetation (CEGL001508)

Global Related Concepts

- *Sarcobatus vermiculatus / Sporobolus airoides* Plant Community (Shaw et al. 1989) =
- *Sarcobatus vermiculatus/Sporobolus airoides* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:III.C.2.a. (Driscoll et al. 1984) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known only from the Northwest New Mexico Visitor Center.

Global Range

This association occurs in the Columbia and Wyoming basins, Colorado Plateau and western Great Plains from eastern Oregon, central and northeastern Wyoming, northwestern and southeastern Colorado, and eastern Utah.

Nations: US

States/Provinces: CO:S2, NM, OR:S4, UT, WY:S3?

Federal Lands: NPS (Arches, Canyonlands, Capitol Reef, Dinosaur, El Malpais, Great Sand Dunes); USFS (Thunder Basin)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 1 rapid plot from 2006: 06JC426.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: G.P. Jones, mod. J. Coles and K.A. Schulz

REFERENCES

Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, Jones 1992, Kagan et al. 2004, Shaw et al. 1989, Terwilliger et al. 1979b, Terwilliger et al. 1979a, Warren n.d., Western Ecology Working Group n.d.

Atriplex canescens / Bouteloua gracilis **Shrubland**

Fourwing Saltbush / Blue Grama Shrubland

CODE	CEGL001283
PHYSIOGNOMIC CLASS	Desert & Semi-Desert (3)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.Ne)
MACROGROUP	Great Basin Saltbrush Scrub (M093)
GROUP	Intermountain Shadscale - Saltbush Scrub Group (G300)

ECOLOGICAL SYSTEM(S)

Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784), Sonora-Mojave Mixed Salt Desert Scrub (CES302.749)

ELEMENT CONCEPT

Global Summary

This saltbush shrubland is found in the southern Great Plains of the United States, from Kansas and Colorado south and west to Arizona, Utah, Wyoming, New Mexico and Texas. In the Great Plains, stands occur on dry barren flats, slopes and bluffs supported by shallow, rocky, alkaline soils. In the Colorado Plateau, this association occurs on valley floors and alluvial flats. Slopes are gentle, and most stands are below 2120 m (6960 feet) elevation. Soils are deep and alkaline. Throughout its range, stands are dominated by *Atriplex canescens* shrubs between 0.5 and 1 m tall. Associated species include *Rhus aromatica*, *Opuntia polyacantha*, *Opuntia phaeacantha*, *Opuntia imbricata*, *Toxicodendron rydbergii*, and *Yucca glauca*. The herbaceous layer of short to medium-tall grasses is dominated by *Bouteloua gracilis* and includes *Bouteloua curtipendula* in the Great Plains and *Achnatherum hymenoides* in the Colorado Plateau as important associated species. Occasionally *Pascopyrum smithii* or *Sporobolus cryptandrus* can codominate, though typically other graminoid species are scarce or absent. The rhizomatous *Bouteloua gracilis* is more tolerant of heavy grazing than most bunch grasses; this association may represent a grazing remnant of what was once a more diverse grass understory.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2040 and 2120 m (6700-6960 feet) in elevation in gently rolling, broad, upland valley bottoms on sandy alluvial substrates. Ground cover is typically soil with a small amount of litter, and little to no gravel, rock, coarse woody debris, or cryptogamic cover.

Global Environment

In the Great Plains, stands occur in dry barren flats, slopes and bluffs. Soils are shallow, rocky and alkaline (Lauver et al. 1999). In the Colorado Plateau, this association occurs on valley floors and alluvial flats. Slopes are gentle, and most stands are below 2120 m (6960 feet) elevation. Soils are deep and alkaline.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Trees usually are absent in these alluvial shrublands, but there are a few *Juniperus monosperma* scattered throughout. *Atriplex canescens* is the dominant shrub species, with the cacti *Opuntia phaeacantha* and *Opuntia imbricata* as frequent associates. The herbaceous layer of this association is variable, nearly equal in cover overall to that of the shrubs. Depending on location and environmental conditions, forbs or graminoids can predominate. The diagnostic species *Bouteloua gracilis* is the most consistently occurring graminoid (in all sample plots). Occasionally *Pascopyrum smithii* or *Sporobolus cryptandrus* can codominate, though typically other graminoid species are scarce or absent. The sandy alluvial soils are good places for annual forbs, depending on environmental conditions of a given year. Annual species that may appear in abundance, although not every year, include *Portulaca oleracea*, *Dyssodia papposa*, and *Sanvitalia abertii*.

Global Vegetation

Throughout its range, stands of this association are dominated by *Atriplex canescens* shrubs between 0.5 and 1 m tall. Associated species include *Rhus aromatica*, *Opuntia polyacantha*, *Opuntia phaeacantha*, *Opuntia imbricata*, *Toxicodendron rydbergii*, and *Yucca glauca*. The herbaceous layer of short to medium-tall grasses is dominated by *Bouteloua gracilis* and includes *Bouteloua curtipendula* in the Great Plains (Lauver et al. 1999) and *Achnatherum hymenoides* in the Colorado Plateau as important associated species. Occasionally *Pascopyrum smithii* or *Sporobolus cryptandrus* can codominate, though typically other graminoid species are scarce or absent.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Atriplex canescens*
Herb (field)	Graminoid	*Bouteloua gracilis*

Globally

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved evergreen shrub	*Atriplex canescens*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Atriplex canescens, *Bassia scoparia*, *Bouteloua gracilis*, *Dyssodia papposa*, *Opuntia imbricata*, *Opuntia phaeacantha*, *Portulaca oleracea*, *Sanvitalia abertii*

Global

Atriplex canescens, *Bouteloua gracilis*

CONSERVATION STATUS RANK

Global Rank & Reasons: G3 (9-Nov-2005). This late-seral shrubland association occurs in the southwestern Great Plains, desert grasslands in Arizona, and alluvial flats in southern Utah. Sites are restricted to alkaline bottomlands. Stands have declined because of exploitation by humans either by farming (plowing) or overgrazing by livestock. An estimated 21-100 occurrences are left. Few are believed to be protected. More survey work in needed to locate examples of this vegetation in good condition.

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

El Malpais National Monument Comments

An *Opuntia imbricata* phase was identified from this association where it is well-represented, exceeding 5% total cover.

Global Comments

Because other grasses are usually associated with *Bouteloua gracilis*, it may be difficult in the field to distinguish this association from closely related ones.

Global Similar Associations

- *Atriplex canescens* / *Pleuraphis jamesii* Shrubland (CEGL001288)
- *Atriplex canescens* / *Sporobolus airoides* Shrubland (CEGL001291)

Global Related Concepts

- *Atriplex canescens/Bouteloua gracilis* (Bourgeron and Engelking 1994) =
- DRISCOLL FORMATION CODE:III.C.1.b. (Driscoll et al. 1984) B
- Mesquite-Saltbush Series (Diamond 1993) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from north of the Sandstone Bluffs Overlook and The Narrows around the La Ventana area.

Global Range

This saltbush type is found in the southern Great Plains of the United States, from Kansas and Colorado south and west to Arizona, Utah, Wyoming, New Mexico and Texas.

Nations: US

States/Provinces: AZ:S2?, CO:S3, KS:SU, NM, TX:S4, UT, WY

Federal Lands: NPS (Capitol Reef, El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 6 field plots from 2006: 06JC389, 06YC123, 06YC153, 06YC155, 06YC161, and 06YC163.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.A. Schulz, mod. J. Coles and M.E. Hall

REFERENCES

Aldous and Shantz 1924, BIA 1979, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Diamond 1993, Driscoll et al. 1984, Hyder et al. 1966, Klipple and Costello 1960, Lauver et al. 1999, Maxwell 1975, Soil Conservation Service 1978, Western Ecology Working Group n.d.

Atriplex canescens / Sporobolus airoides Shrubland

Fourwing Saltbush / Alkali Sacaton Shrubland

CODE	CEGL001291
PHYSIOGNOMIC CLASS	Desert & Semi-Desert (3)
PHYSIOGNOMIC FORMATION	Cool Semi-Desert Scrub & Grassland (3.B.1)
PHYSIOGNOMIC DIVISION	Western North American Cool Semi-Desert Scrub & Grassland (3.B.1.Ne)
MACROGROUP	Great Basin Saltbrush Scrub (M093)
GROUP	Intermountain Shadscale - Saltbush Scrub Group (G300)

ECOLOGICAL SYSTEM(S)

Inter-Mountain Basins Mixed Salt Desert Scrub (CES304.784), Chihuahuan Mixed Salt Desert Scrub (CES302.017)

ELEMENT CONCEPT

Global Summary

This shrubland occurs in the northern Chihuahua Desert extending into the Trans-Pecos of Texas, southwestern Great Plains, and Colorado Plateau. Stands are found in washes, floodplains and on alluvial flats, extending up lower slopes of alluvial fans or bajadas. Elevation ranges from 915-2170 m (3000-7100 feet). Sites are level to gently sloping. Substrates are typically moderately deep, alkaline, calcareous, fine-textured soils or calcareous sands. Some areas are subject to periodic inundation from direct precipitation onto the clayey, somewhat impermeable soils, and runoff from surrounding higher elevations and overtopping drainages. Sediment deposition may occur during these events. Cover of bare soil can be high (>50%). The vegetation is characterized by an open to moderately dense (10-50% cover) short-shrub layer dominated by *Atriplex canescens* with a perennial graminoid layer dominated by *Sporobolus airoides*. The shrub layer has greater cover than the herbaceous layer, which may include other scattered shrubs and dwarf-shrubs, such as *Artemisia filifolia*, *Atriplex confertifolia*, *Atriplex obovata*, *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Isocoma pluriflora*, *Krascheninnikovia lanata*, *Lycium* spp., *Opuntia* spp., *Prosopis glandulosa*, and *Sarcobatus vermiculatus*. Associated herbaceous species, such as *Achnatherum hymenoides*, *Ambrosia psilostachya*, *Artemisia campestris*, *Elymus elymoides*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Sphaeralcea coccinea*, *Sporobolus cryptandrus*, *Sporobolus nealleyi*, and *Suaeda* spp., may be present. *Bouteloua gracilis* cover is typically minor and inconsistent. Forbs are limited and scattered and trees are accidental or absent. Diagnostic of this *Atriplex canescens*-dominated shrubland is a *Sporobolus airoides*-dominated herbaceous layer.

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2020 and 2170 m (6630-7100 feet) in elevation on gently rolling valley floors and plains in clayey alluvial substrates. These areas are subject to periodic inundation from direct precipitation onto the clayey, somewhat impermeable soils, and runoff from surrounding higher elevations and overtopping drainages. Sediment deposition may occur during these events.

Global Environment

This shrubland occurs on alkaline sites in the northern Chihuahua Desert extending into the Trans-Pecos of Texas, southwestern Great Plains, and Colorado Plateau. Sites are in washes, floodplains and on alluvial flats, extending up lower slopes of alluvial fans or bajadas. Elevation ranges from 915-2170 m (3000-7100 feet). Sites are level to gently sloping (1-5%), and soils are typically moderately deep, alkaline, calcareous, fine-textured soils such as silt loam, loamy clay or clay (Francis 1986; Shaw et al. 1989; Muldavin, Chauvin, et al. 2000), although some sites in active floodplains may be rapidly drained sandy soils. Some areas are subject to periodic inundation from direct precipitation onto the clayey, somewhat impermeable soils, and runoff from surrounding higher elevations and overtopping drainages. Sediment deposition may occur during these events. The ground surface is characterized by large patches of tussock grasses intermixed with exposed soil and litter. Cover of bare soil may be high (>50%) (Francis 1986). Evidence of overland flow and erosion, e.g., gullies, rills, plant pedestalling, is common (Soil Conservation Service n.d.).

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Atriplex canescens is the dominant, and often the only, shrub species in this association; cover varies up to 20%. The diagnostic graminoid *Sporobolus airoides*, a species occurring commonly in areas with fine soils that are subject to flooding from runoff, also occurs in these shrublands. Other grasses include *Pascopyrum smithii* and *Bouteloua gracilis*. Forbs include the perennial *Solanum jamesii*, as well as annuals *Grindelia squarrosa*, *Machaeranthera tanacetifolia*, and *Portulaca oleracea*. The invasives *Bassia scoparia* (= *Kochia scoparia*) and *Salsola tragus* also occur. These areas are frequented by elk.

Global Vegetation

The association is characterized by an open to moderately dense (10-50% cover) short-shrub layer dominated by *Atriplex canescens* with a perennial graminoid layer dominated by *Sporobolus airoides* but includes sparse *Atriplex canescens - Sporobolus airoides*-dominated stands (<10% total vegetation cover). The shrub layer generally has greater cover than the herbaceous layer and may include other scattered shrubs and dwarf-shrubs, such as *Artemisia filifolia*, *Atriplex confertifolia*, *Atriplex obovata*, *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Isocoma pluriflora*, *Krascheninnikovia lanata*, *Lycium berlandieri*, *Lycium pallidum*, *Opuntia imbricata*, *Opuntia leptocaulis*, *Opuntia phaeacantha*, *Prosopis glandulosa*, and *Sarcobatus vermiculatus*. Associated herbaceous species, such as *Achnatherum hymenoides*, *Ambrosia psilostachya*, *Artemisia campestris*, *Elymus elymoides*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Sphaeralcea* spp., *Sporobolus cryptandrus*, *Sporobolus nealleyi*, and *Suaeda* spp., may be present. *Bouteloua gracilis* cover is typically minor and inconsistent (Francis 1986; Shaw et al. 1989; Muldavin, Chauvin, et al. 2000). However, *Bouteloua gracilis* with *Sporobolus cryptandrus* is well-represented within Salinas Pueblo Missions National Monument in New Mexico. Introduced species such as *Salsola kali*, *Bromus tectorum*, or *Marrubium vulgare* may be common. Forbs are limited and scattered and trees are accidental or absent.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Atriplex canescens*
Herb (field)	Graminoid	*Sporobolus airoides*

Globally

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved evergreen shrub	*Atriplex canescens*
Herb (field)	Graminoid	*Sporobolus airoides*

CHARACTERISTIC SPECIES

El Malpais National Monument

Atriplex canescens, *Sporobolus airoides*

Global

Atriplex canescens, *Sporobolus airoides*

OTHER NOTEWORTHY SPECIES

Global

Exotic/Invasive: *Bromus tectorum* (exotic, High), *Marrubium vulgare* (exotic, Medium/Low), *Salsola kali* (exotic)

CONSERVATION STATUS RANK

Global Rank & Reasons: G5? (9-Nov-2005). Although this type is widespread, it usually occurs in relatively small patches. Both of the diagnostic species are resistant to moderate grazing, but this association has likely been converted to semi-natural shrublands in heavily grazed areas.

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

El Malpais National Monument Comments

This association has a sparse phase, *Atriplex canescens* / *Sporobolus airoides* Sparse Shrubland, characterized by some areas with little to no herbaceous vegetation.

Global Comments

Stands with relatively low cover of *Atriplex canescens* (10-25%) are included in this association because the shrub density is often variable within stands, but species composition and ecological processes do not change significantly. There are several similar associations that vary according to the abundance of different codominants, especially graminoids. Rangewide review of these types is needed to clarify their extent.

Global Similar Associations

- *Atriplex canescens - Krascheninnikovia lanata* Shrubland (CEGL001285)
- *Atriplex canescens* / *Achnatherum hymenoides* Shrubland (CEGL001289)
- *Atriplex canescens* / *Bouteloua gracilis* Shrubland (CEGL001283)
- *Atriplex canescens* / *Calycoseris parryi* Shrubland (CEGL001284)
- *Atriplex canescens* / *Pleuraphis jamesii* Shrubland (CEGL001288)
- *Atriplex canescens* / *Sporobolus wrightii* Shrubland (CEGL001292)
- *Atriplex canescens* Shrubland (CEGL001281)

Global Related Concepts

- *Atriplex canescens - Atriplex confertifolia* / *Sporobolus airoides* Vegetation Type (Dick-Peddie 1986) I
- *Atriplex canescens - Sarcobatus vermiculatus* / *Sporobolus airoides* Vegetation Type (Dick-Peddie 1986) I
- *Atriplex canescens* / *Sporobolus airoides - Sitanion hystrix* Plant Community (Francis 1986) ?
- *Atriplex canescens* / *Sporobolus airoides* Plant Association (Baker 1984) =
- *Atriplex canescens* / *Sporobolus airoides* Plant Association (Muldavin, Chauvin, et al. 2000) ?
- *Atriplex canescens* / *Sporobolus airoides* Plant Community (Shaw et al. 1989) =

- *Atriplex canescens / Sporobolus airoides* (Bourgeron and Engelking 1994) =
- Alkali Sacaton-Fourwing Saltbush Series (Diamond 1993) B
- DRISCOLL FORMATION CODE:III.C.1.b. (Driscoll et al. 1984) B
- Saline Overflow Range Site #37 B (Soil Conservation Service n.d.) ?
- Salt Flat Range Site #34 B (Soil Conservation Service n.d.) ?
- Saltbush Series with Great Basin Desert Scrub (Dick-Peddie 1986) B

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the plains around Malpais Windmill, North Pasture, and north of the Sandstone Bluffs Overlook.

Global Range

This shrubland occurs in the northern Chihuahua Desert extending into Trans-Pecos Texas, the southwestern Great Plains and Colorado Plateau in Colorado, New Mexico, Arizona, and Utah. It is reported from California and likely also occurs in Nevada and Mexico.

Nations: MX?, US

States/Provinces: AZ, CA, CO:SU, NM, NV?, TX:S3, UT:S3S5, WY

Federal Lands: NPS (Arches, Canyonlands, Capitol Reef, El Malpais, Salinas Pueblo Missions, Wupatki)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots from 2006: 06JC412, 06JC420, 06YC111, 06YC120, and 06YC124.

Local Description Authors: E. Muldavin and A. Kennedy

Global Description Authors: K.A. Schulz, mod. J. Coles, K.S. King, M.E. Hall

REFERENCES

Baker 1984; Bourgeron and Engelking 1994; CONHP unpubl. data 2003; Diamond 1993; Dick-Peddie 1986; Donart et al. 1978; Driscoll et al. 1984; Francis 1986; Hansen et al. 2004b; Muldavin, Chauvin, et al. 2000; Shaw et al. 1989; Soil Conservation Service n.d.; USFS 1937; Vest 1962; Western Ecology Working Group n.d.

4. Park Specials

Atriplex canescens / Panicum obtusum Shrubland [Park Special]

Fourwing Saltbush / Vine-mesquite Shrubland
Code: CEPS009511

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs at around 2010 m (6600 feet) in elevation in gently rolling to level, broad, upland valley bottoms. The sparsely vegetated, clayey soil is derived from alluvium.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Atriplex canescens is the dominant shrub species in this association. Depending on current conditions, some areas recently inundated by rain and runoff may have only *Atriplex canescens* and the herbaceous graminoid *Panicum obtusum*. In other areas, the herbaceous layer of this association may be luxuriant, reaching 90% in total cover, equally distributed between graminoids and forbs. The diagnostic species *Panicum obtusum* is typically dominant in the herbaceous layer, though occasionally *Bouteloua gracilis* is also abundant. The forbs of these shrublands are locally abundant depending on environmental conditions in a given year, and most frequently include desert grassland species such as *Portulaca oleracea*, *Chamaesyce serpyllifolia*, and *Sanvitalia abertii*. The invasive *Bassia scoparia* (= *Kochia scoparia*) may also be present in abundance.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Atriplex canescens*
Herb (field)	Graminoid	*Panicum obtusum*

CHARACTERISTIC SPECIES

El Malpais National Monument

Atriplex canescens, *Panicum obtusum*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known only from the alluvial flats southwest of Las Ventanas Ridge.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots from 2006: 06JC411, 06JC422, 06JC423, 06YC174, and 06YC175.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

REFERENCES

Western Ecology Working Group n.d.

Bouteloua gracilis - Muhlenbergia montana **Herbaceous Vegetation [Park Special]**

Blue Grama - Mountain Muhly Herbaceous Vegetation
Code: CEPS009500

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2240 and 2375 m (7360-7790 feet) in elevation, typically on gently rolling lavaflows, volcanic debris, and sedimentary deposits. Substrates are primarily derived from Hoya de Cibola lavaflows and volcanic debris associated with older flows and cinder cones, though they can occasionally be derived from San Andres limestone. Ground surface cover is variable and in various areas may be dominated by gravel, soil, or rock.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

This transitional shortgrass prairie-montane grassland is characterized by a grassy herbaceous layer that typically exceeds 25% cover. *Bouteloua gracilis* or *Muhlenbergia montana* may dominate in a particular area, although *Bouteloua gracilis* has the higher relative cover. Forbs are variable in these grasslands, ranging from 0.5-30% of the overall cover, and most frequently include *Heterotheca villosa* and *Glandularia bipinnatifida*. Trees are limited in frequency and abundance in this association (usually <1%), but may include *Pinus ponderosa*, *Pinus edulis*, and a few *Juniperus monosperma*. Shrubs seldom exceed 2% of all cover, and are comprised mostly of *Opuntia phaeacantha* and *Fallugia paradoxa*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Forb	*Heterotheca villosa*
Herb (field)	Graminoid	*Bouteloua gracilis, Muhlenbergia montana*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, *Heterotheca villosa*, *Muhlenbergia montana*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Rendija, Mesita Blanca, and the Hoya de Cibola flow south of Little Hole-In-The-Wall.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots from 2006: 06JC309, 06JC316, 06JC350, 06YC059, and 06YC072.

Local Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Bouteloua gracilis Ruderal Herbaceous Vegetation [Park Special]

Blue Grama Ruderal Herbaceous Vegetation
Code: CEPS009501

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2010 and 2150 m (6600-7060 feet) in elevation in gently rolling, upland valleys and in depositional areas within old lavaflows. One area is located near a stock tank. There is evidence of past soil disturbance and burning. Substrates are derived from alluvium, and ground surface cover is dominated by soil; there is a small amount of litter.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

This weedy grassland is dominated by the native grass *Bouteloua gracilis*, but the non-native *Bassia scoparia* (= *Kochia scoparia*) occurs as frequently and is often more abundant along with a suite of other ruderal forbs such as

Solanum jamesii, *Grindelia squarrosa*, *Tragopogon dubiu*s, *Verbesina encelioides*, and *Salsola tragus*, among others. Shrubs such as *Atriplex canescens* are thinly scattered in this association, and trees are typically absent.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Forb	*Bassia scoparia*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bassia scoparia, *Bouteloua gracilis*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNA (ruderal) (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Zuni-Acoma trailhead, the alluvial flats south of Las Ventanas Ridge, and the North Pasture.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 4 field plots from 2006: 06JC424, 06YC040, 06YC141, and 06YC165.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

REFERENCES

Western Ecology Working Group n.d.

Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus Woodland [Park Special]

One-seed Juniper / Blue Grama - Sand Dropseed Woodland
Code: CEPS009507

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2020 and 2120 m (6640-6960 feet) in elevation at a variety of aspects on gently rolling broad upland valleys or gentle footslopes of low hills, often in a matrix of exposed lava and patchy areas of soil accumulation. Substrates are primarily derived from Dakota sandstone, Mancos shale, alluvium, or lavaflow (El Calderon flow). Typically, ground surface cover is dominated by soil, though occasionally rock or litter can be significant components.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this association vary from more sparse savanna (10%) to very open woodland (25%) and are dominated by *Juniperus monosperma*. *Pinus edulis* occurs in more than half of the plots, but represents only a small proportion of the total cover in the canopy. Seedlings and saplings of both species are poorly represented or absent. *Opuntia phaeacantha* and *Opuntia imbricata* are the most commonly occurring shrub species. *Ericameria nauseosa* occurs in 4 of 12 plots and is relatively abundant in terms of cover. The herbaceous layer of this association varies from well-represented to abundant, typically with graminoids predominant. The diagnostic species *Bouteloua gracilis* and *Sporobolus cryptandrus* are codominant, while other graminoids are poorly represented or absent. Forbs are common to well-represented and include such xeric woodland species as *Mirabilis multiflora*, *Sphaeralcea fendleri*, *Portulaca oleracea*, and *Sphaeralcea coccinea*. Overall species richness is moderately high with 12 graminoids and 48 forbs identified from this association.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Herb (field)	Graminoid	*Bouteloua gracilis, Sporobolus cryptandrus*

CHARACTERISTIC SPECIES

El Malpais National Monument

Bouteloua gracilis, *Juniperus monosperma*, *Mirabilis multiflora*, *Opuntia imbricata*, *Opuntia phaeacantha*, *Portulaca oleracea*, *Sphaeralcea coccinea*, *Sphaeralcea fendleri*, *Sporobolus cryptandrus*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Zuni-Acoma trailheads and the Dakota Sandstone bluffs near the Natural Arch.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 13 field plots from 2006: 06JC278, 06JC279, 06JC280, 06JC281, 06JC283, 06JC398, 06JC400, 06JC403, 06JC406, 06JC407, 06YC158, 06YC164, and 06YC166.

Local Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Juniperus monosperma / Fraxinus cuspidata Woodland [Park Special]

One-seed Juniper / Fragrant Ash Woodland
Code: CEPS009508

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2085 and 2090 m (6840-6860 feet) elevation on gently rolling lava plateaus and in collapse features of the Bandera or Twin Craters lavaflows. The ground surface is rough and broken and dominated by lava rock often with occasional patches of wind- or water-deposited sediments.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

The *Juniperus monosperma* tree canopies of this association are typically very open (25-30% cover), though they may occasionally be as sparse as 10%. Regeneration is scarce or absent. Other conifer species such as *Pinus edulis* or *Pinus ponderosa* are rare or incidental. The open canopies allow for a well-represented shrub layer dominated by the diagnostic species *Fraxinus cuspidata* with *Fallugia paradoxa* and *Forestiera pubescens* as common associates. The herbaceous canopy is typically well-represented, though it can range as low as 2.5% total cover. Graminoids predominate and include a mix of cool-season and xeric woodland grasses such as *Bouteloua gracilis*, *Elymus elymoides*, *Muhlenbergia pauciflora*, *Poa fendleriana*, and *Sporobolus cryptandrus*. Forbs are typically poorly represented but most frequently include *Artemisia carruthii*. Overall species richness is low with 11 graminoids and 10 forbs identified from this association.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus monosperma*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Fraxinus cuspidata*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia carruthii, *Bouteloua gracilis*, *Echinocereus coccineus*, *Elymus elymoides*, *Fallugia paradoxa*, *Forestiera pubescens*, *Fraxinus cuspidata*, *Heliomeris multiflora*, *Holodiscus dumosus*, *Juniperus monosperma*, *Muhlenbergia pauciflora*, *Opuntia imbricata*, *Opuntia phaeacantha*, *Opuntia polyacantha*, *Poa fendleriana*, *Rhus trilobata*, *Sporobolus cryptandrus*, *Yucca baccata*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Zuni-Acoma Trail.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 6 field plots from 2005 and 2006: 05MA011, 06AB228, 06JC269, 06JC270, 06JC273, and 06JC274.

Local Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Pascopyrum smithii - Bouteloua gracilis **Herbaceous Swale Vegetation [Park Special]**

Western Wheatgrass - Blue Grama Herbaceous Vegetation
Western Wheatgrass - Blue Grama Mixedgrass Prairie
Code: NHNM000857

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2155 and 2390 m (7070-7840 feet) in elevation in open meadows and valley bottoms wit h fine-textured soils. Substrates are derived from alluvium, and ground cover is dominated by soil.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

In this shortgrass prairie grassland, graminoids dominate (generally >25% cover) with *Bouteloua gracilis* and *Pascopyrum smithii* making up most of the graminoid cover, along with a few other grass species. An occasional tree seedling (*Pinus edulis*) is found, but otherwise trees are typically absent from this grassland. In the shrub layer, *Atriplex canescens* is the most frequently occurring and abundant, with *Ericameria nauseosa*, *Opuntia phaeacantha*, and *Gutierrezia sarothrae* common associates, but overall cover seldom exceeds 2.5%. Although relatively diverse in species, forbs are low in cover (3%); they may include *Solanum jamesii*, *Sphaeralcea fendleri*, and the annuals *Portulaca oleracea* and *Salsola tragus*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Bouteloua gracilis, Pascopyrum smithii*

CHARACTERISTIC SPECIES

El Malpais National Monument

Atriplex canescens, *Bouteloua gracilis*, *Pascopyrum smithii*, *Portulaca oleracea*

CONSERVATION STATUS RANK

Global Rank & Reasons: G5 (23-Feb-1994).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 2 - Moderate

El Malpais National Monument Comments

Two phases were identified from this association. An *Atriplex canescens* phase occurs where that species exceeds 5% total cover, and an *Ericameria nauseosa* phase occurs where it reaches 4% cover.

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Bandera Crater, North Pasture, Malpais Windmill, and the Lava Falls area.

Nations: US

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 2 field plots from 2006: 06YC110, and 06YC135.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

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Pascopyrum smithii / Grindelia squarrosa Herbaceous Vegetation [Park Special]

Western Wheatgrass / Curly-cup Gumweed Herbaceous Vegetation
Code: CEPS009502

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2150 and 2360 m (7060-7730 feet) in elevation on alluvial deposits in swales or playa-like valley bottoms on deeply weathered plateaus of the oldest lavaflows. The surface cover is primarily soil with litter scattered among the grasses.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

In this shortgrass prairie grassland, *Pascopyrum smithii* dominates and typically exceed 25% cover but can reach 40%. There are a few other herbaceous species such as *Grindelia squarrosa* and some patches of *Bassia scoparia* (= *Kochia scoparia*), a non-native weedy species. Shrubs are sparsely distributed and include *Ericameria nauseosa* and *Gutierrezia sarothrae*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Pascopyrum smithii*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Laguna Juan Garcia, The Narrows, and the North Pasture.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots from 2006 and 2007: 06JC413, 06YC099, 06YC140, 06YC142, and 07AB036.

Local Description Authors: A. Kennedy, E. Muldavin and A. Cully

REFERENCES

Western Ecology Working Group n.d.

Pinus edulis - Juniperus deppeana - Quercus grisea Woodland [Park Special]

Two-needle Pinyon - Alligator Juniper - Gray Oak Woodland
Code: CEPS009509

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2330 and 2450 m (7640-8040 feet) elevation on moderate shoulder or footslopes of low, controlled hills on moderately warm southeasterly or warm southwesterly aspects. Substrates are sandy, derived from Glorieta sandstone. The ground surface cover may be dominated by rock or litter with some exposed soil and gravel. There is little coarse woody debris or cryptogamic cover.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this woodland association are moderately open (40-60% cover) and are dominated by *Pinus edulis* along with a lesser component of *Juniperus deppeana*. There are a few seedlings and saplings of both species. Occasionally, mature *Juniperus monosperma* or *Juniperus scopulorum* are scattered about in these woodlands, as well as a few *Pinus ponderosa*. In the subcanopy, shrub-statured *Quercus grisea* mean cover is around 14%, dominating other shrubs and subshrubs. The herbaceous layer has about 12% cover, with graminoids making up 10%. *Bouteloua gracilis* is the most abundant graminoid. The poorly represented forbs include a mix of xeric and dry-mesic woodland forbs such as *Heliomeris multiflora* and *Bahia dissecta*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus deppeana, Pinus edulis*
Tree canopy	Broad-leaved evergreen tree	*Quercus grisea*

CHARACTERISTIC SPECIES

El Malpais National Monument

Juniperus deppeana, *Pinus edulis*, *Quercus grisea*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

El Malpais National Monument Comments

A *Poa fendleriana* phase was identified from this association in stands where there is a strong component of cool-season grasses which can also include *Elymus elymoides*, *Koeleria macrantha*, or *Muhlenbergia montana*.

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the area of Cerritos de Jaspe.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 3 field plots from 2006: 06JC261, 06YC024, and 06YC028.

Local Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Pinus edulis - (*Juniperus* spp.) / Cinder Woodland [Park Special]

Two-needle Pinyon - (Juniper species) / Cinder Woodland
Code: CEPS009512

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between around 2290 and 2450 m (7500-8030 feet) in elevation on steep sideslopes and shoulder slopes of volcano craters. Substrates are derived from the Bandera, El Calderon, and Lava cinder cones. Ground surface is scoria or gravel with relatively high (up to 40%) cover of litter in places.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Tree canopies of this woodland association range from sparse savanna (10% cover) to moderately open woodland (50%) and are dominated by *Pinus edulis*. At El Calderon, stands are codominated by *Pinus edulis* and *Juniperus monosperma*. There are few seedlings or saplings in these stands. Sapling or mature *Pinus ponderosa* trees occur in four of the six sampling plots. The understory of this woodland is characteristically sparse, and shrub species range from absent to around 3% in cover. Graminoids are also low in cover (up to about 2.5%); *Muhlenbergia montana* and *Bouteloua gracilis* are the most frequently occurring and abundant. Forbs are low in cover but diverse, with *Phacelia serrata*, *Bahia dissecta*, and *Ipomopsis aggregata* the most frequently occurring and abundant species.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus edulis*

CHARACTERISTIC SPECIES

El Malpais National Monument

Juniperus monosperma, *Pinus edulis*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (28-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerro Bandera, El Calderon, and Lava Crater.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 7 field plots from 2006: 06AB216, 06AB217, 06AB219, 06AB220, 06JC233, 06JC346, and 06YC007.

Local Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Pinus ponderosa / Artemisia filifolia Woodland [Park Special]

Ponderosa Pine / Sand Sagebrush Woodland
Code: CEPS009503

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association is known from a single area at 2040 m (6700 feet) in elevation. It occurs in low coppice dunes. The soil is derived from eolian deposits, with a fair amount of litter (30% of total cover) and a small amount of wood (1%).

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

In this open woodland, *Pinus ponderosa* trees are scattered throughout the dunes; some are dead, apparently from insect damage. In the inter-tree spaces, there are stands of *Artemisia filifolia* with cover between 10 and 25% along with *Ericameria nauseosa* and *Chrysothamnus pulchellus* (= *Lorandersonia pulchella* as secondary components of the shrub layer. The herbaceous layer is well-developed, and reflecting the sandy soil, *Sporobolus cryptandrus* is the dominant graminoid. The forbs are important in this association, and twice as abundant (10% relative cover) as the graminoids. The two most abundant forb species are *Heterotheca villosa* and *Dimorphocarpa wislizeni*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Artemisia filifolia*
Herb (field)	Graminoid	*Sporobolus cryptandrus*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia filifolia, *Bouteloua gracilis*, *Dimorphocarpa wislizeni*, *Ericameria nauseosa*, *Hesperostipa comata*, *Heterotheca villosa*, *Pinus ponderosa*, *Sporobolus cryptandrus*, *Tradescantia occidentalis*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Sandstone Bluffs area.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 1 field plot from 2006: 06YC156.

Local Description Authors: E. Muldavin and A. Cully

REFERENCES

Western Ecology Working Group n.d.

Pinus ponderosa / Sporobolus cryptandrus Woodland [Park Special]

Ponderosa Pine / Sand Dropseed Woodland
Code: CEPS009510

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs at 2150 m (7060 feet) elevation in a very gently rolling valley bottom with low sandy hills. Substrates of this stand are derived from Quaternary sandy alluvium, and ground surface cover is dominated by litter; soil is relatively well-developed. There is evidence of old logging activity. The soil and substrate are deep enough for pocket gopher (*Thomomys* sp.) burrows and harvester ant (*Pogonomyrmex* sp.) activity and disturbance.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

Pinus ponderosa dominates this association but is sparsely distributed (15% canopy cover) along with *Juniperus monosperma* in the interspaces of the ponderosa canopy. *Pinus ponderosa* snags and trees with lightning scars are seen. Shrubs in these stands are low in cover, allowing for an abundant herbaceous stratum; graminoids are the predominant group. The diagnostic species *Sporobolus cryptandrus* is abundant and dominant; other graminoids are poorly represented. Forbs are also relatively high in cover and include a mix of xeric woodland and desert grassland species. Disturbance has provided conditions for non-native weedy annual species, such as *Bassia scoparia* (= *Kochia scoparia*) and *Salsola tragus*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Herb (field)	Graminoid	*Sporobolus cryptandrus*

CHARACTERISTIC SPECIES

El Malpais National Monument

Pinus ponderosa, *Sporobolus cryptandrus*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known only from the east side of the monument at the North Pasture.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 1 field plot from 2006: 06YC139.

Local Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Populus tremuloides / Ribes cereum Woodland [Park Special]

Quaking Aspen / Wax Currant Woodland
Code: CEPS009504

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs between 2270 and 2400 m (7440-7880 feet) elevation on gently rolling lava plateaus and collapse features of the Bandera lavaflow and occasionally on the Twin Craters or Hoya de Cibola flows. Typically, ground surface cover is dominated by basalt rock and litter.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

This mesic broadleaf woodland (10-20% canopy cover) is dominated by *Populus tremuloides*. Sapling *Populus tremuloides* can be abundant. Frequently, *Juniperus scopulorum* is common to well-represented in the subcanopy as saplings or mature individuals. The understory of this association is characteristically shrubby and represented by the diagnostic species *Ribes cereum* along with other mesic shrub species such as *Forestiera pubescens*, *Holodiscus dumosus*, and *Rhus trilobata*. In contrast, the herbaceous layer is poorly represented, and overall species richness and cover are low, with 11 graminoids and 6 forbs found from this association.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Ribes cereum*

CHARACTERISTIC SPECIES

El Malpais National Monument

Elymus elymoides, *Forestiera pubescens*, *Juniperus scopulorum*, *Populus tremuloides*, *Rhus trilobata*, *Ribes cereum*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from Cerritos de Jaspe, Little-Hole-In-The-Wall, and the Bandera flow to the east and the Hoya de Cibola flow to the south of Little Hole-In-The-Wall.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 5 field plots from 2006: 06JC265, 06JC304, 06JC325, 06YC080, and 06YC081.

Local Description Authors: E. Muldavin and A. Kennedy

REFERENCES

Western Ecology Working Group n.d.

Pseudotsuga menziesii / Holodiscus dumosus Lavaflow Woodland [Park Special]

Douglas-fir / Rockspirea Lavaflow Woodland
Code: CEPS009505

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

The association occurs at 2370 m (7800 feet) elevation on pitted and ridged lava, with a surface composed of cobbles and rocks.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

In this open woodland, mature *Pseudotsuga menziesii* are the dominant trees in the canopy; *Juniperus scopulorum* is important in the subcanopy. Together, they make up about 15% canopy cover. The understory is distinctly shrubby and dominated by *Holodiscus dumosus* along with other mesic-tending species such as *Forestiera pubescens* and *Ribes cereum*. The herbaceous layer is limited (<1% cover), and the most common species are

Piptatherum micranthum and *Geranium lentum*.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	**Lifeform**	**Species**
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Holodiscus dumosus*
Herb (field)	Graminoid	*Piptatherum micranthum*

CHARACTERISTIC SPECIES

El Malpais National Monument

Ericameria nauseosa, *Forestiera pubescens*, *Geranium lentum*, *Holodiscus dumosus*, *Piptatherum micranthum*, *Pseudotsuga menziesii*, *Ribes cereum*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is known from the Bandera Flow.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 1 field plot from 2006: 06JC242.

Local Description Authors: E. Muldavin and A. Cully

REFERENCES

Western Ecology Working Group n.d.

Pseudotsuga menziesii / Ribes (leptanthum, cereum) Woodland [Park Special]

Douglas-fir / (Trumpet Gooseberry, Wax Currant) Woodland
Code: CEPS009506

ENVIRONMENTAL DESCRIPTION

El Malpais National Monument Environment

This association occurs at 2400 m (7800 feet) elevation on the slopes of a cinder cone. The substrate is rocky, and there is abundant woody debris from dead and downed trees, as well as litter.

VEGETATION DESCRIPTION

El Malpais National Monument Vegetation

This moderate-canopied woodland (40% cover) is dominated by *Pseudotsuga menziesii*, with minor components of *Juniperus scopulorum* and *Populus tremuloides*. Both *Pseudotsuga menziesii* and *Populus tremuloides* exhibited mortality in the park; there are numerous snags and a high percentage (25% total cover) of woody debris in the sampling area. On the other hand, there is also evidence of regeneration of all the tree species. The understory is distinctly shrubby (typically >25% cover) and dominated by *Ribes leptanthum*; *Holodiscus dumosus* and *Salix scouleriana* are also components of this stratum indicating relatively moist conditions. Herbaceous species are few, scattered, and not abundant (<3% cover). *Piptatherum micranthum*, *Poa fendleriana*, and *Carex geophila* are representatives of the graminoids, while *Artemisia carruthii* is the single forb species documented at the site.

MOST ABUNDANT SPECIES

El Malpais National Monument

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Ribes leptanthum*
Herb (field)	Graminoid	*Piptatherum micranthum*

CHARACTERISTIC SPECIES

El Malpais National Monument

Artemisia carruthii, *Carex geophila*, *Holodiscus dumosus*, *Juniperus scopulorum*, *Piptatherum micranthum*, *Poa fendleriana*, *Populus tremuloides*, *Pseudotsuga menziesii*, *Ribes leptanthum*, *Salix scouleriana*

CONSERVATION STATUS RANK

Global Rank & Reasons: GNR (22-Apr-2010).

CLASSIFICATION

Status: Nonstandard

Classification Confidence: 3 - Weak

ELEMENT DISTRIBUTION

El Malpais National Monument Range

This association is found only in the Cerro Candelaria area.

Nations: US

States/Provinces: NM

Federal Lands: NPS (El Malpais)

ELEMENT SOURCES

El Malpais National Monument Plots: The description is based on 1 field plot from 2006: 06AB209.

Local Description Authors: E. Muldavin and A. Cully

REFERENCES

Western Ecology Working Group n.d.

5. Sparse Vegetation

Sparse Vegetation / Boulder Rockland

Sparse Vegetation / Boulder Rockland
Code: NPS_NM013

DISTRIBUTION

Sedimentary hills

ENVIRONMENTAL DESCRIPTION

This sparsely vegetated land cover type is characterized by large boulder and scree.

VEGETATION DESCRIPTION

Sparsely vegetated.

ELEMENT SOURCES

Data: El Malpais National Monument PLOTS.MDB database available at: http://www.usgs.gov/core_science_systems/csas/vip/

NHNM Plots: NA

Local Description Authors: E. Muldavin

Sparse Vegetation / Lava Flow

Sparse Vegetation / Lava Flow
Code: NPS_NM067

DISTRIBUTION

Common on younger basalt lava flows .

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.

VEGETATION DESCRIPTION

Sparsely vegetated.

ELEMENT SOURCES

Data: El Malpais National Monument PLOTS.MDB database available at: http://www.usgs.gov/core_science_systems/csas/vip/

NHNM Plots: NA

Local Description Authors: E. Muldavin

Sparse Vegetation / Alluvial Flat

Sparse Vegetation / Alluvial Flat
Code: NPS_NM049

DISTRIBUTION

Lowland alluvial flats.

ENVIRONMENTAL DESCRIPTION

This sparsely vegetated land cover type is characterized by extensive areas of exposed soils in lowland areas receiving runoff waters laden with sediments.

VEGETATION DESCRIPTION

Sparsely vegetated.

ELEMENT SOURCES

Data: El Malpais National Monument PLOTS.MDB database available at: http://www.usgs.gov/core_science_systems/csas/vip/

NHNM Plots: NA

Local Description Authors: E. Muldavin

Sparse Vegetation / Cinder Cone

Sparse Vegetation / Cinder Cone
Code: NPS_NM066

DISTRIBUTION

Occasional throughout the park.

ENVIRONMENTAL DESCRIPTION

This sparsely vegetated land cover type is on steep unstable cinder cone slopes characterized by mobile volcanic pumice and cinders

VEGETATION DESCRIPTION

Sparsely vegetated.

