National Park Service
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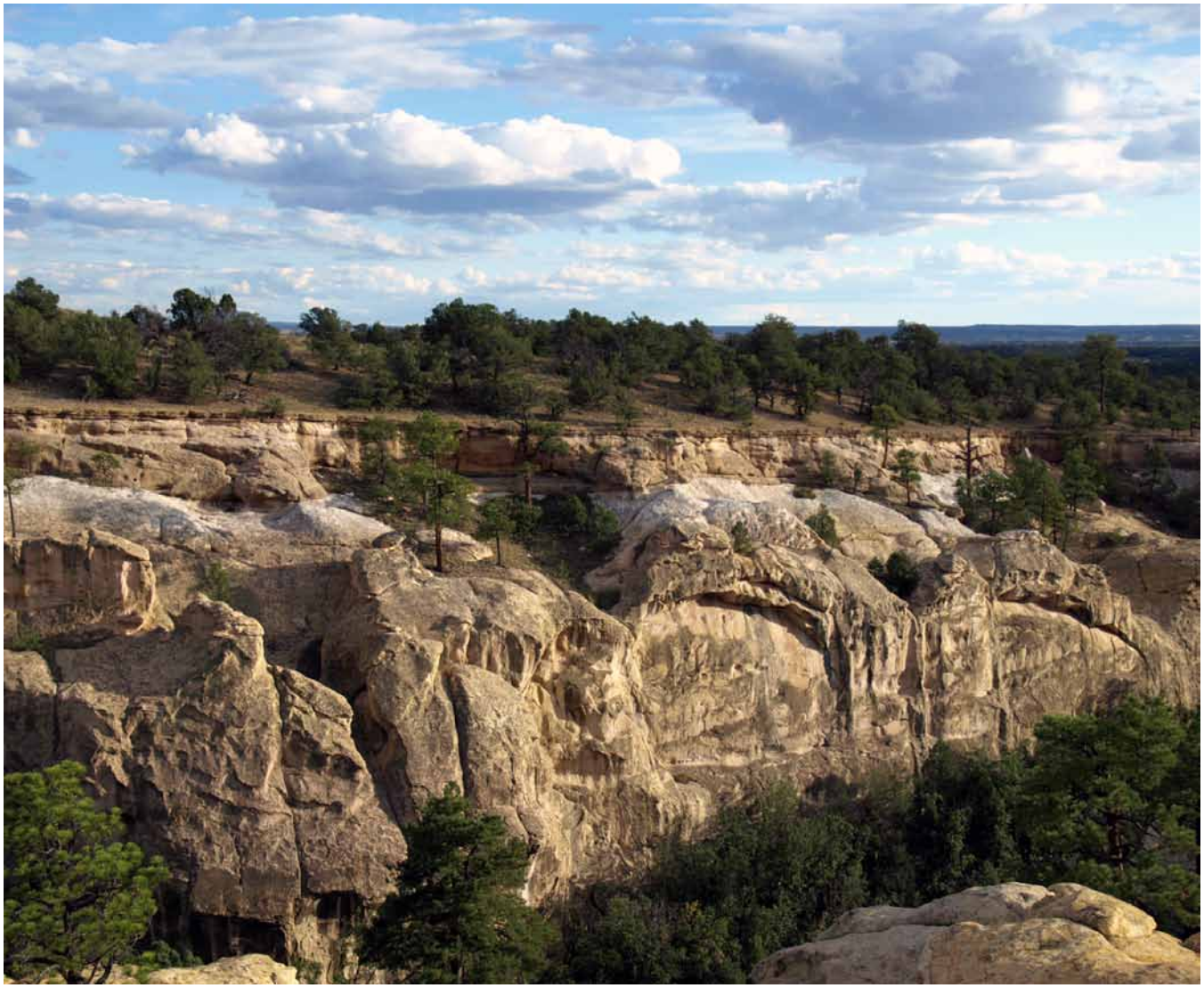
Vegetation Classification and Distribution Mapping Report

El Morro National Monument

Natural Resource Technical Report NPS/SCPN/NRTR–2010/365



ON THE COVER

View from the Mesa Top Trail with the Zuni Mountains in the background, El Morro National Monument/photo by Lisa Thomas.

Vegetation Classification and Distribution Mapping Report

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

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

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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This report is available from the web sites of the Southern Colorado Plateau Network (http://www.nature.nps.gov/im/units/SCPN), NPS Natural Resource Program Center (http://www.nature.nps.gov/publications/NRPM), and USGS-NPS Vegetation Characterization Program (http://biology.usgs.gov/npsveg).