ELEMENT SOURCES

Data: El Malpais National Monument PLOTS.MDB database available at: http://www.usgs.gov/core_science_systems/csas/vip/

NHNM Plots: NA

Local Description Authors: E. Muldavin

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Appendix E: Level 2 Map Unit Summaries

Appendix E contains the map unit summaries for the vegetation map of El Malpais National Monument, based on Table 8 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 yellow against a backdrop of shaded relief and elevation
- An image map showing the delineation of a representative polygon(s) in the 2003 color aerial photography
- The total hectares and acres of the unit and number of polygons as derived from the GIS

1 Southern Rocky Mountain White Fir - Douglas-fir Dry Forest

A Douglas-fir/Gooseberry Cinder Forest

Area

22.4 ha, 55.4 ac

Polygons

14

Primary component associations

Pseudotsuga menziesii / *Ribes (leptanthum, cereum)* Woodland (Bandera and Twin Craters lava flows)

Secondary component associations

Pseudotsuga menziesii / *Muhlenbergia montana* Forest (Bandera and Twin Craters lava flows)

Related inclusions

Populus tremuloides / Mixed Shrubs / Cinder Woodland (Bandera and Twin Craters lava flows)

Sparse Vegetation / Cinder Cone (Bandera and Twin Craters lava flows)

Pinus edulis - Juniperus scopulorum / *Holodiscus dumosus* Woodland (Twin Craters lava flow)

Elevation

7720–8231 ft (2354–2509 m)

Summary

Open forest dominated by Douglas-fir. This minor unit occurs as scattered stands on the steep, inner and outer slopes of cinder cones on the Bandera and Twin Craters flows. Rocky Mountain juniper and aspen are common canopy associates, particularly inside the cones (aspens often form small shrub-size copses at the bottom of the craters). Understories beneath the canopies can be grassy and dominated by mountain muhly and other montane species (e.g., muttongrass), or a mix of mesic shrubs such as rockspirea, trumpet gooseberry, and Scouler's willow. Slopes tend to be unstable and there can be inclusions of barren cinder rubble.

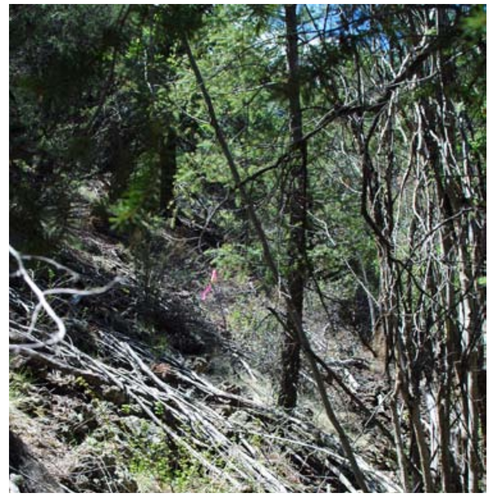

Figure E-1. Ground photo of map unit 1A.

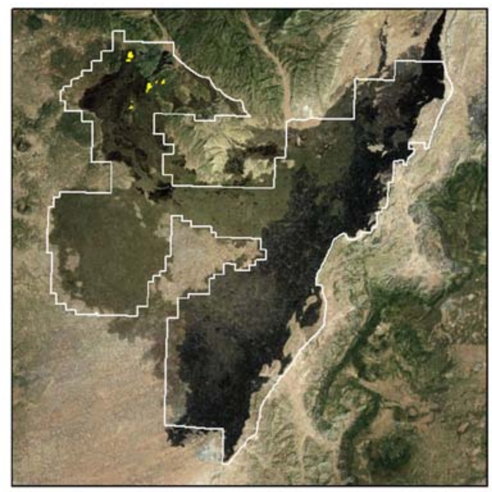

Figure E-2. Distribution of the polygons (in yellow) of map unit 1A.

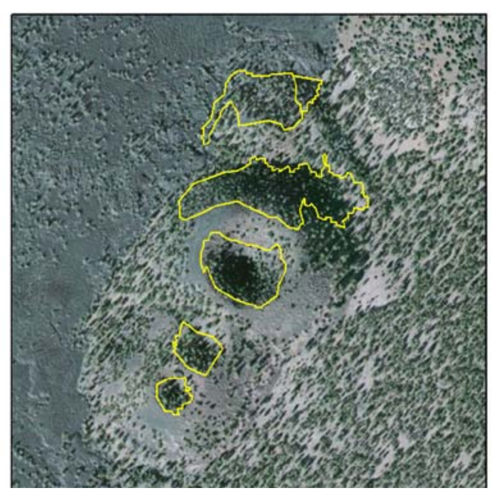

Figure E-3. Aerial photo of representative polygons of map unit 1A.

1 Southern Rocky Mountain White Fir - Douglas-fir Dry Forest

B Douglas-fir/Rockspirea Lava Woodland

Area

113.3 ha, 279.9 ac

Polygons

18

Primary component associations

Pseudotsuga menziesii / Holodiscus dumosus Lavaflow Woodland
(Bandera lava flow)

Secondary component associations

Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland
(Bandera lava flow)

Sparse Vegetation / Lava Flow
(Bandera lava flow)

Related inclusions

Populus tremuloides / Ribes cereum Woodland
(Bandera lava flow)

Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland
(Bandera lava flow)

Elevation

7674–7987 ft (2340–2435 m)

Summary

Sparse woodland dominated by Douglas-fir that is a minor unit on the rugged Bandera lava flow terrain. Rocky Mountain juniper and aspen are common canopy associates along with various mesic shrubs such as rock-spirea, New Mexico privet, and wax currant. Trees typically are stunted and scattered among mostly barren, exposed a'a lava (aspens often form small shrub-size copses in the cracks in crevices of the lava).

Figure E-4. Ground photo of map unit 1B.

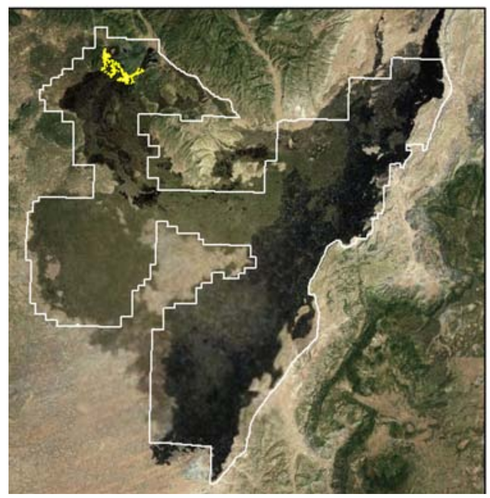

Figure E-5. Distribution of the polygons (in yellow) of map unit 1B.

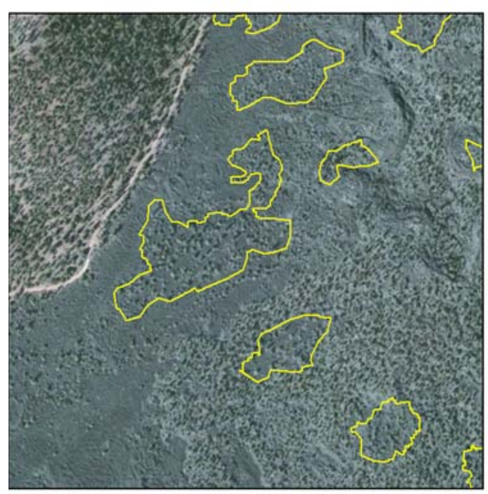

Figure E-6. Aerial photo of representative polygons of map unit 1B.

1 Southern Rocky Mountain White Fir - Douglas-fir Dry Forest

C Douglas-fir/Gambel Oak Foothill Forest

Area

13.1 ha, 32.4 ac

Polygons

3

Primary component associations

Pseudotsuga menziesii / Quercus gambelii Forest
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

n/a

Related inclusions

Pinus ponderosa / Quercus gambelii Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Elevation

7634–8060 ft (2327–2457 m)

Summary

Open forest dominated by Douglas-fir that is a minor unit on the sedimentary limestone and sandstone hills islands (kapukas) within the Bandera and Twin Craters lava flows. Rocky Mountain juniper and Gambel oak are common in the canopy and understory. Ground cover is predominantly scattered, cool-season graminoids such as junegrass, muttongrass, and Ross' sedge. Stands are small and associated with relatively gentle north-facing slopes.

Figure E-7. Ground photo of map unit 1C.

Figure E-8. Distribution of the polygons (in yellow) of map unit 1C.

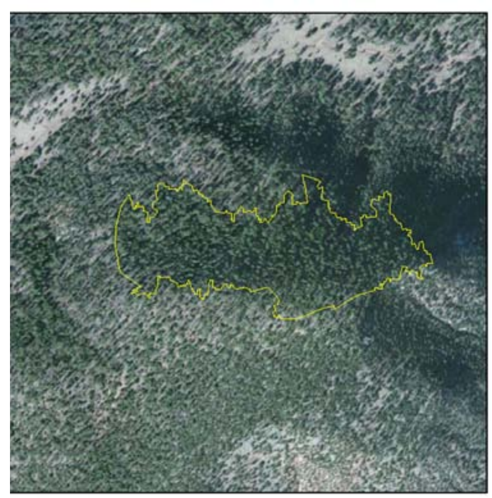

Figure E-9. Aerial photo of representative polygons of map unit 1C.

2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland

A Ponderosa Pine/Mountain Muhly-Gambel Oak Cinder Forest

Area

433.7 ha, 1071.8 ac

Polygons

19

Primary component associations

Pinus ponderosa / Muhlenbergia montana Woodland
(Bandera and Twin Craters lava flows)

Secondary component associations

Pinus ponderosa / Quercus gambelii Woodland
(Bandera and Twin Craters lava flows)

Pinus ponderosa / Carex inops ssp. *heliophila* Woodland
(Bandera lava flow)

Related inclusions

Sparse Vegetation / Cinder Cone
(Bandera and Twin Craters lava flows)

Elevation

7516–8323 ft (2291–2537 m)

Summary

Open forest dominated by ponderosa pine which occurs occasionally on the steep, inner and outer slopes of cinder cones on the Bandera and Twin Craters flows. Rocky Mountain juniper and pinyon pine can be common sub-canopy associates. Understories can be shrubby and dominated by Gambel oak, which can form dense, clonal patches as a small tree or shrub. Other sites lack significant shrubs and range from sparse with scattered deer sedges to grassy and dominated by mountain muhly. Slopes tend to be unstable and there can be inclusion of barren cinder rubble.

Figure E-10. Ground photo of map unit 2A.

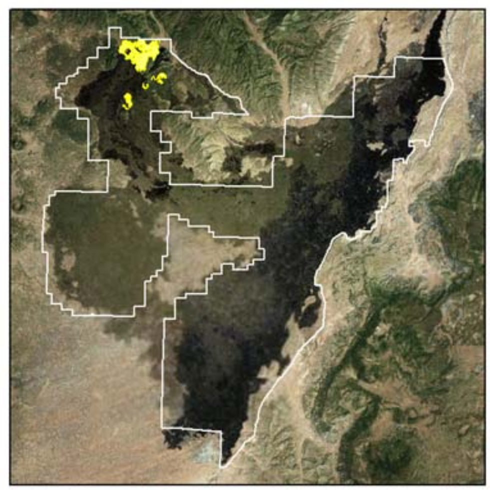

Figure E-11. Distribution of the polygons (in yellow) of map unit 2A.

Figure E-12. Aerial photo of representative polygons of map unit 2A.

2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland

B Ponderosa Pine/Mutton Bluegrass Cinder Forest

Area

35.7 ha, 88.1 ac

Polygons

11

Primary component associations

Pinus ponderosa / Poa fendleriana Woodland
(El Calderon lava flow)

Secondary component associations

Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland
(El Calderon lava flow)

Related inclusions

Sparse Vegetation / Cinder Cone
(El Calderon lava flow)

Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland
(El Calderon lava flow)

Elevation

7279–7581ft (2219–2311 m)

Summary

Open forest dominated by ponderosa pine which is a minor unit on the steep, inner and outer slopes of cinder cones on the El Calderon flow. Rocky Mountain juniper and pinyon pine can be common sub-canopy associates. Understories tend to be sparse with scattered bunch grasses such as mutton bluegrass and deer sedges. Some sites can also have significant shrub cover dominated by wax currant, rockspirea, and Apache plume, particularly at the bottoms of craters or on unstable steep external slopes. There can be extensive inclusions of barren cinder rubble.

Figure E-13. Ground photo of map unit 2B.

Figure E-14. Distribution of the polygons (in yellow) of map unit 2B.

Figure E-15. Aerial photo of representative polygons of map unit 2B.

2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland

C Ponderosa Pine/Apache Plume Lava Woodland

Area

7223.6 ha, 17849.8 ac

Polygons

328

Primary component associations

Pinus ponderosa / *Fallugia paradoxa* Woodland
(McCarty's lava flow)

Secondary component associations

Sparse Vegetation / Lava Flow
(McCarty's lava flow)

Related inclusions

Pinus edulis - *Juniperus* spp. / *Fallugia paradoxa* Woodland
(McCarty's lava flow)

Fallugia paradoxa / Rockland Shrubland
(McCarty's lava flow)

Elevation

6625–7336 ft (2020–2237 m)

Summary

Very open ponderosa pine woodland that is widespread on the southern McCartys lava flow. Stands are dominated by low-statured ponderosa pine along with scattered pinyon pine, Rocky Mountain juniper, and one-seed juniper. Sites tend to have extensive areas of exposed, non-vegetated basalt lava with shrubs such as Apache plume, skunkbush sumac, and New Mexico olive growing in the fissures and cracks. Grass cover is low, but scattered bunches of blue grama and little bluestem can be common in the smaller cracks; there is little soil accumulation on the lava surface.

Figure E-16. Ground photo of map unit 2C.

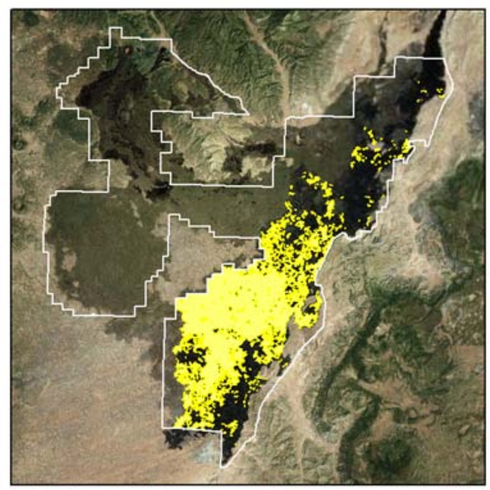

Figure E-17. Distribution of the polygons (in yellow) of map unit 2C.

Figure E-18. Aerial photo of representative polygons of map unit 2C.

2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland

D Ponderosa Pine/Apache Plume-Wax Current Lava Woodland

Area

601.5 ha, 1486.4 ac

Polygons

122

Primary component associations

Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland
(Bandera and Twin Craters lava flows)

Secondary component associations

Sparse Vegetation / Lava Flow
(Bandera and Twin Craters lava flows)

Related inclusions

Populus tremuloides / Ribes cereum Woodland
(Bandera and Twin Craters lava flows)

Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland
(Bandera and Twin Craters lava flow)

Elevation

7053–7913 ft (2150–2413 m)

Summary

Very open ponderosa pine woodland that is an occasional unit on the western Bandera and Twin Craters lava flows. Stands are dominated by low-statured ponderosa pine along with scattered Rocky Mountain juniper and pinyon pines. Sites tend to have extensive exposed, non-vegetated basalt lava with shrubs such as wax currant, Apache plume, skunkbush sumac, and New Mexico olive growing in the fissures and cracks. Grass cover is low but scattered bunches of blue grama, little bluestem, muttongrass, and mountain muhly can be common where pockets of soil have accumulated on the lava surface.

Figure E-19. Ground photo of map unit 2D.

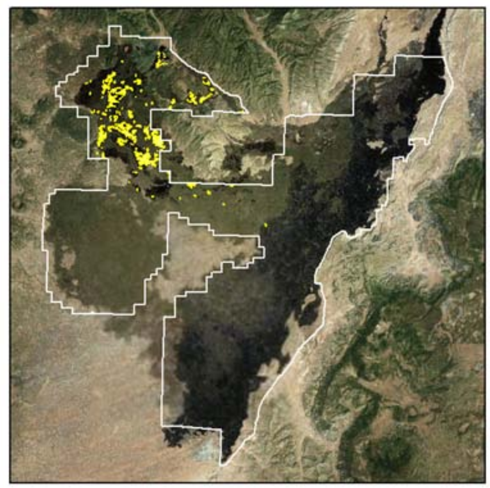

Figure E-20. Distribution of the polygons (in yellow) of map unit 2D.

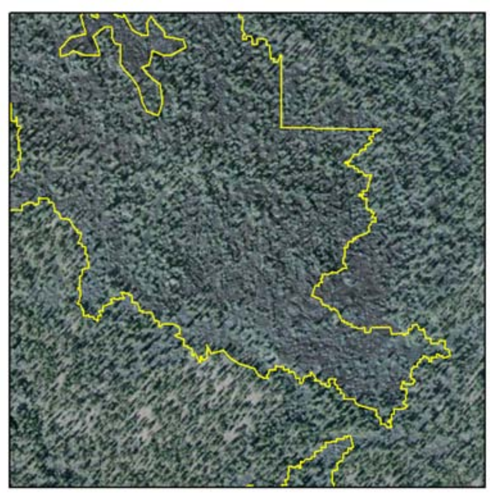

Figure E-21. Aerial photo of representative polygons of map unit 2D.

2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland

E Ponderosa pine /Apache Plume/ Mountain Muhly Lava Woodland

Area

3158.6 ha, 7805.0 ac

Polygons

82

Primary component associations

Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland
(Bandera lava flow)

Secondary component associations

Pinus ponderosa / Muhlenbergia montana Woodland
(Bandera lava flow)

Related inclusions

Sparse Vegetation / Lava Flow
(Bandera lava flow)

Pinus ponderosa / Bouteloua gracilis Woodland
(Bandera lava flow)

Pinus ponderosa / Carex inops ssp. *heliophila* Woodland
(Bandera lava flow)

Pinus ponderosa / Schizachyrium scoparium Woodland
(Bandera lava flow)

Elevation

6815–7928 ft (2078–2417 m)

Summary

Open ponderosa pine woodland that is a major unit on the western Bandera lava flow. Stands are dominated by moderate-statured ponderosa pine along with scattered Rocky Mountain juniper and pinyon pine. Shrubs such as wax currant, Apache plume, skunkbush sumac, and New Mexico olive are well represented across the flow. Grass cover can be abundant and sometimes relatively continuous (compared to 2D), and dominated by mountain muhly with blue grama and little bluestem common associates. Sites can have inclusions of exposed, non-vegetated basalt lava, but less so than in 2D.

Figure E-22. Ground photo of map unit 2E.

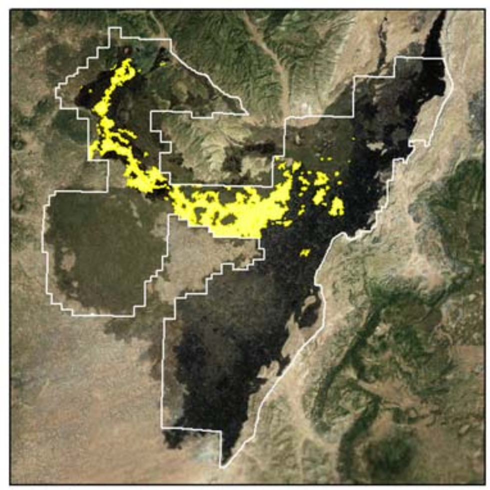

Figure E-23. Distribution of the polygons (in yellow) of map unit 2E.

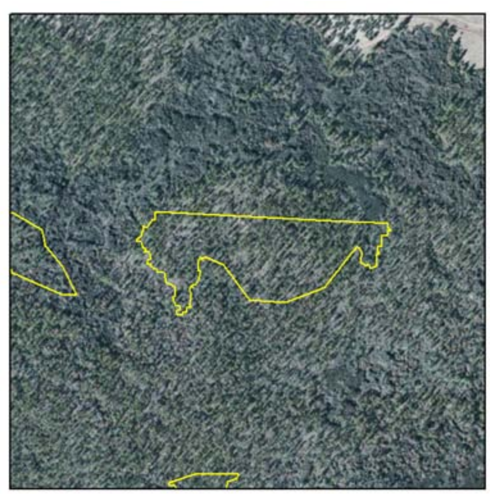

Figure E-24. Aerial photo of representative polygons of map unit 2E.

2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland

F Ponderosa Pine/Deer Sedge Lava Woodland

Area

1304.6 ha, 3223.7 ac

Polygons

89

Primary component associations

Pinus ponderosa / *Carex inops* ssp. *heliophila* Woodland
(Twin Craters lava flow)

Secondary component associations

Pinus ponderosa / *Muhlenbergia montana* Woodland
(Twin Craters lava flow)

Sparse Vegetation / Lava Flow
(Twin Craters lava flow)

Related inclusions

n/a

Elevation

6697 to 7851 ft (2042–2394 m)

Summary

Open ponderosa pine woodland common to the western Twin Craters lava flow. Stands are characterized by moderate-statured ponderosa pine along with scattered Rocky Mountain juniper, and oneseed juniper. Shrub cover is low and sites are typified by scattered bunch grasses (mountain muhly) and deer sedges with extensive areas of exposed lava.

Figure E-25. Ground photo of map unit 2F.

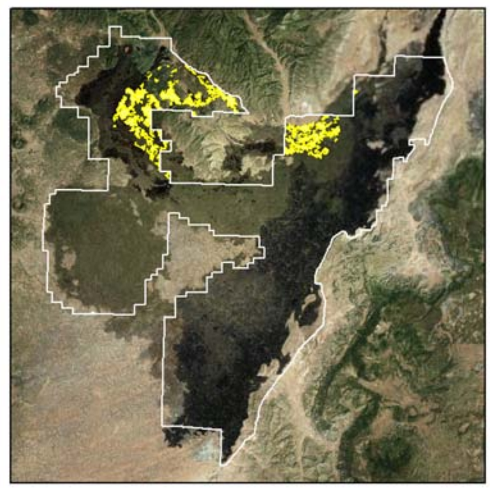

Figure E-26. Distribution of the polygons (in yellow) of map unit 2F.

Figure E-27. Aerial photo of representative polygons of map unit 2F.

2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland

G Ponderosa Pine/Mountain Muhly-Deer Sedge Lava Woodland

Area

4727.5 ha, 11681.8 ac

Polygons

116

Primary component associations

Pinus ponderosa / Muhlenbergia montana Woodland
(Hoya de Cibola lava flow)

Secondary component associations

Pinus ponderosa / Carex inops ssp. *heliophila* Woodland
(Hoya de Cibola lava flow)

Pinus ponderosa / Bouteloua gracilis Woodland
(Hoya de Cibola lava flow)

Sparse Vegetation / Lava Flow
(Hoya de Cibola lava flow)

Related inclusions

Pseudotsuga menziesii / Muhlenbergia montana Forest
(Hoya de Cibola lava flow)

Pinus ponderosa / Schizachyrium scoparium Woodland
(Hoya de Cibola lava flow)

Pinus ponderosa / Fallugia paradoxa - Ribes cereum Woodland
(Hoya de Cibola lava flow)

Populus tremuloides / Ribes cereum Woodland
(Hoya de Cibola lava flow)

Elevation

6675–7790 ft (2035–2375 m)

Summary

Open woodland of moderate-statured ponderosa pine that dominates the Hoya de Cibola lava flow. Stands can also support scattered Douglas-fir and aspen on more mesic and cooler sites, while other conifers such as Rocky Mountain juniper and pinyon pine are uncommon or absent. Shrub cover is low and the sites tend to be typified by scattered bunch grasses (sideoats grama, mountain muhly, blue grama, muttongrass, and little bluestem) and deer sedges, with extensive areas of exposed lava.

Figure E-28. Ground photo of map unit 2G.

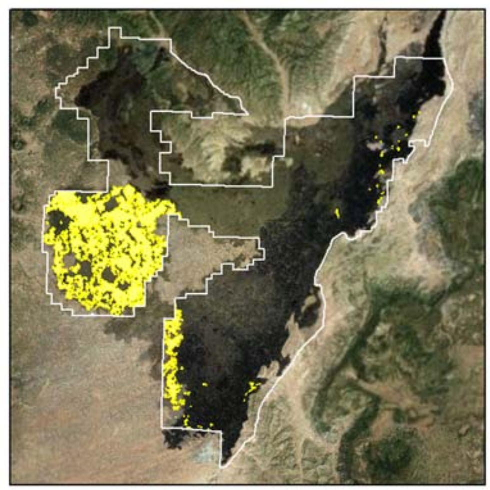

Figure E-29. Distribution of the polygons (in yellow) of map unit 2G.

Figure E-30. Aerial photo of representative polygons of map unit 2G.

2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland

H Ponderosa Pine/Oak Lava Woodland

Area

2067.1 ha, 5107.9 ac

Polygons

144

Primary component associations

Pinus ponderosa / *Quercus* × *pauciloba* Woodland
(McCarty's and Bandera lava flows)

Secondary component associations

Pinus ponderosa / *Quercus gambelii* Woodland
(McCarty's lava flow)

Sparse Vegetation / Lava Flow
(McCarty's lava flow)

Related inclusions

Sparse Vegetation / Lava Flow
(McCarty's lava flow)

Elevation

6642–7408 ft (2025–2259 m)

Summary

Very open ponderosa pine woodland that is a major unit on the southern McCartys flow and mid-Bandera flow (often near the edges of the flows). Stands are dominated by low-statured ponderosa pine along with scattered pinyon pine, Rocky Mountain juniper, and oneseed juniper. Sites are characterized by scattered scrub oak (wavy leaf and Gambel's) that can be dense in the fissures and cracks of the lava. Other shrubs such as wax currant, Apache plume, skunkbush sumac, and New Mexico olive can also be common. Grass cover is low but scattered bunches of blue grama and little bluestem can be common in the smaller cracks; there is little soil accumulation on the lava surface.

Figure E-31. Ground photo of map unit 2H.

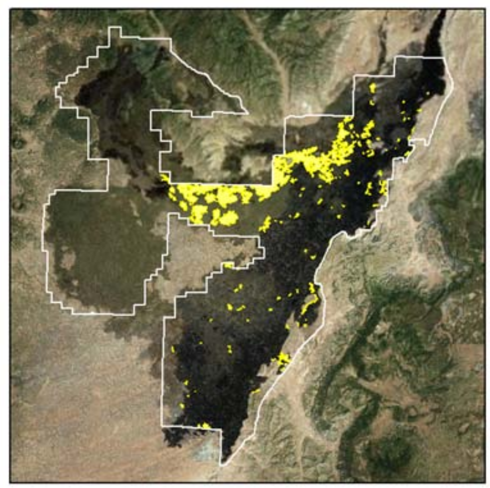

Figure E-32. Distribution of the polygons (in yellow) of map unit 2H.

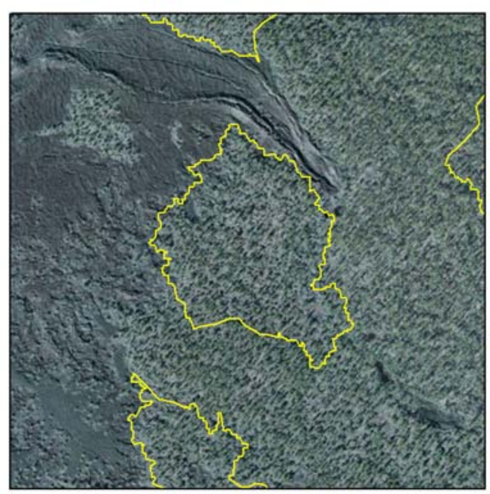

Figure E-33. Aerial photo of representative polygons of map unit 2H.

2 Southern Rocky Mountain Ponderosa Pine Forest & Woodland

I Ponderosa Pine/Gambel Oak/Mountain Muhly Foothill Woodland

Area

383.1 ha, 946.6 ac

Polygons

117

Primary component associations

Pinus ponderosa / Quercus gambelii Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

Pinus ponderosa / Muhlenbergia montana Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Related inclusions

n/a

Elevation

6667–8066 ft (2033–2459 m)

Summary

Ponderosa pine-dominated woodland that occurs occasionally on hill slopes of sedimentary rock limestone and sandstone (these are often islands, or kapukas, surrounded by lava flow). The sub-canopy commonly has pinyon pine, alligator juniper, and oneseed juniper. Gambel's oak is typically well represented in the understory as a small tree or shrub (and occasionally wavyleaf oak). Sites can also be grassy and dominated by blue grama and mountain muhly.

Figure E-34. Ground photo of map unit 2I.

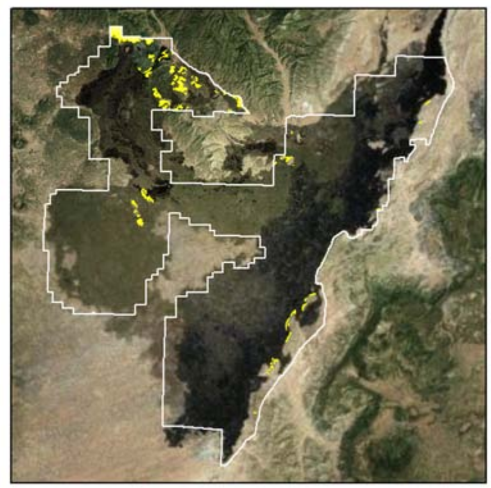

Figure E-35. Distribution of the polygons (in yellow) of map unit 2I.

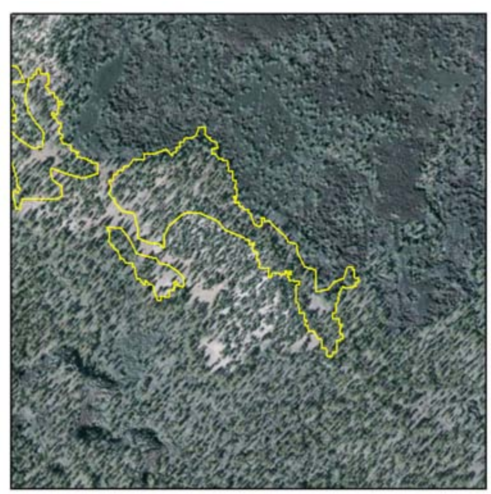

Figure E-36. Aerial photo of representative polygons of map unit 2I.

3 Southern Rocky Mountain Ponderosa Pine Savanna

A Ponderosa Pine Cinder Forest Savanna

Area

202.5 ha, 500.3 ac

Polygons

11

Primary component associations

Pinus ponderosa / *Muhlenbergia montana* Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Secondary component associations

Pinus ponderosa / *Poa fendleriana* Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Related inclusions

Pinus ponderosa / *Festuca arizonica* Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Pinus ponderosa / *Bouteloua gracilis* Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Populus tremuloides / Mixed Shrubs / Cinder Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Elevation

7622–8398 ft (2324–2561 m)

Summary

Open to moderately-closed ponderosa pine woodland savanna dominated by ponderosa pine that is a minor unit in the northwestern sector of the park. It occurs as scattered stands on the steep, inner and outer slopes of old cinder cones (e.g., Cerro Rendija) extending down to the plains. Relatively tall ponderosa pines form open canopies along with scattered Rocky Mountain juniper, alligator juniper and pinyon pine. Understories are characteristically grassy and dominated by mountain muhly, muttongrass, Arizona fescue, and blue grama. Shrubs are uncommon or absent. These older volcanic cones tend to have comparatively well-developed soils that are stable, with little exposed pumice. This unit can be found adjacent to or intermixed with 4B.

Figure E-37. Ground photo of map unit 3A.

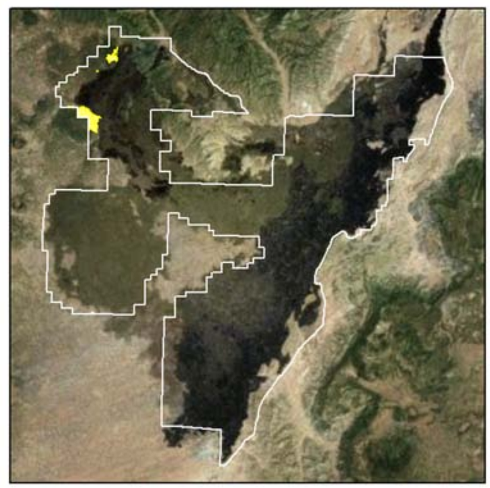

Figure E-38. Distribution of the polygons (in yellow) of map unit 3A.

Figure E-39. Aerial photo of representative polygons of map unit 3A.

3 Southern Rocky Mountain Ponderosa Pine Savanna

B Ponderosa Pine/Mountain Muhly Lava Woodland Savanna

Area

4300.9 ha, 10627.7 ac

Polygons

222

Primary component associations

Pinus ponderosa / *Muhlenbergia montana* Woodland
(Hoya de Cibola lava flow)

Pinus ponderosa / *Bouteloua gracilis* Woodland
(Twin Craters lava flow)

Secondary component associations

Pinus ponderosa / *Muhlenbergia montana* Woodland
(Twin Craters lava flow)

Pinus ponderosa / *Bouteloua gracilis* Woodland
(Hoya de Cibola lava flow)

Related inclusions

Pinus ponderosa / *Schizachyrium scoparium* Woodland
(Hoya de Cibola and Twin Craters lava flows)

Sparse Vegetation / Lava Flow
(Hoya de Cibola lava flow)

Elevation

6854–7883 ft (2090–2403 m)

Summary

Open woodland savanna dominated by ponderosa pine that is a major unit on the Twin Craters and Hoya de Cibola lava flows in the northwestern sector of the park. Relatively tall ponderosa pine form open canopies along with scattered Rocky Mountain juniper, alligator juniper and pinyon pine in the sub-canopy. Understories are characteristically grassy, with sometimes nearly continuous cover and dominated by mountain muhly followed by blue grama, sideoats grama, and little bluestem. Shrubs are uncommon or absent. Comparatively, these older lava surfaces have a modicum of a soil mantle and limited exposed lava.

Figure E-40. Ground photo of map unit 3B.

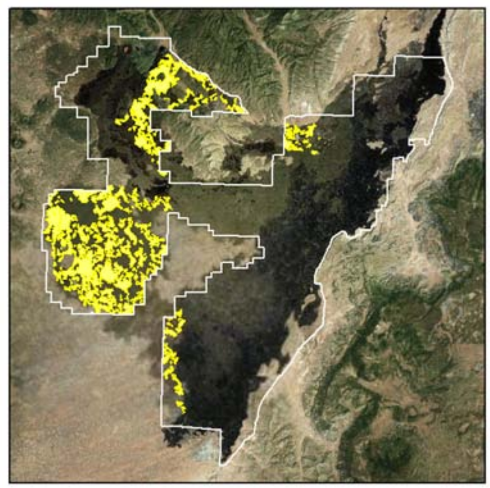

Figure E-41. Distribution of the polygons (in yellow) of map unit 3B.

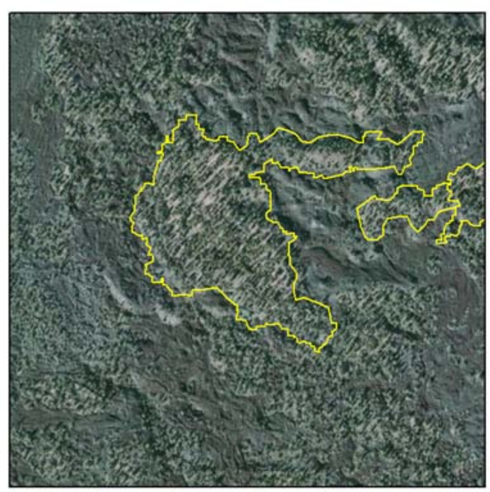

Figure E-42. Aerial photo of representative polygons of map unit 3B.

3 Southern Rocky Mountain Ponderosa Pine Savanna

C Ponderosa Pine/Mountain Muhly-Blue Grama Plains and Valley Woodland Savanna

Area

1212.8 ha, 2996.9 ac

Polygons

103

Primary component associations

Pinus ponderosa / Muhlenbergia montana Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Pinus ponderosa / Bouteloua gracilis Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

Pinus ponderosa / Muhlenbergia montana Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Pinus ponderosa / Bouteloua gracilis Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Related inclusions

n/a

Elevation

7056–8082 ft (2151–2464 m)

Summary

Open woodland savanna dominated by ponderosa pine that is a major unit off the lava flows on surrounding old basalt and alluvial plains, and on lower slopes and associated valleys of sedimentary rock limestone and sandstone hills (these are often islands, or kapukas, surrounded by lava flow). Relatively tall ponderosa pine form open canopies along with scattered Rocky Mountain juniper, alligator juniper and pinyon pine. Understories are characteristically grassy with sometimes nearly continuous cover and dominated by mountain muhly followed by blue grama, muttongrass, and deer sedge. Shrubs are uncommon or absent; the most common is rubber rabbitbrush. Sites tend to have comparatively well-developed soils; exposed lava or rock is minimal.

Figure E-43. Ground photo of map unit 3C.

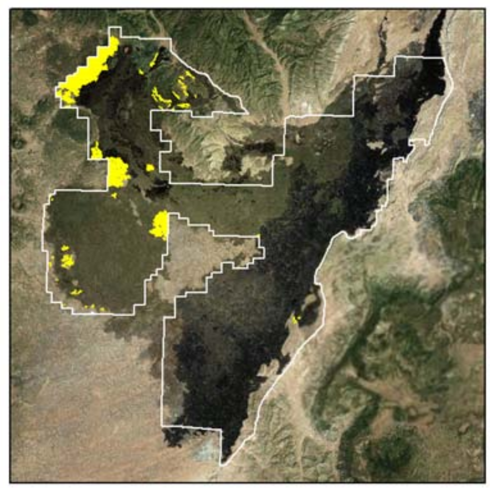

Figure E-44. Distribution of the polygons (in yellow) of map unit 3C.

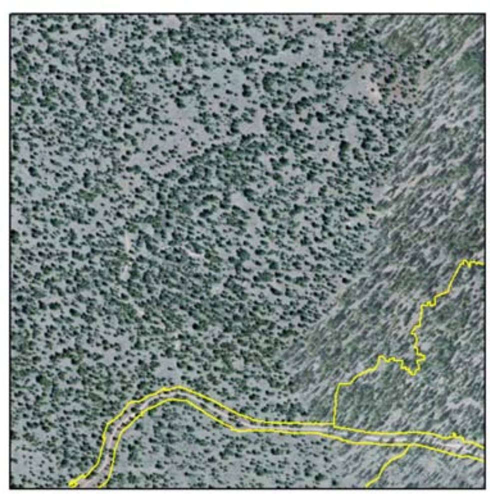

Figure E-45. Aerial photo of representative polygons of map unit 3C.

3 **Southern Rocky Mountain Ponderosa Pine Savanna**

D Ponderosa Pine/Mesa Dropseed Sandy Plains Woodland Savanna

Area

50.6 ha, 125.1 ac

Polygons

25

Primary component associations

Pinus ponderosa / Sporobolus cryptandrus Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Secondary component associations

Pinus ponderosa / Artemisia filifolia Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Related inclusions

n/a

Elevation

6640–7158 ft (2024–2182 m)

Summary

Very open ponderosa pine woodland savanna that is a minor unit off the lava flows in the surrounding plains, usually where wind-blown sands have accumulated. Relatively tall ponderosa pine form open canopies along with scattered oneseed juniper and pinyon pine. Understories are characteristically grassy with sometimes nearly continuous cover and dominated by blue grama along with sand-tolerant species such as mesa dropseed, sand dropseed, and sandhill muhly. Shrubs can be common to well represented; the most prevalent are rubber rabbitbrush and sand sagebrush. Sites tend to have comparatively well-developed sandy soils; exposed lava or rock is minimal. Interspersed with 7A, 8A, 9D where trees are absent.

Figure E-46. Ground photo of map unit 3D.

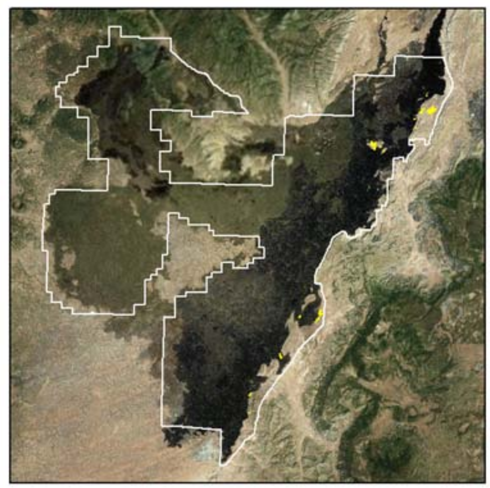

Figure E-47. Distribution of the polygons (in yellow) of map unit 3D.

Figure E-48. Aerial photo of representative polygons of map unit 3D.

4 Southern Rocky Mountain Pinyon - Juniper Woodland

A Pinyon-Juniper Cinder Woodland

Area

58.1 ha, 143.6 ac

Polygons

11

Primary component associations

Pinus edulis - (*Juniperus* spp.) / Cinder Woodland
(El Calderon and Twin Craters lava flows)

Secondary component associations

Pinus edulis - *Juniperus* spp. / *Fallugia paradoxa* Woodland
(Twin Craters lava flow)

Related inclusions

Sparse Vegetation / Cinder Cone
(El Calderon and Twin Craters lava flows)

Elevation

7335–8092 ft (2236–2467 m)

Summary

Open woodland dominated by pinyon pine and oneseed juniper that is a minor unit on steep, inner and outer slopes of cinder cones on the Twin Craters and El Calderon flows. Shrubs are common and dominated by Gambel's oak as a small tree or shrub intermixed with apache plume. Herbaceous cover tends to be sparse with scattered bunch grasses such as blue grama and muttongrass. There can be inclusions of barren cinder rubble. Intermixed with the 6A where trees are absent.

Figure E-49. Ground photo of map unit 4A.

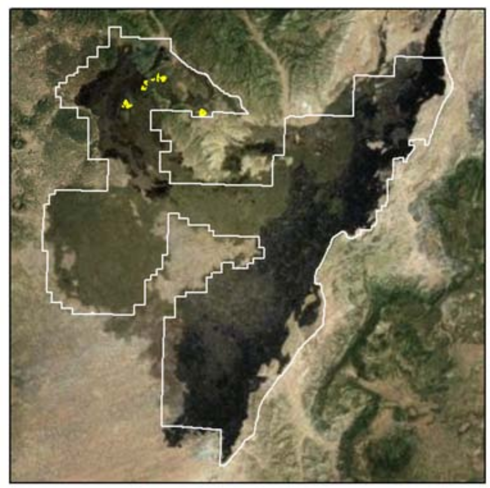

Figure E-50. Distribution of the polygons (in yellow) of map unit 4A.

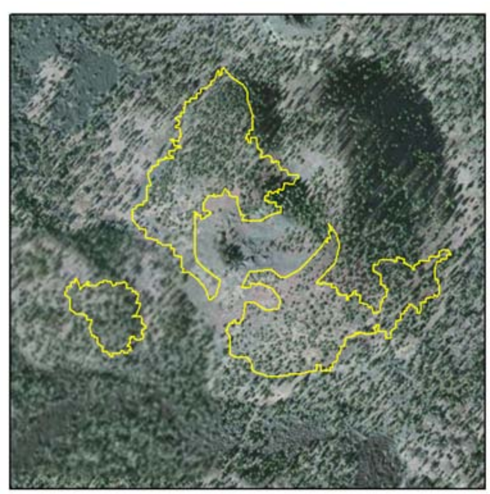

Figure E-51. Aerial photo of representative polygons of map unit 4A.

4 Southern Rocky Mountain Pinyon - Juniper Woodland

B Pinyon-Juniper/Blue Grama Cinder Woodland Savanna

Area

128.2 ha, 316.7 ac

Polygons

4

Primary component associations

Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Secondary component associations

Pinus edulis - (Juniperus spp.) / Cinder Woodland
(Old Basalt Lava flows and Holocene wind or water deposits)

Related inclusions

n/a

Elevation

7572–8401 ft (2309–2561 m)

Summary

Open woodland savanna dominated by pinyon pine with Rocky Mountain juniper and alligator juniper as co-dominates in the canopy. It is a minor unit in the northwestern sector of the park which occurs as scattered stands on southerly aspects of steep, inner and outer slopes of old cinder cones (e.g., *Cerro Rendija*) and extending down to the plains. The inter-tree spaces range from sparse to grassy with blue grama as the dominant and mountain muhly and muttongrass as common co-dominants. Shrubs are uncommon or absent. These older volcanic cones tend to have comparatively stable, well-developed soils. This unit can be found adjacent to or intermixed with 3A.

Figure E-52. Ground photo of map unit 4B.

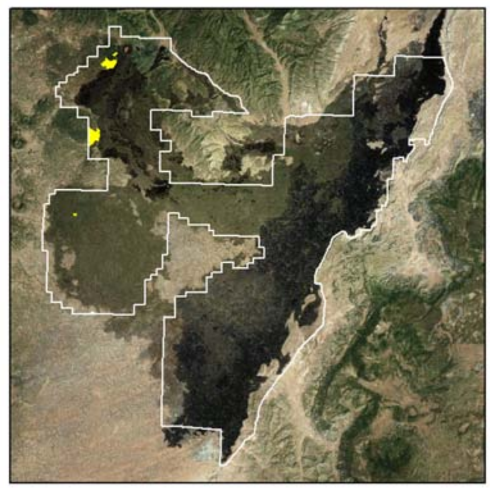

Figure E-53. Distribution of the polygons (in yellow) of map unit 4B.

Figure E-54. Aerial photo of representative polygons of map unit 4B.

4 Southern Rocky Mountain Pinyon - Juniper Woodland

C Pinyon-Juniper/Wavyleaf Oak Lava Woodland

Area

691.1 ha, 1707.7 ac

Polygons

82

Primary component associations

Pinus edulis - Juniperus monosperma / Quercus × *pauciloba* Woodland
(McCarty's and Bandera lava flows)

Secondary component associations

Juniperus monosperma / Quercus × *pauciloba* Woodland
(McCarty's lava flow)

Sparse Vegetation / Lava Flow
(McCarty's and Bandera lava flows)

Related inclusions

n/a

Elevation

6558–7278 ft (1999–2219 m)

Summary

Very open woodland dominated by pinyon pine and oneseed juniper which is a major unit in the central portion of the McCartys flow and eastern Bandera (often near the edges of the flows). Sites are characterized by scattered scrub wavyleaf that can be dense in the fissures and cracks of the lava. Other common shrubs may include Apache plume, skunkbush sumac, and New Mexico olive. Sites tend to have extensive, exposed non-vegetated basalt lava. Grass cover is low but scattered bunches of blue grama, sideoats grama, and little bluestem can be common in the smaller cracks; there is little soil accumulation on the lava surface. At the southern end of its distribution, it is often found adjacent to or intermixed with 2H (ponderosa pine dominated); to the north 5B (no pinyon).

Figure E-55. Ground photo of map unit 4C.

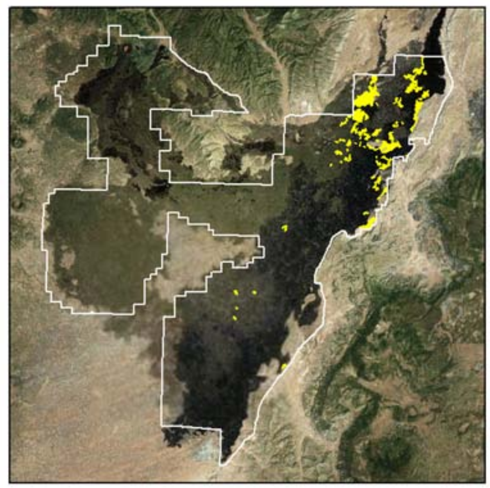

Figure E-56. Distribution of the polygons (in yellow) of map unit 4C.

Figure E-57. Aerial photo of representative polygons of map unit 4C.

4 Southern Rocky Mountain Pinyon - Juniper Woodland

D Pinyon-Juniper/Apache Plume Lava Woodland

Area

2052.4 ha, 5071.5 ac

Polygons

319

Primary component associations

Pinus edulis - Juniperus spp. / Fallugia paradoxa Woodland
(McCarty's lava flow)

Secondary component associations

Sparse Vegetation / Lava Flow
(McCarty's lava flow)

Related inclusions

n/a

Elevation

6546–7258 ft (1996–2213 m)

Summary

Very open woodland dominated by short-statured pinyon pine and one-seed juniper. This is a major unit of the central portion of the McCartys flow. Sites tend to have extensive, exposed, non-vegetated basalt lava with shrubs such as Apache plume, skunkbush sumac, and New Mexico olive growing in the fissures and cracks. Grass cover is low but scattered bunches of blue grama and little bluestem can be common in the smaller cracks; there is little soil accumulation on the lava surface. At the southern end of its distribution, this unit is often found adjacent to or intermixed with 2C; to the north, 5A.

Figure E-58. Ground photo of map unit 4D.

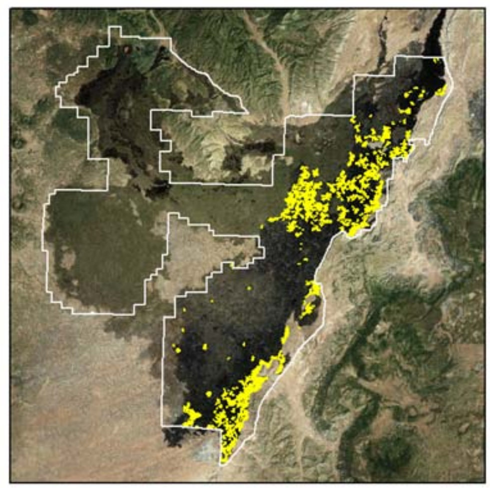

Figure E-59. Distribution of the polygons (in yellow) of map unit 4D.

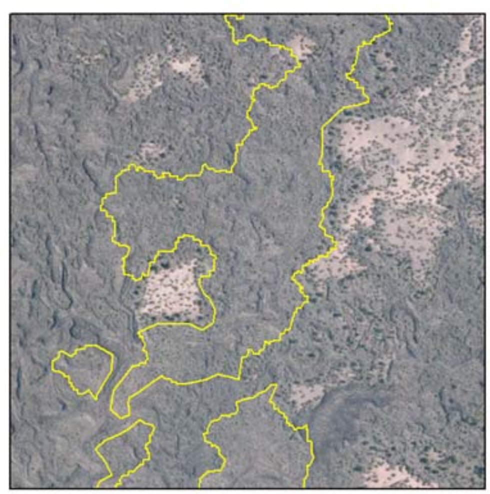

Figure E-60. Aerial photo of representative polygons of map unit 4D.

4 Southern Rocky Mountain Pinyon - Juniper Woodland

E Pinyon-Rocky Mountain Juniper/Rockspirea Lava Woodland

Area

929.2 ha, 2296.2 ac

Polygons

127

Primary component associations

Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland (Bandera lava flow)

Secondary component associations

Pinus edulis - Juniperus spp. / Fallugia paradoxa Woodland (Bandera lava flow)

Sparse Vegetation / Lava Flow (Bandera lava flow)

Related inclusions

Populus tremuloides / Ribes cereum Woodland (Bandera lava flow)

Elevation

6845–7954 ft (2087–2425 m)

Summary

Very open woodland dominated by pinyon pine and Rocky Mountain juniper that is an occasional unit in the central portions of the Bandera and Twin Craters lava flows. Sites tend to have extensive, exposed, non-vegetated basalt lava with shrubs such as rockspirea, Apache plume, skunkbush sumac, and New Mexico olive growing in the fissures and cracks. Grass cover is low but scattered bunches of blue grama, mutton-grass, and mountain muhly can be common where pockets of soil have accumulated on the lava surface.

Figure E-61. Ground photo of map unit 4E.

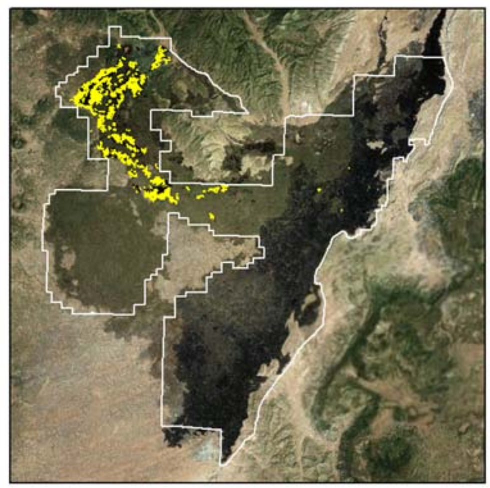

Figure E-62. Distribution of the polygons (in yellow) of map unit 4E.

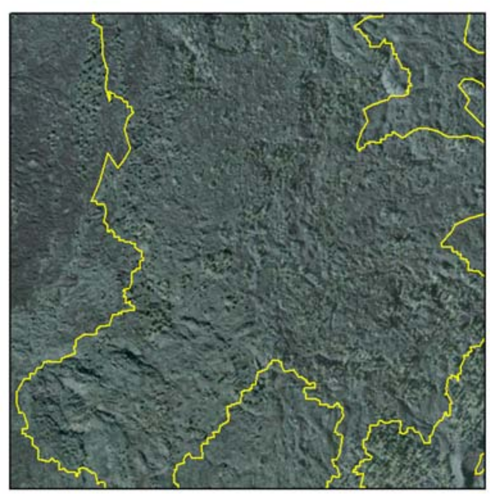

Figure E-63. Aerial photo of representative polygons of map unit 4E.

4 Southern Rocky Mountain Pinyon - Juniper Woodland

F Pinyon-Juniper/Blue Grama Lava Woodland Savanna

Area

340.0 ha, 840.2 ac

Polygons

92

Primary component associations

Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland
(El Calderon lava flow, Old Basalt lava flows and Holocene wind or water deposits)

Secondary component associations

n/a

Related inclusions

Sparse Vegetation / Lava Flow
(El Calderon lava flow)

Elevation

6671–7735 ft (2034–2358 m)

Summary

Open woodland savanna dominated by pinyon pine, Rocky Mountain juniper, and oneseed juniper. This is an occasional unit off the lava flows on surrounding old basalt and alluvial plains, and on the gentle rolling surface of the older El Calderon lava flow. Inter-tree spaces are characteristically grassy with sometimes nearly continuous cover and dominated by blue grama, with mountain muhly, muttongrass, and deer sedges as common associates. Shrubs are uncommon or absent; the most common is rubber rabbitbrush. Sites tend to have comparatively well-developed soils; exposed lava or rock is minimal. At higher elevations, this unit can be found adjacent to or intermixed with 3C.

Figure E-64. Ground photo of map unit 4F.

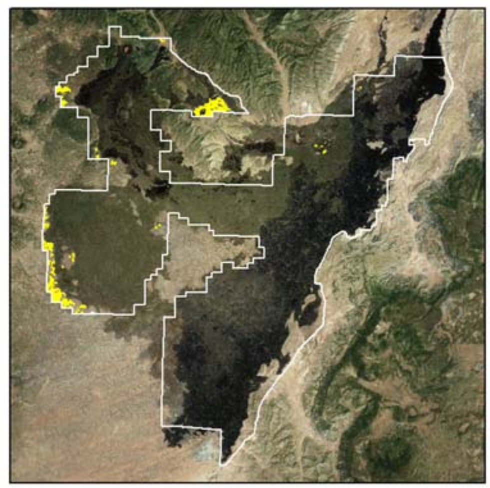

Figure E-65. Distribution of the polygons (in yellow) of map unit 4F.

Figure E-66. Aerial photo of representative polygons of map unit 4F.

4 Southern Rocky Mountain Pinyon - Juniper Woodland

G Pinyon-Juniper/Blue Grama-Mesa Dropseed Sandy Plains and Valley Woodland Savanna

Area

558.6 ha, 1380.3 ac

Polygons

151

Primary component associations

Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland
(Old Basalt lava flows and Holocene wind or water deposits, Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus Woodland
(Old Basalt lava flows and Holocene wind or water deposits)

Related inclusions

n/a

Elevation

6628 to 7800 ft (2021–2378 m)

Summary

Open woodland savanna dominated by pinyon pine and oneseed juniper. This is an occasional unit off the lava flows in the surrounding plains and sedimentary hill slopes where wind-blown sands have accumulated. Understories are characteristically grassy, dominated by blue grama along with sand tolerant species such as mesa dropseed, sand dropseed, and sandhill muhly. Shrubs are uncommon or absent; the most prevalent is rubber rabbitbrush. Sites tend to have comparatively well-developed sandy soils; exposed lava or rock is minimal. At higher elevations, this unit can be found adjacent to or intermixed with ponderosa pine-dominated 3D; at lower elevations, 5G (juniper only).

Figure E-67. Ground photo of map unit 4G

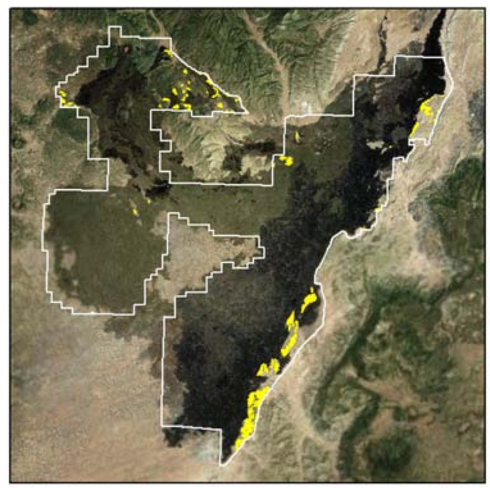

Figure E-68. Distribution of the polygons (in yellow) of map unit 4G.

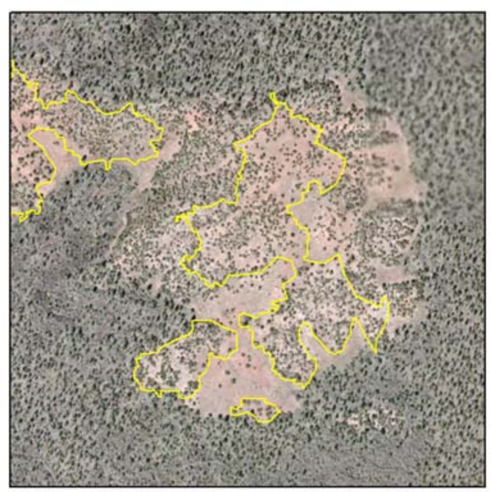

Figure E-69. Aerial photo of representative polygons of map unit 4G.

4 Southern Rocky Mountain Pinyon - Juniper Woodland

H Pinyon-Juniper/Blue Grama-Needlegrass Foothill Woodland

Area

668.9 ha, 1652.9 ac

Polygons

73

Primary component associations

Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

Pinus edulis / Achnatherum scribneri Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Pinus edulis - Juniperus monosperma / Quercus × *pauciloba* Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Related inclusions

Pinus edulis - Juniperus deppeana - Quercus grisea Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Juniperus monosperma / Muhlenbergia pauciflora Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Elevation

6677–8076 ft (2036–2462 m)

Summary

Open woodland savanna dominated by pinyon pine, alligator juniper, and oneseed juniper. Stands of this common unit occur on hill slopes of sedimentary rock limestone and sandstone (these are often islands, or kapukas, surrounded by lava flow). Sites range from sparse to grassy and dominated by blue grama, Scribner needlegrass, mountain muhly, and muttongrass. Scattered scrub wavyleaf and gray oak can also occur.

Figure E-70. Ground photo of map unit 4H.

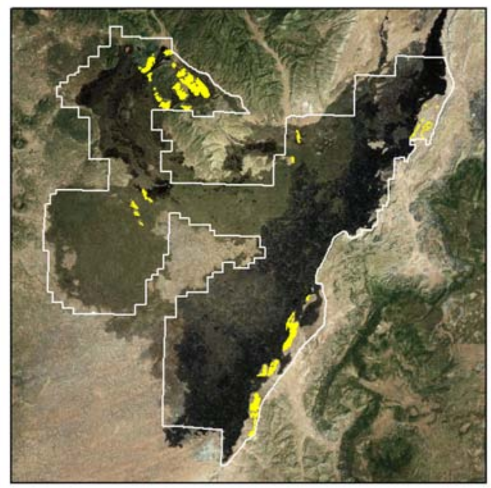

Figure E-71. Distribution of the polygons (in yellow) of map unit 4H.

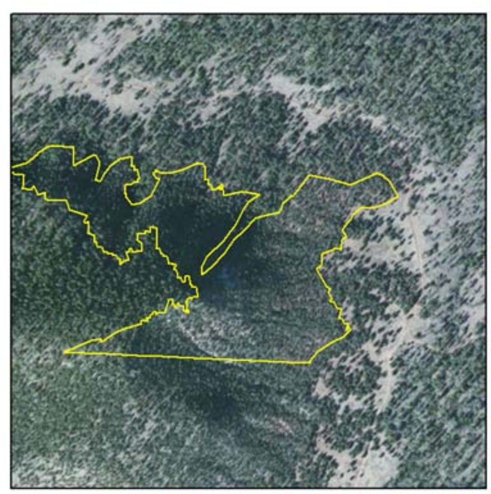

Figure E-72. Aerial photo of representative polygons of map unit 4H.

5 Southern Rocky Mountain Juniper Woodland & Savanna

A Oneseed Juniper/Apache Plume Lava Woodland

Area

523.0 ha, 1292.4 ac

Polygons

69

Primary component associations

Juniperus monosperma / Fallugia paradoxa Woodland
(McCarty's lava flow)

Secondary component associations

Sparse Vegetation / Lava Flow
(McCarty's lava flow)

Related inclusions

n/a

Elevation

6554–6991 ft (1998–2131 m)

Summary

Very open woodland dominated by oneseed juniper. This is a common unit in the northern portion of the McCartys flow. Sites tend to have extensive, exposed, non-vegetated basalt lava with shrubs such as Apache plume, skunkbush sumac, and New Mexico olive commonly growing in the fissures and cracks. Grass cover is low, but scattered bunches of sideoats grama and little bluestem can be common in the smaller cracks; there is little soil accumulation on the lava surface. At the southern end of its distribution, it is often found adjacent to or intermixed with 4D; 6A without trees to the north.

Figure E-73. Ground photo of map unit 5A.

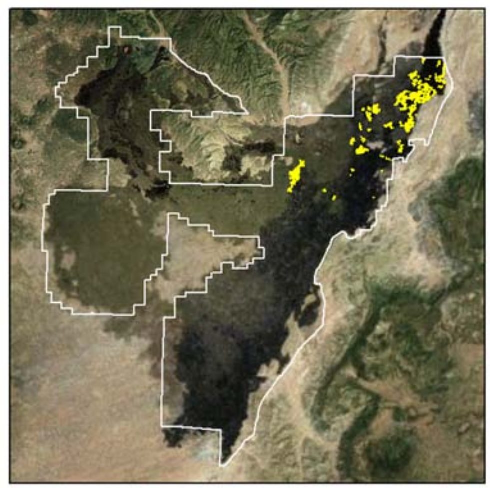

Figure E-74. Distribution of the polygons (in yellow) of map unit 5A.

Figure E-75. Aerial photo of representative polygons of map unit 5A.

5 Southern Rocky Mountain Juniper Woodland & Savanna

B Oneseed Juniper/Fragrant Ash-Wavyleaf Oak Lava Woodland

Area

426.3 ha, 1053.4 ac

Polygons

34

Primary component associations

Juniperus monosperma / Fraxinus cuspidata Woodland [Park Special] (Bandera lava flow)

Secondary component associations

Juniperus monosperma / Quercus × *pauciloba* Woodland (Bandera lava flow)

Related inclusions

Sparse Vegetation / Lava Flow (Bandera lava flow)

Elevation

6621–7161 ft (2018–2183 m)

Summary

Very open woodland dominated by oneseed juniper that is a common unit in the eastern portion of the Bandera flow. Sites are characterized by scattered scrub wavyleaf that can be dense in the fissures and cracks of the lava. Other common shrubs may include Apache plume, skunkbush sumac, and New Mexico olive. Sites tend to have extensive, exposed, non-vegetated basalt lava. Grass cover is low, but scattered bunches of blue grama, sideoats grama, and little bluestem can be common in the smaller cracks; there is little soil accumulation on the lava surface. At the western end of its distribution, this unit is often found adjacent to or intermixed with 2H (ponderosa pine-dominated) or 4C (pinyon dominated) scrub oak units.

Figure E-76. Ground photo of map unit 5B.

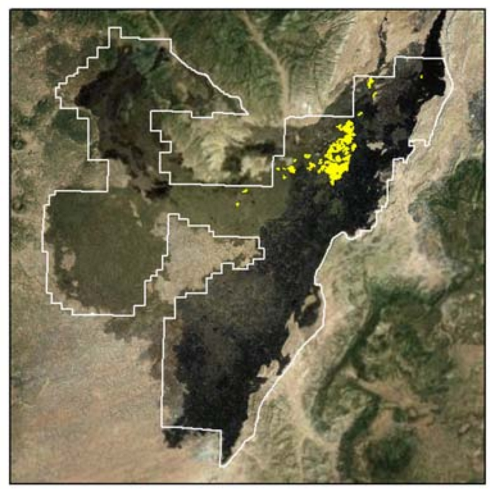

Figure E-77. Distribution of the polygons (in yellow) of map unit 5B.

Figure E-78. Aerial photo of representative polygons of map unit 5B.

5 Southern Rocky Mountain Juniper Woodland & Savanna

C Oneseed Juniper/Fragrant Ash Lava Woodland

Area

140.8 ha, 348.0 ac

Polygons

16

Primary component associations

Juniperus monosperma / Fraxinus cuspidata Woodland [Park Special]
(Twin Craters lava flow)

Secondary component associations

Sparse Vegetation / Lava Flow
(Twin Craters lava flow)

Related inclusions

n/a

Elevation

6684–6949 ft (2038–2119 m)

Summary

Very open woodland dominated by oneseed juniper that is a minor unit in the eastern portion of the Twin Craters flow. Sites are characterized by scattered shrubs in the fissures and cracks of the lava. The most abundant shrub is fragrant ash with Apache plume, wax currant, and New Mexico olive common associates. Sites tend to have extensive, exposed, non-vegetated basalt lava. Grass cover is low, but scattered bunches of blue grama and sideoats grama can be common in the smaller cracks; there is little soil accumulation on the lava surface.

Figure E-79. Ground photo of map unit 5C.

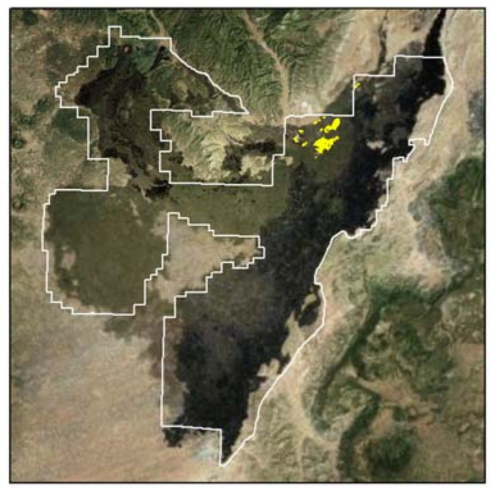

Figure E-80. Distribution of the polygons (in yellow) of map unit 5C.

Figure E-81. Aerial photo of representative polygons of map unit 5C.

5 Southern Rocky Mountain Juniper Woodland & Savanna

D Oneseed Juniper/Blue Grama Lava Woodland

Area

1054.0 ha, 2604.5 ac

Polygons

60

Primary component associations

Juniperus monosperma / Bouteloua gracilis Woodland
(Hoya de Cibola lava flow)

Secondary component associations

Sparse Vegetation / Lava Flow
(Hoya de Cibola lava flow)

Related inclusions

n/a

Elevation

6555–7324 ft (1999 to 2233 m)

Summary

Open woodland savanna dominated by oneseed juniper that is a wide-spread unit in the lower elevations of the Hoya de Cibola lava flow. Inter-tree spaces are characteristically grassy dominated by blue grama and little bluestem and intermixed with exposed lava outcrops. Shrubs are limited to scattered Apache plume, New Mexico olive, and skunk-bush sumac found on the exposed lava. At higher elevations and cooler aspects, this unit can be found adjacent to or intermixed with ponderosa pine-dominated 2G and 3B units.

Figure E-82. Ground photo of map unit 5D.

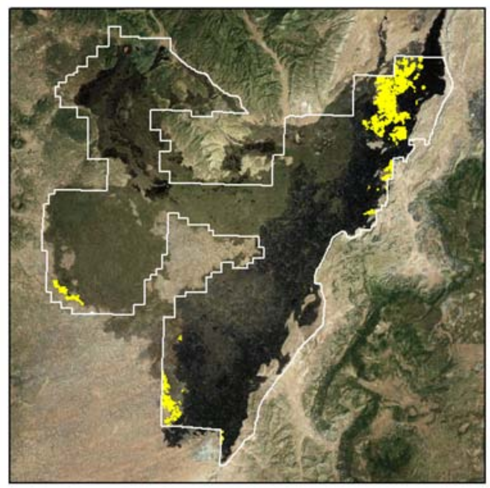

Figure E-83. Distribution of the polygons (in yellow) of map unit 5D.

Figure E-84. Aerial photo of representative polygons of map unit 5D.

5 Southern Rocky Mountain Juniper Woodland & Savanna

E Oneseed Juniper/Blue Grama Woodland Savanna

Area

1048.4 ha, 2590.7 ac

Polygons

121

Primary component associations

Juniperus monosperma / Bouteloua gracilis Woodland
(Twin Craters and Hoya de Cibola lava flows)

Secondary component associations

n/a

Related inclusions

Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland
(Twin Craters and Hoya de Cibola lava flows)

Elevation

6555–7424 ft (1998–2263 m)

Summary

Open woodland savanna dominated by oneseed juniper that is a common unit in the eastern portion of the Twin Craters lava flow and in the lower elevations of the Hoya de Cibola lava flow. Inter-tree spaces are characteristically grassy with sometimes nearly continuous cover and dominated by blue grama and little bluestem. Shrubs are uncommon or absent along with exposed lava rock. At higher elevations and cooler aspects, this unit can be found adjacent to or intermixed with ponderosa pine-dominated 3A.

Figure E-85. Ground photo of map unit 5E.

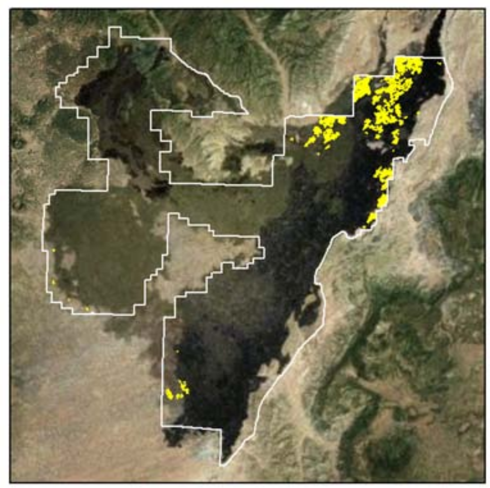

Figure E-86. Distribution of the polygons (in yellow) of map unit 5E.

Figure E-87. Aerial photo of representative polygons of map unit 5E.

5 Southern Rocky Mountain Juniper Woodland & Savanna

F Oneseed Juniper/Blue Grama-Mesa Dropseed Sandy Plains Woodland Savanna

Area

449.4 ha, 1110.6 ac

Polygons

90

Primary component associations

Juniperus monosperma / Bouteloua gracilis Woodland
(El Calderon lava flow, Old Basalt lava flows and Holocene wind or water deposits, Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus Woodland
(El Calderon lava flow, Old Basalt lava flows and Holocene wind or water deposits, Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Related inclusions

Artemisia filifolia / Bouteloua (curtipendula, gracilis) Shrubland
(Old Basalt lava flows and Holocene wind or water deposits)

Elevation

6556–7383 ft (1999–2251 m)

Summary

Open woodland savanna dominated by oneseed juniper. This is a minor unit on the older El Calderon lava flow and off-the-lava flows in the surrounding plains and sedimentary hill slopes where wind-blown sands have accumulated. Understories are characteristically grassy with sometimes nearly continuous cover and dominated by blue grama along with sand-tolerant species such as mesa dropseed, sand dropseed, galleta, and sandhill muhly. Shrubs can be common and may include rubber rabbitbrush, fourwing saltbush, and sand sagebrush. Sites tend to have comparatively well-developed sandy soils; exposed lava or rock is minimal. At higher elevations, this unit can be found adjacent to or intermixed with 4G (pinyon dominated) and 3D (ponderosa pine dominated).

Figure E-88. Ground photo of map unit 5F.

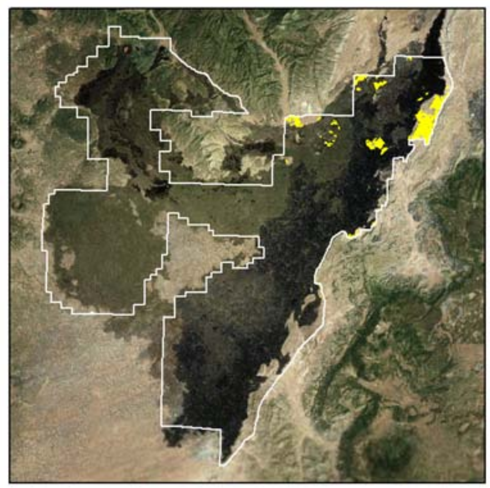

Figure E-89. Distribution of the polygons (in yellow) of map unit 5F.

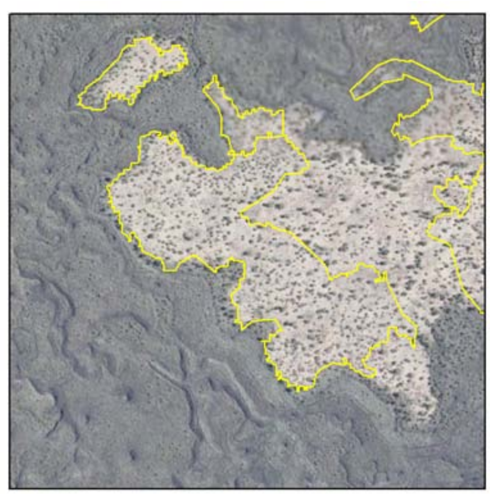

Figure E-90. Aerial photo of representative polygons of map unit 5F.

5 Southern Rocky Mountain Juniper Woodland & Savanna

G Oneseed Juniper/Wavyleaf Oak/Blue Grama Foothill Woodland Savanna

Area

63.9 ha, 157.8 ac

Polygons

21

Primary component associations

Juniperus monosperma / Bouteloua gracilis Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

Juniperus monosperma / Quercus × *pauciloba* Woodland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Related inclusions

n/a

Elevation

6644–7294 ft (2026–2224 m)

Summary

Open woodland savanna dominated by oneseed juniper. Stands of this minor unit occur on hill slopes of sedimentary rock limestone and sandstone (these are often islands, or kapukas, surrounded by lava flow). Inter-tree spaces are characterized by patches of grasses dominated by grama grasses (blue, sideoats, black, and hairy) and galleta. Shrubs may be well represented with wavyleaf oak the most common along with mountain mahogany. Similar units are 4H (pinyon pine dominated) and 2I (ponderosa pine dominated).

Figure E-91. Ground photo of map unit 5G.

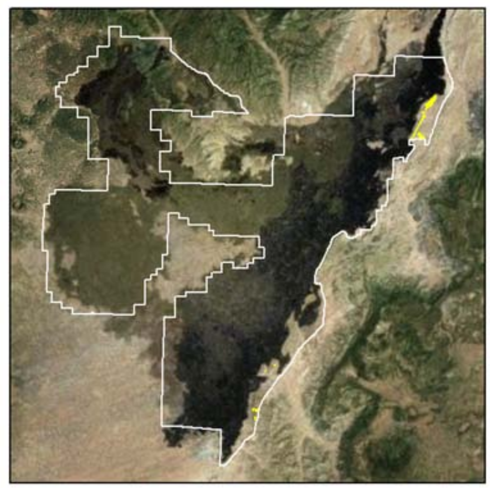

Figure E-92. Distribution of the polygons (in yellow) of map unit 5G.

Figure E-93. Aerial photo of representative polygons of map unit 5G.

6 Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland

A Apache Plume Cinder Scrub

Area

12.6 ha, 31.1 ac

Polygons

12

Primary component associations

Fallugia paradoxa / Rockland Shrubland
(Twin Craters lava flow)

Secondary component associations

Sparse Vegetation / Cinder Cone
(Twin Craters lava flow)

Related inclusions

n/a

Elevation

7412–8031 ft (2260–2448 m)

Summary

Shrubland dominated by Apache plume that is a minor unit found on steep, inner and outer slopes of cinder cones on the Twin Craters flows. Herbaceous cover tends to be sparse, with bunch grasses such as blue grama and bottlebrush squirreltail scattered across cinder rubble along with occasional cacti. Intermixed with the 1A, 2A, and 4A and where trees are present.

Figure E-94. Ground photo of map unit 6A.

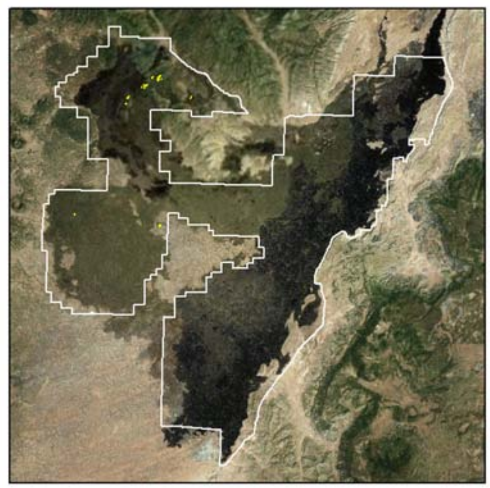

Figure E-95. Distribution of the polygons (in yellow) of map unit 6A.

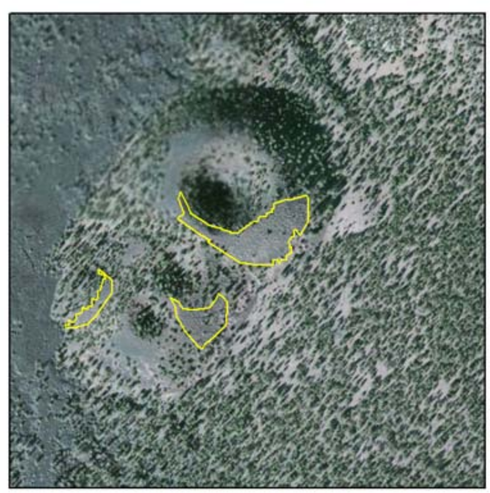

Figure E-96. Aerial photo of representative polygons of map unit 6A.

6 Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland

B Apache Plume-Skunkbush Sumac Lava Scrub

Area

6289.8 ha, 15542.5 ac

Polygons

192

Primary component associations

Fallugia paradoxa / Rockland Shrubland
(McCarty's lava flow)

Secondary component associations

Fallugia paradoxa - Rhus trilobata Shrubland
(McCarty's lava flow)

Sparse Vegetation / Lava Flow
(McCarty's lava flow)

Related inclusions

n/a

Elevation

6547–7290 ft (1996–2223 m)

Summary

Shrubland dominated by Apache plume and skunkbush sumac that is a widespread across the northern McCartys lava flow. Herbaceous cover tends to be sparse, with bunch grasses such as blue grama and bottle-brush squirreltail scattered across cinder rubble along with occasional cacti. Intermixed with the 1A, 2A, and 4A and where trees are present.

Figure E-97. Ground photo of map unit 6B.

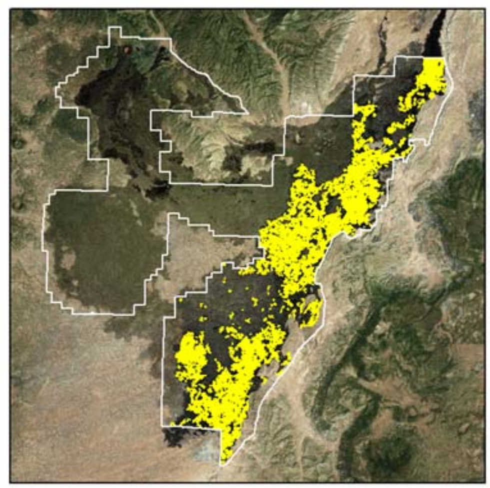

Figure E-98. Distribution of the polygons (in yellow) of map unit 6B.

Figure E-99. Aerial photo of representative polygons of map unit 6B.

6 Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland

C Skunkbush Sumac-Gooseberry-Apache Plume-Lava Scrub

Area

572.5 ha, 1414.6 ac

Polygons

208

Primary component associations

Rhus trilobata - *Ribes cereum* Shrubland
(Bandera, Twin Craters, and El Calderon lava flows)

Fallugia paradoxa - *Rhus trilobata* Shrubland
(Hoya de Cibola lava flow)

Secondary component associations

Fallugia paradoxa - *Rhus trilobata* Shrubland
(Bandera and El Calderon lava flows)

Sparse Vegetation / Lava Flow
(Bandera, Twin Craters, Hoya de Cibola, and El Calderon lava flows)

Related inclusions

Populus tremuloides / *Ribes cereum* Woodland
(Bandera, Twin Craters, Hoya de Cibola, and El Calderon lava flows)

Elevation

6676–8005 ft (2036–2440 m)

Summary

Mixed shrubland common across all flows except McCartys. Skunkbush sumac and wax currant are the most abundant shrubs, but Apache plume, New Mexico olive, common chokecherry, and scrub aspen can be common. Herbaceous cover tends to be sparse, with bunch grasses such as blue grama, mountain muhly, and muttongrass scattered in lava cracks and depressions.

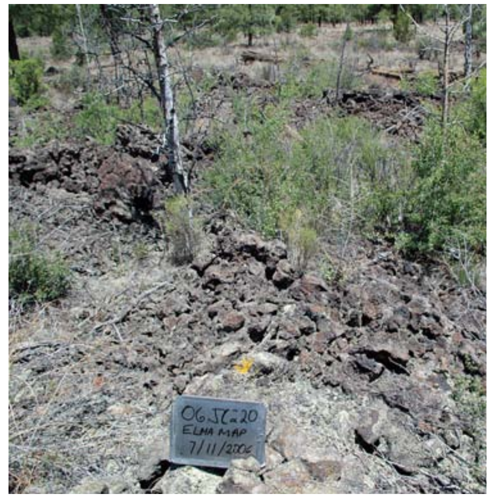

Figure E-100. Ground photo of map unit 6C.

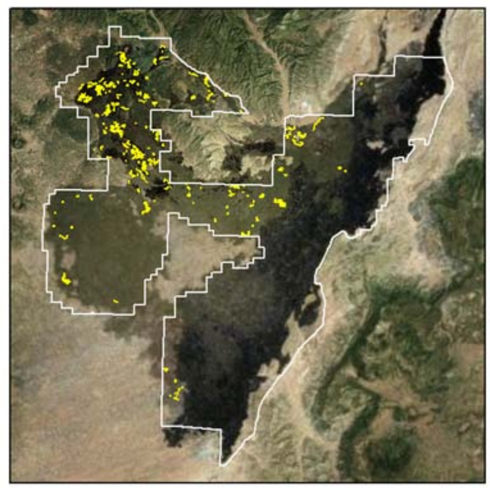

Figure E-101. Distribution of the polygons (in yellow) of map unit 6C.

Figure E-102 Aerial photo of representative polygons of map unit 6C.

7 Intermountain Shadscale-Saltbush Scrub

A Fourwing Saltbush Shrub-Steppe

Area

234.6 ha, 579.8 ac

Polygons

58

Primary component associations

Atriplex canescens / Sporobolus airoides Shrubland
(Old Basalt lava flows and Holocene wind or water deposits)

Secondary component associations

Atriplex canescens / Bouteloua gracilis Shrubland
(Old Basalt lava flows and Holocene wind or water deposits)

Atriplex canescens / Panicum obtusum Shrubland
(Old Basalt lava flows and Holocene wind or water deposits)

Related inclusions

Sparse Vegetation / Alluvial Flat
(Old Basalt lava flows and Holocene wind or water deposits)

Elevation

6555–7210 ft (1998–2198 m)

Summary

Shrubland dominated by fourwing saltbush that is a minor unit off the lava flows in the surrounding lowland plains, usually in areas where silts and clays have been deposited by runoff from the surrounding landscape. Inter-shrub spaces are typically grassy with sometimes nearly continuous cover dominated by alkali sacaton, vine mesquite grass, blue grama, western wheatgrass, and creeping muhly. Sites where water inundation is more persistent, the ground surface may be near barren.

Figure E-103. Ground photo of map unit 7A.

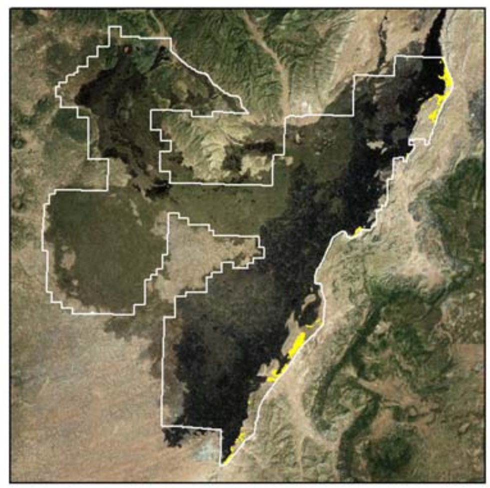

Figure E-104. Distribution of the polygons (in yellow) of map unit 7A.

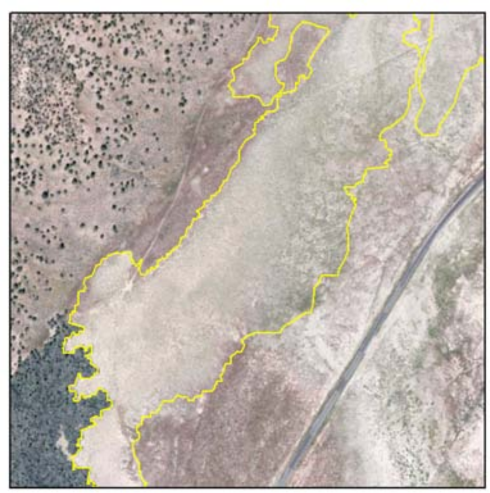

Figure E-105. Aerial photo of representative polygons of map unit 7A.

8 Great Plains Sand Shrubland

A Sand Sagebrush Sandy Plains Shrubland

Area

65.8 ha, 162.7 ac

Polygons

38

Primary component associations

Artemisia filifolia / Bouteloua (curtipendula, gracilis) Shrubland (Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

n/a

Related inclusions

n/a

Elevation

6656–7177 ft (2029–2188 m)

Summary

Shrubland dominated by sand sagebrush that is a minor unit off the lava flows in the surrounding plains and sedimentary hill footslopes where wind-blown sands have accumulated. Inter-shrub spaces are typically grassy and dominated by blue grama along with sand-tolerant species such as Indian ricegrass, sand dropseed, and big bluestem. Rubber rabbitbrush and fourwing saltbush may also be present. Sites tend to have comparatively well-developed sandy soils; exposed lava or rock is minimal.

Figure E-106. Ground photo of map unit 8A.

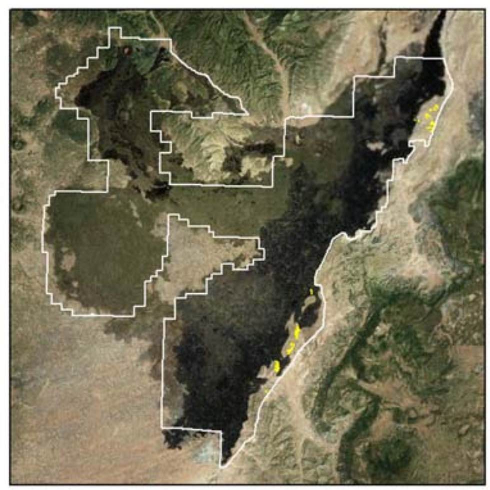

Figure E-107. Distribution of the polygons (in yellow) of map unit 8A.

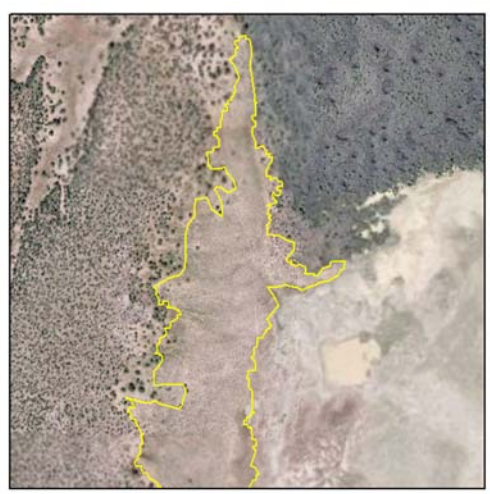

Figure E-108. Aerial photo of representative polygons of map unit 8A.

9 Great Plains Shortgrass Prairie

A Rubber Rabbitbrush/Blue Grama Shrub-Steppe

Area

369.7 ha, 913.6 ac

Polygons

136

Primary component associations

Ericameria nauseosa / Bouteloua gracilis Shrub Herbaceous Vegetation
(Bandera, Twin Craters, and El Calderon lava flows; Old Basalt lava flows and Holocene wind or water deposits)

Secondary component associations

Bouteloua gracilis Herbaceous Vegetation
(Bandera and El Calderon lava flows, Old Basalt lava flows and Holocene wind or water deposits)

Related inclusions

Bouteloua gracilis Herbaceous Vegetation
(Twin Craters lava flow)

Krascheninnikovia lanata / Bouteloua gracilis Dwarf-shrub Herbaceous Vegetation
(Old Basalt lava flows and Holocene wind or water deposits)

Elevation

6699–8058 ft (2042–2457 m)

Summary

Grassland dominated by blue grama with rubber rabbitbrush as a common shrub and sub-shrub component (<5% cover). This unit is most common off the lava flows in the surrounding old basalt plains, but is occasional on the Bandera, Twin Craters and El Calderon lava flows where sediments have accumulated. Other common grasses include ring muhly and purple threeawn. Broom snakeweed and tulip pricklypear cactus can also be prevalent.

Figure E-109. Ground photo of map unit 9A.

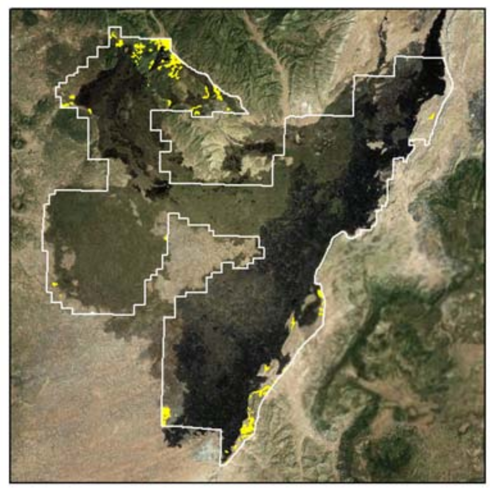

Figure E-110. Distribution of the polygons (in yellow) of map unit 9A.

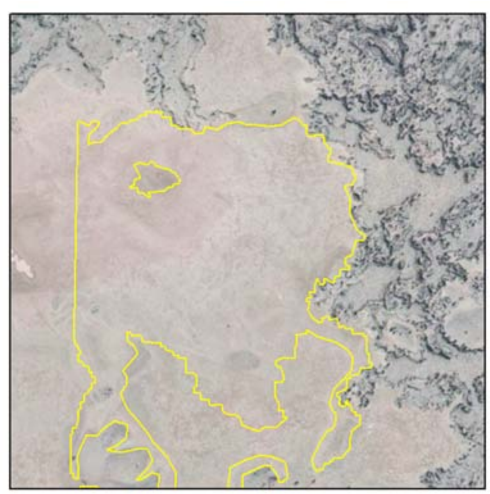

Figure E-111. Aerial photo of representative polygons of map unit 9A.

9 Great Plains Shortgrass Prairie

B Blue Grama-Mountain Muhly Lava Plains-Foothill Grassland

Area

528.0 ha, 1304.6 ac

Polygons

218

Primary component associations

Bouteloua gracilis - Muhlenbergia montana Herbaceous Vegetation (Hoya de Cibola and El Calderon lava flows, Old Basalt lava flows and Holocene wind or water deposits, Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

Bouteloua gracilis Herbaceous Vegetation
(Hoya de Cibola lava flow, Old Basalt lava flows and Holocene wind or water deposits, Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Bouteloua gracilis - Pleuraphis jamesii Herbaceous Vegetation
(El Calderon lava flow)

Related inclusions

Bouteloua gracilis - Pleuraphis jamesii Herbaceous Vegetation
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Elevation

6555–7807 ft (1998–2380 m)

Summary

Grassland dominated by grama that is common on the older lava flows (Hoya de Cibola and El Calderon) and occasional in the surrounding plains and sedimentary hill footslopes. Other common grasses in this relatively mesic grassland unit include mountain muhly, galletta, and muttongrass. Shrubs are limited and mostly represented by broom snakeweed and tulip pricklypear cactus.

Figure E-112. Ground photo of map unit 9B.

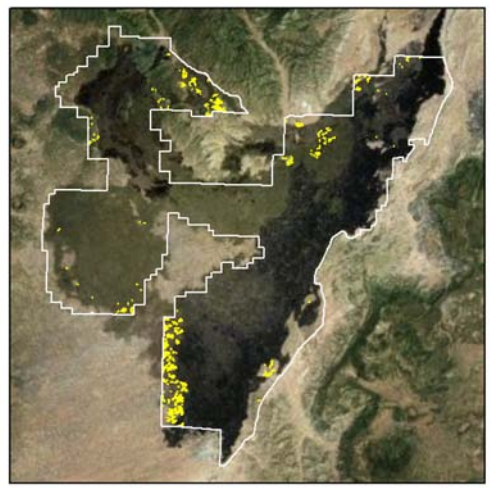

Figure E-113. Distribution of the polygons (in yellow) of map unit 9B.

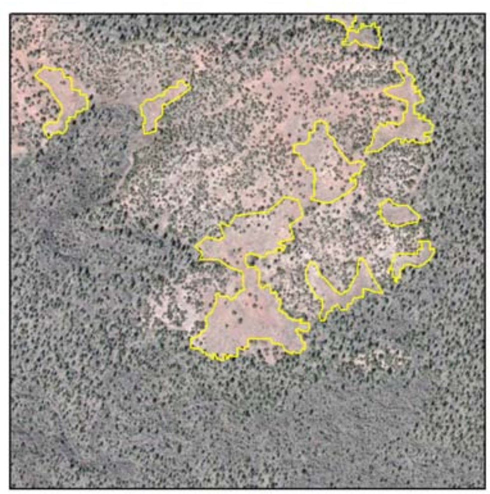

Figure E-114. Aerial photo of representative polygons of map unit 9B.

9 Great Plains Shortgrass Prairie

C Fringed Sage/Blue Grama Lava Plains Grassland

Area

863.9 ha, 2134.8 ac

Polygons

161

Primary component associations

Artemisia frigida / Bouteloua gracilis Dwarf-shrubland
(Old Basalt lava flows and Holocene wind or water deposits)

Secondary component associations

Bouteloua gracilis Herbaceous Vegetation
(Old Basalt lava flows and Holocene wind or water deposits)

Related inclusions

n/a

Elevation

6885–7744 ft (2099–2361 m)

Summary

Grassland dominated by blue grama with fringed sage as a common sub-shrub component (<5% cover). This unit is most common off the lava flows in the surrounding old basalt loamy plains. Rubber rabbitbrush may be present but seldom exceeds 1% cover. Other common grasses include ring muhly, bottlebrush squirreltail, and purple threeawn. Broom snakeweed and tulip pricklypear cactus can also be prevalent.

Figure E-115. Ground photo of map unit 9C.

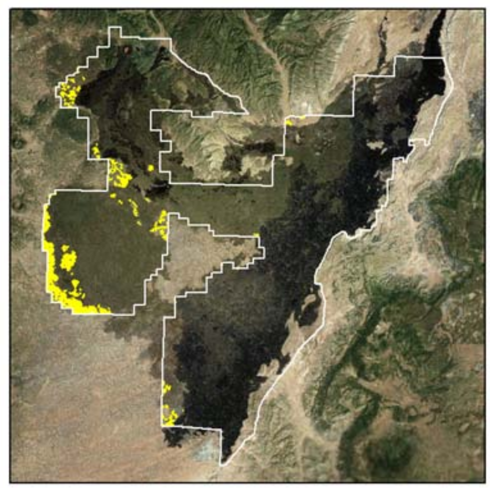

Figure E-116. Distribution of the polygons (in yellow) of map unit 9C.

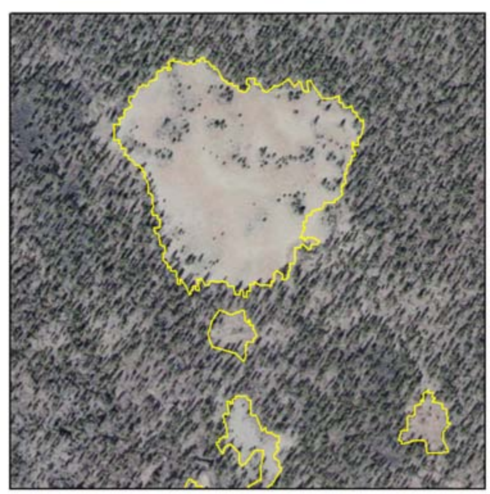

Figure E-117. Aerial photo of representative polygons of map unit 9C.

9 Great Plains Shortgrass Prairie

D Blue Grama/Mesa Dropseed Sandy Plains Grassland

Area

223.8 ha, 553.1 ac

Polygons

72

Primary component associations

Bouteloua gracilis - Sporobolus cryptandrus Herbaceous Vegetation (Old Basalt lava flows and Holocene wind or water deposits)

Secondary component associations

n/a

Related inclusions

n/a

Elevation

6648–7247 ft (2027–2209 m)

Summary

Grassland dominated by blue grama and sand dropseed. This minor unit occurs off the lava flows in the surrounding plains where wind-blown sands have accumulated, often against the lava flows. Shrubs tend to be scattered with winterfat and four-wing saltbush the most prevalent.

Figure E-118. Ground photo of map unit 9D.

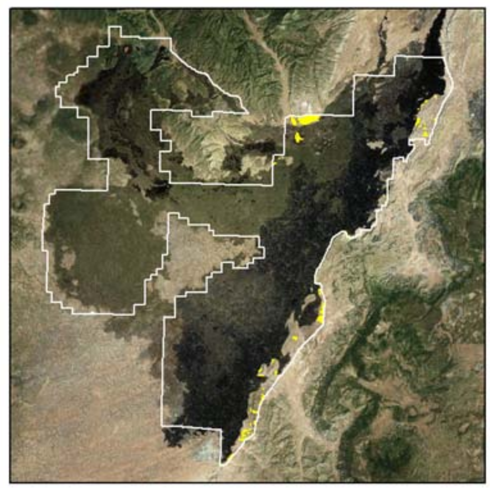

Figure E-119. Distribution of the polygons (in yellow) of map unit 9D.

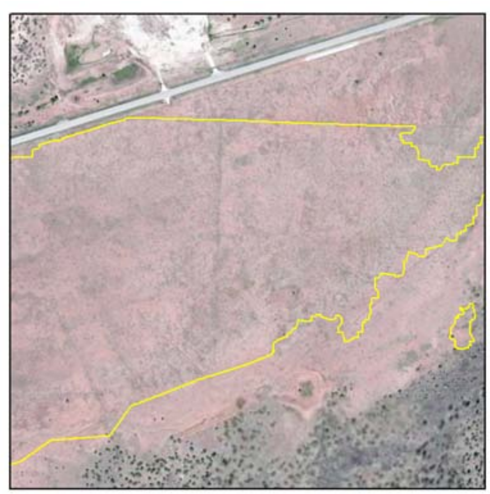

Figure E-120. Aerial photo of representative polygons of map unit 9D.

9 Great Plains Shortgrass Prairie

E Blue Grama Ruderal Grassland

Area

77.7 ha, 192.0 ac

Polygons

28

Primary component associations

Bouteloua gracilis Ruderal Herbaceous Vegetation
(Old Basalt lava flows and Holocene wind or water deposits)

Secondary component associations

Sparse Vegetation / Alluvial Flat
(Old Basalt lava flows and Holocene wind or water deposits)

Related inclusions

n/a

Elevation

6581–7555 ft (2006–2303 m)

Summary

Disturbed grasslands dominated by blue grama and various weedy forbs (amaranth, purslane, kochia, prickly Russian thistle, etc.). Stands of this minor unit occur on sites that have had significant human disturbance (e.g., intensive livestock grazing, corrals, roads) or, in some cases, extended periods of inundation from runoff waters from the surrounding landscape (particularly on alluvial flats). Other common grasses include alkali sacaton and galleta, but shrubs are few except for weedy cacti such as tree cholla or tulip pricklypear.

Figure E-121. Ground photo of map unit 9E.

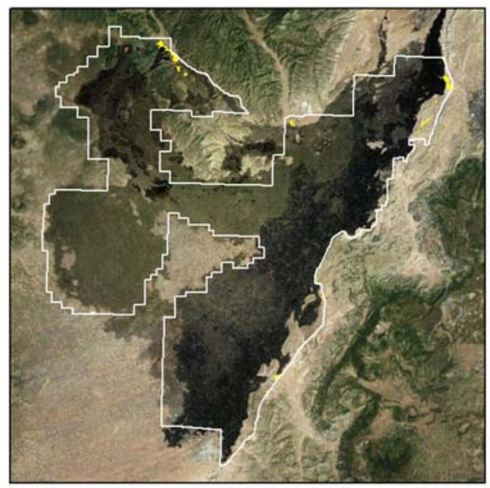

Figure E-122. Distribution of the polygons (in yellow) of map unit 9E.

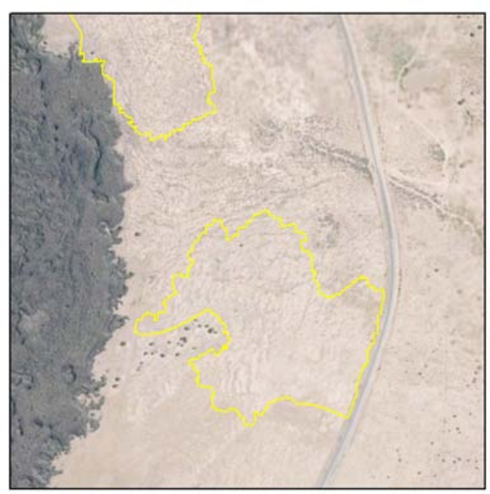

Figure E-123. Aerial photo of representative polygons of map unit 9E.

9 Great Great Plains Shortgrass Prairie

F Blue Grama-Western Wheatgrass Lowland Grassland

Area

501.0 ha, 1237.9 ac

Polygons

102

Primary component associations

Bouteloua gracilis Herbaceous Vegetation
(Old Basalt lava flows and Holocene wind or water deposits)

Pascopyrum smithii - Bouteloua gracilis Herbaceous Swale Vegetation
(Old Basalt lava flows and Holocene wind or water deposits

Secondary component associations

Pascopyrum smithii / Grindelia squarrosa Herbaceous Vegetation
(Old Basalt lava flows and Holocene wind or water deposits)

Sporobolus airoides Monotype Herbaceous Vegetation
(Old Basalt lava flows and Holocene wind or water deposits)

Related inclusions

Sparse Vegetation / Alluvial Flat
(Old Basalt lava flows and Holocene wind or water deposits)

Sarcobatus vermiculatus / Sporobolus airoides Shrubland
(Old Basalt lava flows and Holocene wind or water deposits)

Elevation

6621–7742 ft (2018–2360 m)

Summary

Grassland dominated by blue grama, western wheatgrass and/or alkali sacaton that is a common unit off the lava flows in the surrounding lowland plains, usually in areas where silts and clays have been deposited by runoff from the surrounding landscape. On alluvial flat sites where water inundation is more persistent, there may be extensive barren patches intermixed with the grass cover. Shrubs tend to be scattered with rubber rabbitbrush and four-wing saltbush the most prevalent.

Figure E-124. Ground photo of map unit 9F.

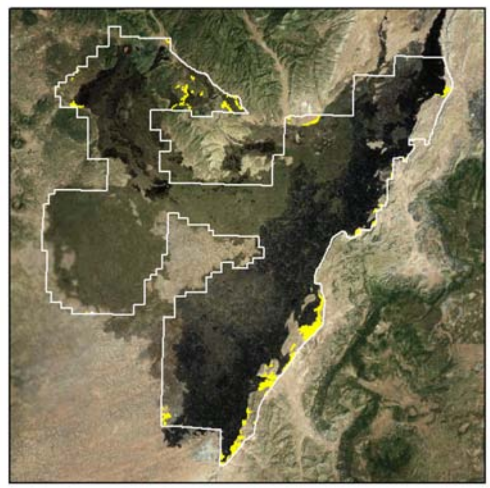

Figure E-125. Distribution of the polygons (in yellow) of map unit 9F.

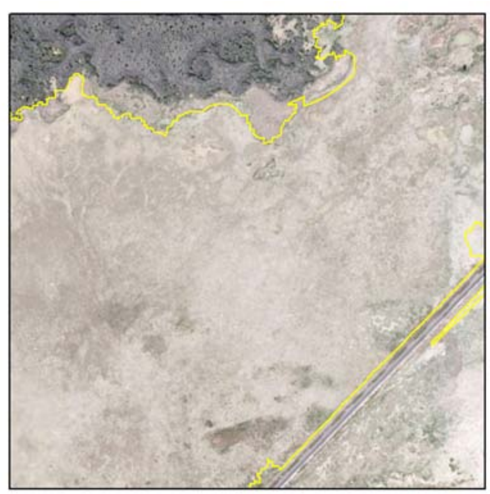

Figure E-126. Aerial photo of representative polygons of map unit 9F.

10 Barren Rock and Ground

A Barren Lava Flow

Area

1064.0 ha, 2629.1 ac

Polygons

198

Primary component associations

Sparse Vegetation / Lava Flow
(McCarty's, Bandera, Twin Craters, Hoya de Cibola, and El Calderon lava flows)

Secondary component associations

n/a

Related inclusions

n/a

Elevation

6553–7945 ft (1998–2422 m)

Summary

Sparse basalt lava flow with little or no vegetation cover (usually <1%). Most commonly is a'a lava, but younger pahoehoe can also be barren.

Figure E-127. Ground photo of map unit 10A.

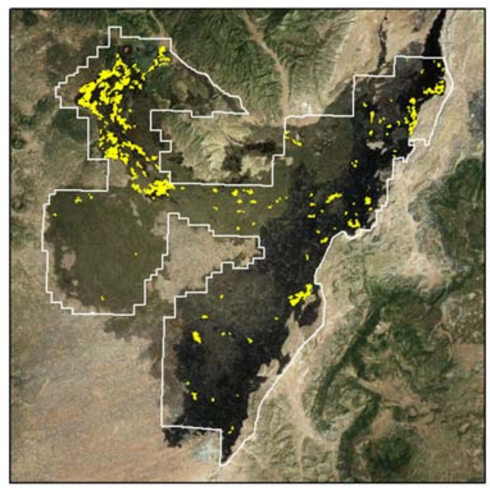

Figure E-128. Distribution of the polygons (in yellow) of map unit 10A.

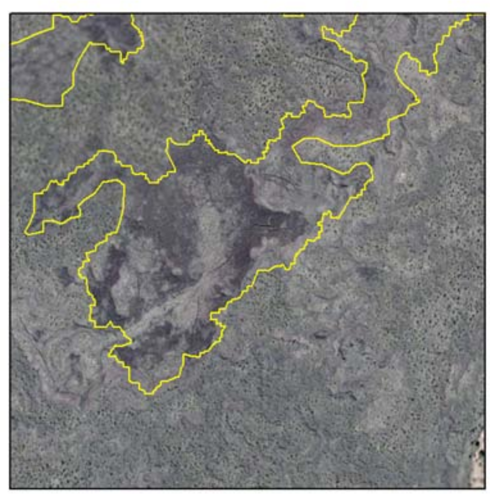

Figure E-129. Aerial photo of representative polygons of map unit 10A.

10 Barren Rock and Ground

B Barren Cinder Volcano

Area

47.8 ha, 118.0 ac

Polygons

17

Primary component associations

Sparse Vegetation / Cinder Cone
(Bandera, Twin Craters, Hoya de Cibola, and El Calderon lava flows)

Secondary component associations

n/a

Related inclusions

n/a

Elevation

7269–8322 ft (2216–2537 m)

Summary

Non-vegetated slopes of cinder cones (vegetation cover usually <1%).

Figure E-130. Ground photo of map unit 10B.

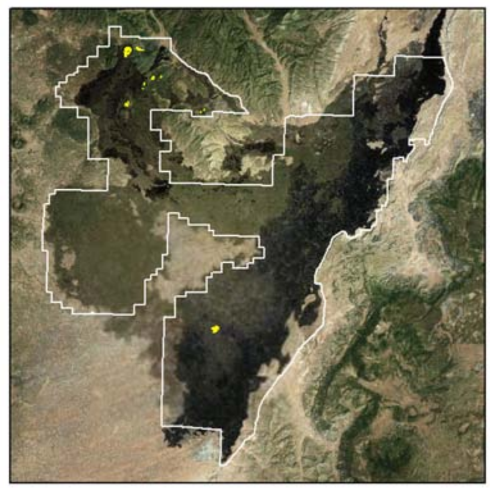

Figure E-131. Distribution of the polygons (in yellow) of map unit 10B.

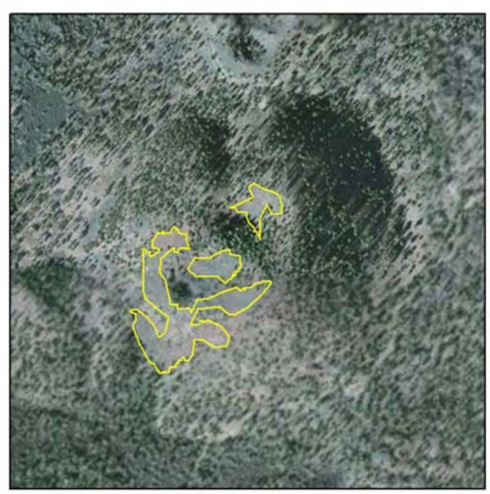

Figure E-132. Aerial photo of representative polygons of map unit 10B.

10 Barren Rock and Ground

C Barren Alluvial Flat

Area

50.6 ha, 125.2 ac

Polygons

16

Primary component associations

Sparse Vegetation / Alluvial Flat
(Old Basalt lava flows and Holocene wind or water deposits)

Secondary component associations

n/a

Related inclusions

n/a

Elevation

6632–7731 ft (2022–2357 m)

Summary

Non-vegetated alluvial flats (usually <1% cover); areas where silts and clays have been deposited by runoff from the surrounding landscape. Annual forbs or grasses may be present following significant rainfall.

Figure E-133. Ground photo of map unit 10C.

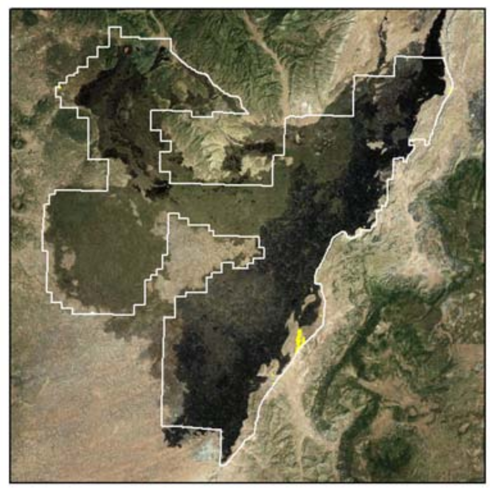

Figure E-134. Distribution of the polygons (in yellow) of map unit 10C.

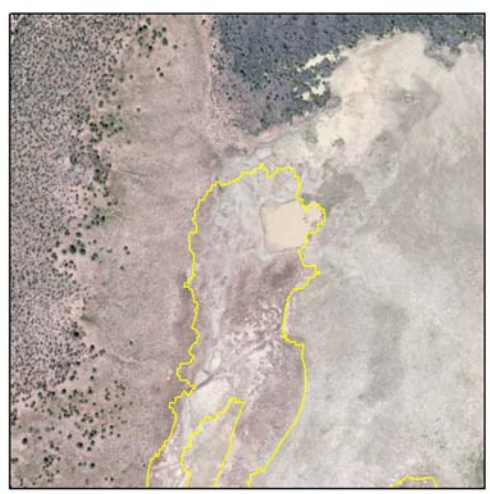

Figure E-135. Aerial photo of representative polygons of map unit 10C.

10 Barren Rock and Ground

D Rockland/Scarp/Cliff

Area

28.8 ha, 71.2 ac

Polygons

17

Primary component associations

Sparse Vegetation / Boulder Rockland
(Pennsylvanian or Jurassic sedimentary rocks [limestones or sandstones])

Secondary component associations

n/a

Related inclusions

n/a

Elevation

6633–7201 ft (2022–2195 m)

Summary

Sparsely vegetated cliffs and boulder-strewn escarpments of limestone or sandstone sedimentary hills. Scattered shrubs and herbs may occur among the rocks, but cover is usually less than 1%.

Figure E-136. Ground photo of map unit 10D.

Figure E-137. Distribution of the polygons (in yellow) of map unit 10D.

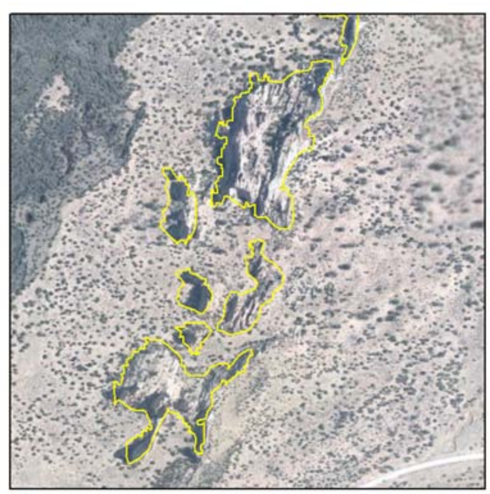

Figure E-138. Aerial photo of representative polygons of map unit 10D.

11 Urban or Built-up Land

A Urban or Built-up Land

Area

8.7 ha, 21.5 ac

Polygons

11

Primary component associations

n/a

Secondary component associations

n/a

Related inclusions

n/a

Elevation

7061–7960 ft (2153–2427 m)

Summary

Disturbed ground in and around urban areas or other human habitations.

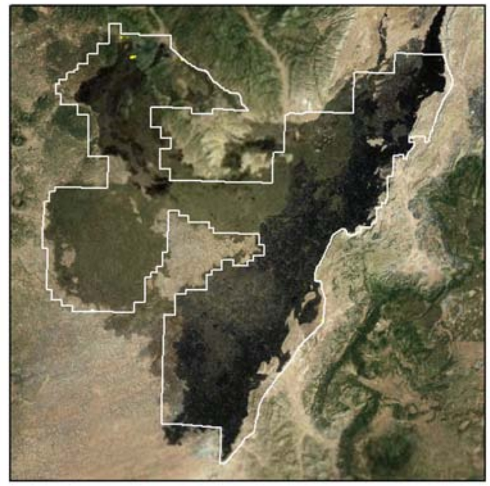

Figure E-139. Distribution of the polygons (in yellow) of map unit 11A.

Figure E-140. Aerial photo of representative polygons of map unit 11A.

11 Urban or Built-up Land

B Roads, Parking Lots

Area

227.4 ha, 561.9 ac

Polygons

20

Primary component associations

n/a

Secondary component associations

n/a

Related inclusions

n/a

Elevation

6592–7963 ft (2010–2428 m)

Summary

Paved or gravel roads and parking lots.

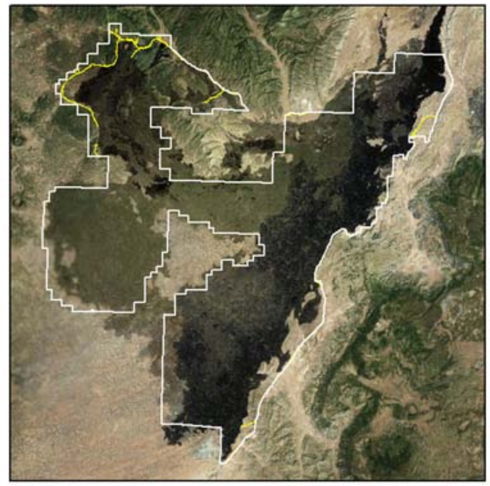

Figure E-141. Distribution of the polygons (in yellow) of map unit 11B.

Figure E-142. Aerial photo of representative polygons of map unit 11B.

11 Urban or Built-up Land

C Building

Area

0.3 ha, 0.8 ac

Polygons

12

Primary component associations

n/a

Secondary component associations

n/a

Related inclusions

n/a

Elevation

7492–7921 ft (2284–2415 m)

Summary

Public and private buildings.

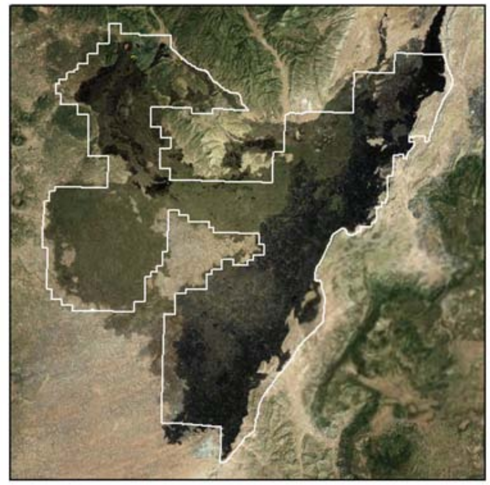

Figure E-143. Distribution of the polygons (in yellow) of map unit 11C.

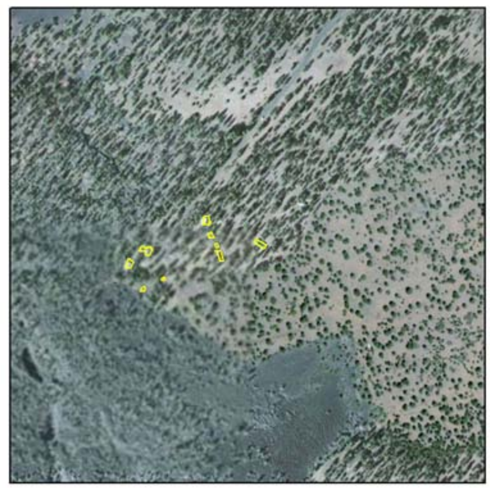

Figure E-144. Aerial photo of representative polygons of map unit 11C.

Appendix F: El Malpais National Monument NVC Association Lookup Table

Plant associations are grouped into separate tables by NVCS macrogroup. The corresponding groups are also noted. Each plant association is designated as either a primary component (1), secondary component (2), or Inclusion (i). See section *3.2.2 Vegetation map units and legend development* on page 41 in the report for an explanation of map unit components.

Table F-1

Madrean Lowland Evergreen Woodland (M010)
- Madrean Pinyon - Juniper Woodland (G200)
- Madrean Juniper Savanna & Woodland (G487)

	Map unit name	Pinyon-Juniper/Blue Grama-Needlegrass Foothill Woodland
NVCS Association	**Map unit**	4H
Pinus edulis - Juniperus deppeana - Quercus grisea Woodland		i
Juniperus monosperma / Muhlenbergia pauciflora Woodland		i

Table F-2

Rocky Mountain Subalpine & High Montane Conifer Forest (M020)
- Rocky Mountain Subalpine & Montane Aspen Forest & Woodland (G222)

	Map unit name	Douglas-fir/Gooseberry Cinder Forest	Douglas-fir/Rockspirea Lava Woodland	Ponderosa Pine/Apache Plume-Wax Current Lava Woodland	Ponderosa Pine/Mountain Muhly-Deer Sedge Lava Woodland	Ponderosa Pine Cinder Forest Savanna	Pinyon-Rocky Mountain Juniper/Rockspirea Lava Woodland	Skunkbush Sumac-Gooseberry-Apache Plume- Lava Scrub
NVCS Association	**Map unit**	1A	1B	2D	2G	3A	4E	6C
Populus tremuloides / Mixed Shrubs / Cinder Woodland		i				i		
Populus tremuloides / *Ribes cereum* Woodland			i	i	i		i	i

Table F-3

Southern Rocky Mountain Lower Montane Forest (M022)
- Southern Rocky Mountain White Fir - Douglas-fir Dry Forest (G226)
- Southern Rocky Mountain Ponderosa Pine Forest & Woodland (G228)
- Southern Rocky Mountain Ponderosa Pine Savanna (G229)

	Map unit name	Douglas-fir/Gooseberry Cinder Forest	Douglas-fir/Rockspirea Lava Woodland	Douglas-fir/Gambel Oak Foothill Forest	Ponderosa Pine/Mountain Muhly-Gambel Oak Cinder Forest	Ponderosa Pine/Mutton Bluegrass Cinder Forest	Ponderosa Pine/Apache Plume Lava Woodland	Ponderosa Pine/Apache Plume-Wax Current Lava Woodland	Ponderosa pine /Apache Plume/ Mountain Muhly Lava Woodland	Ponderosa Pine/Deer Sedge Lava Woodland	Ponderosa Pine/Mountain Muhly-Deer Sedge Lava Woodland	Ponderosa Pine/Oak Lava Woodland	Ponderosa Pine/Gambel Oak/Mountain Muhly Foothill Woodland	Ponderosa Pine Cinder Forest Savanna	Ponderosa Pine/Mountain Muhly Lava Woodland Savanna	Ponderosa Pine/Mountain Muhly-Blue Grama Plains and Valley Woodland Savanna	Ponderosa Pine/Mesa Dropseed Sandy Plains Woodland Savanna
NVCS Association	**Map unit**	1A	1B	1C	2A	2B	2C	2D	2E	2F	2G	2H	2I	3A	3B	3C	3D
Pinus ponderosa / *Artemisia filifolia* Woodland																	2
Pinus ponderosa / *Bouteloua gracilis* Woodland									i		2			i	1,2	1,2	
Pinus ponderosa / *Carex inops* ssp. *heliophila* Woodland					2				i	1	2						
Pinus ponderosa / *Fallugia paradoxa* - *Ribes cereum* Woodland						2		1	1		i						
Pinus ponderosa / *Fallugia paradoxa* Woodland							1										
Pinus ponderosa / *Festuca arizonica* Woodland														i			
Pinus ponderosa / *Muhlenbergia montana* Woodland					1				2	2	1		2	1	1,2	1,2	
Pinus ponderosa / *Poa fendleriana* Woodland						1								2			
Pinus ponderosa / *Quercus gambelii* Woodland				i	2							2	1				
Pinus ponderosa / *Quercus* × *pauciloba* Woodland												1					
Pinus ponderosa / *Schizachyrium scoparium* Woodland									i		i				i		
Pinus ponderosa / *Sporobolus cryptandrus* Woodland																	1
Pseudotsuga menziesii / *Holodiscus dumosus* Lavaflow Woodland			1														
Pseudotsuga menziesii / *Muhlenbergia montana* Forest		2									i						
Pseudotsuga menziesii / *Quercus gambelii* Forest				1													
Pseudotsuga menziesii / *Ribes (leptanthum, cereum)* Woodland		1															

Table F-4

Rocky Mountain Two-needle Pinyon - Juniper Woodland (M027) • Southern Rocky Mountain Juniper Woodland & Savanna (G252) • Southern Rocky Mountain Pinyon - Juniper Woodland (G253)																				
Map unit name	Douglas-fir/Gooseberry Cinder Forest	Douglas-fir/Rockspirea Lava Woodland	Ponderosa Pine/Mutton Bluegrass Cinder Forest	Ponderosa Pine/Apache Plume Lava Woodland	Ponderosa Pine/Apache Plume-Wax Current Lava Woodland	Pinyon-Juniper Cinder Woodland	Pinyon-Juniper/Blue Grama Cinder Woodland Savanna	Pinyon-Juniper/Wavyleaf Oak Lava Woodland	Pinyon-Juniper/Apache Plume Lava Woodland	Pinyon-Rocky Mountain Juniper/Rockspirea Lava Woodland	Pinyon-Juniper/Blue Grama Lava Woodland Savanna	Pinyon-Juniper/Blue Grama-Mesa Dropseed Sandy Plains and Valley Woodland Savanna	Pinyon-Juniper/Blue Grama-Needlegrass Foothill Woodland	Oneseed Juniper/Apache Plume Lava Woodland	Oneseed Juniper/Fragrant Ash-Wavyleaf Oak Lava Woodland	Oneseed Juniper/Fragrant Ash Lava Woodland	Oneseed Juniper/Blue Grama Lava Woodland	Oneseed Juniper/Blue Grama Woodland Savanna	Oneseed Juniper/Blue Grama-Mesa Dropseed Sandy Plains Woodland Savanna	Oneseed Juniper/Wavyleaf Oak/Blue Grama Foothill Woodland Savanna
NVCS Association / **Map unit**	1A	1B	2B	2C	2D	4A	4B	4C	4D	4E	4F	4G	4H	5A	5B	5C	5D	5E	5F	5G
Juniperus monosperma / Bouteloua gracilis - Sporobolus cryptandrus Woodland												2							2	
Juniperus monosperma / Bouteloua gracilis Woodland																i	1	1	1	1
Juniperus monosperma / Fallugia paradoxa Woodland														1						
Juniperus monosperma / Fraxinus cuspidata Woodland															1	1				
Juniperus monosperma / Quercus × pauciloba Woodland								2							2					2
Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Woodland							1				1	1	1					i		
Pinus edulis - (Juniperus spp.) / Cinder Woodland						1	2													
Pinus edulis - Juniperus monosperma / Quercus × pauciloba Woodland								1					2							
Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland	i	i	i		i					1										
Pinus edulis - Juniperus spp. / *Fallugia paradoxa* Woodland				i		2			1	2										
Pinus edulis / Achnatherum scribneri Woodland													2							

Table F-5

Southern Rocky Mountain Montane Shrubland (M049) • Southern Rocky Mountain Cercocarpus-Mixed Foothill Shrubland (G276)					
	Map unit name	Ponderosa Pine/Apache Plume Lava Woodland	Apache Plume Cinder Scrub	Apache Plume-Skunkbush Sumac Lava Scrub	Skunkbush Sumac-Gooseberry-Apache Plume- Lava Scrub
NVCS Association	**Map unit**	2C	6A	6B	6C
Fallugia paradoxa - Rhus trilobata Shrubland				2	1,2
Fallugia paradoxa / Rockland Shrubland		i	1	1	
Rhus trilobata - Ribes cereum Shrubland					1

Table F-6

Great Plains Sand Grassland & Shrubland (M052) • Great Plains Sand Shrubland (G069)			
	Map unit name	Oneseed Juniper/Blue Grama-Mesa Dropseed Sandy Plains Woodland Savanna	Sand Sagebrush Sandy Plains Shrubland
NVCS Association	**Map unit**	5F	8A
Artemisia filifolia / Bouteloua (curtipendula, gracilis) Shrubland		i	1

Table F-7

Great Plains Shortgrass Prairie & Shrubland (M053) • Great Plains Shortgrass Prairie (G144)							
	Map unit name	Rubber Rabbitbrush/Blue Grama Shrub-Steppe	Blue Grama-Mountain Muhly Lava Plains-Foothill Grassland	Fringed Sage/Blue Grama Lava Plains Grassland	Blue Grama/Mesa Dropseed Sandy Plains Grassland	Blue Grama Ruderal Grassland	Blue Grama-Western Wheatgrass Lowland Grassland
NVCS Association	**Map unit**	9A	9B	9C	9D	9E	9F
Artemisia frigida / Bouteloua gracilis Dwarf-shrubland				1			
Bouteloua gracilis - Sporobolus cryptandrus Herbaceous Vegetation					1		
Bouteloua gracilis Herbaceous Vegetation		2,i	2	2			1
Bouteloua gracilis Ruderal Herbaceous Vegetation						1	
Pascopyrum smithii - Bouteloua gracilis Herbaceous Swale Vegetation							1
Pascopyrum smithii / Grindelia squarrosa Herbaceous Vegetation							2

Table F-8

Great Basin Saltbrush Scrub (M093) • Intermountain Shadscale - Saltbush Scrub (G300)		
	Map unit name	Fourwing Saltbush Shrub-Steppe
NVCS Association	**Map unit**	7A
Atriplex canescens / Bouteloua gracilis Shrubland		2
Atriplex canescens / Panicum obtusum Shrubland		2
Atriplex canescens / Sporobolus airoides Shrubland		1

Table F-9

North American Warm Semi-Desert Cliff, Scree & Rock Vegetation (M117)
- North American Warm Semi-Desert Cliff, Scree & Pavement Sparse Vegetation (G569)

	Map unit name	Douglas-fir/Gooseberry Cinder Forest	Douglas-fir/Rockspirea Lava Woodland	Ponderosa Pine/Mountain Muhly-Gambel Oak Cinder Forest	Ponderosa Pine/Mutton Bluegrass Cinder Forest	Ponderosa Pine/Apache Plume Lava Woodland	Ponderosa Pine/Apache Plume-Wax Current Lava Woodland	Ponderosa pine /Apache Plume/ Mountain Muhly Lava Woodland	Ponderosa Pine/Deer Sedge Lava Woodland	Ponderosa Pine/Mountain Muhly-Deer Sedge Lava Woodland	Ponderosa Pine/Oak Lava Woodland	Ponderosa Pine/Mountain Muhly Lava Woodland Savanna	Pinyon-Juniper Cinder Woodland	Pinyon-Juniper/Wavyleaf Oak Lava Woodland	Pinyon-Juniper/Apache Plume Lava Woodland	Pinyon-Rocky Mountain Juniper/Rockspirea Lava Woodland	Pinyon-Juniper/Blue Grama Lava Woodland Savanna	Oneseed Juniper/Apache Plume Lava Woodland	Oneseed Juniper/Fragrant Ash-Wavyleaf Oak Lava Woodland	Oneseed Juniper/Fragrant Ash Lava Woodland	Oneseed Juniper/Blue Grama Lava Woodland	Apache Plume Cinder Scrub	Apache Plume-Skunkbush Sumac Lava Scrub	Skunkbush Sumac-Gooseberry-Apache Plume- Lava Scrub	Fourwing Saltbush Shrub-Steppe	Blue Grama Ruderal Grassland	Blue Grama-Western Wheatgrass Lowland Grassland	Barren Lava Flow	Barren Cinder Volcano	Barren Alluvial Flat	Rockland/Scarp/Cliff
NVCS Association	**Map unit**	1A	1B	2A	2B	2C	2D	2E	2F	2G	2H	3B	4A	4C	4D	4E	4F	5A	5B	5C	5D	6A	6B	6C	7A	9E	9F	10A	10B	10C	10D
Sparse Vegetation / Alluvial Flat				1																									i	2	i
Sparse Vegetation / Boulder Rockland					1																										
Sparse Vegetation / Cinder Cone			1			i		i	i								i									2					
Sparse Vegetation / Lava Flow		1					2			2	2	i	2	2	2,i	i		2	2	2	i	2	i	2	2		2	2			

Table F-10

Rocky Mountain-Vancouverian Subalpine & High Montane Mesic Grass & Forb Meadow (M168) • Southern Rocky Mountain Montane-Subalpine Grassland (G268)		
	Map unit name	Blue Grama-Mountain Muhly Lava Plains-Foothill Grassland
NVCS Association	**Map unit**	9B
Bouteloua gracilis - Muhlenbergia montana Herbaceous Vegetation		1

Table F-11

Great Basin & Intermountain Dry Shrubland & Grassland (M171) • Intermountain Semi-Desert Shrubland & Steppe (G310) • Intermountain Semi-Desert Grassland (G311)				
	Map unit name	Rubber Rabbitbrush/Blue Grama Shrub-Steppe	Blue Grama-Mountain Muhly Lava Plains-Foothill Grassland	Blue Grama-Western Wheatgrass Lowland Grassland
NVCS Association	**Map unit**	9A	9B	9F
Bouteloua gracilis - Pleuraphis jamesii Herbaceous Vegetation			2,i	
Ericameria nauseosa / Bouteloua gracilis Shrub Herbaceous Vegetation		1		
Krascheninnikovia lanata / Bouteloua gracilis Dwarf-shrub Herbaceous Vegetation		i		
Sarcobatus vermiculatus / Sporobolus airoides Shrubland				i
Sporobolus airoides Monotype Herbaceous Vegetation				2

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