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Acronyms

BOR	U.S. Bureau of Reclamation
DEM	digital elevation model
DOQ	digital orthophoto quadrangle
ELMO	El Morro National Monument
F	Fahrenheit
FGDC	Federal Geographic Data Committee
ft	foot/feet
GAP	Gap Analysis Program
GIS	Geographic Information System(s)
GPS	Global Positioning System
ha	hectare(s)
I&M	Inventory & Monitoring
km	kilometer(s)
m	meter(s)
mi	mile(s)
NHNM	Natural Heritage New Mexico
NLCD	National Land Cover Data
NMSEO	New Mexico State Engineer's Office
NPS	National Park Service
NVC	National Vegetation Classification
NVCS	National Vegetation Classification Standard
SCPN	Southern Colorado Plateau Network
TNC	The Nature Conservancy
USGS	U.S. Geological Survey
USGS–BRD	U.S. Geological Survey–Biological Resources Discipline
UTM	Universal Transverse Mercator
VMP	USGS-NPS Vegetation Mapping Program

Abstract

El Morro National Monument (ELMO) encompasses approximately 419.4 ha (1,036 acres) in west-central New Mexico. The park is bounded by a variety of public and privately owned lands, and protected from grazing. The vegetation is represented by roughly 400 species of vascular plants (Rink et al. 2009) in a limited set of communities representing pinyon-juniper woodlands, ponderosa-pine woodlands, blue-grama grasslands, four-winged saltbush shrublands, and some Gambel-oak shrublands. In 2005, this project was initiated to map the vegetation and develop a classification for the plant communities in the study area. The ELMO vegetation inventory was conducted in accordance with the following protocols and standards specified by the USGS-NPS Vegetation Mapping Program:

Nationally defined standards
- National Vegetation Classification Standard
- Spatial Data Transfer Standard
- Metadata Standard
- Positional Accuracy
- Taxonomy

Additional program-defined standards
- Classification Accuracy
- Minimum Mapping Unit

This report documents those efforts.

A multi-year program was initiated to complete vegetation mapping at ELMO, consisting of two major tasks. Phase I was the development of a classification system. Phase II was the production of a digital vegetation map.

Prior work by Dr. Anne Cully was used as base information for the classification. Additional data was collected to expand upon the vegetation types at ELMO. The described types are based on the floristic alliance and association units maintained by NatureServe (U.S. National Vegetation Classification; NVC). To classify vegetation, we used 32 plots collected by Anne Cully in 2001, in addition to 47 observation points collected in 2005. These plots were compared to existing vegetation types within the NVC and assigned an appropriate type. A total of 22 plant-association descriptions are detailed in this report. From these 22 plant associations, we derived 18 vegetation map units. An additional two map units show bare rock and other unvegetated surfaces, such as roads and buildings, and one is a "Weedy Forbs/Prairie Dog Colony" map unit.

To produce the digital map, we used 1:12,000-scale, true-color aerial photography acquired on September 1, 2004, in addition to the field plots. Both avenues were used to interpret the vegetation. All 21 map units were developed and directly cross-walked or matched to corresponding plant associations and land-use classes. All of the interpreted and remotely sensed data were converted to Geographic Information System (GIS) databases using ArcGIS© software. Draft maps were printed, reviewed, and revised.

Products developed for El Morro National Monument are described and presented in this report, and are stored on the accompanying CD. These include:

- A final report that details the production steps, results and discussion;
- A spatial GIS database containing vegetation and plots;
- Digital photos from each observation point, along with representative ground photos for each map class and miscellaneous park views;
- Printable graphics of all spatial database layers;
- Metadata for spatial database layers that are Federal Geographic Data Committee (FGDC)-compliant; and
- Vegetation descriptions of the vegetation communities.

In addition, ELMO and the National Park Service Inventory and Monitoring Program both received copies of:

- 9 × 9-in prints of the 1:12,000-scale aerial photography;
- Uncompressed digital aerial photos;
- Digital data files and hard-copy data sheets of the observation points; and
- Hard-copy vegetation maps.

The CD associated with this report contains text and metadata files, keys, lists, field data, spatial data, the vegetation map, graphics, and ground photos. The U.S. Geological Survey will post this project on its website, http://biology.usgs.gov/npsveg.

For more information on the NVC standards, please go to the FGDC's National Vegetation Classification Standard website, http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation. For more information on NVC associations in the U.S., please go to NatureServe's website, http://www.natureserve.org. The U.S. Bureau of Reclamation offers numerous services and programs, and may be visited at http://www.usbr.gov.

Acknowledgements

Although there are only two authors to this report, many people provided input and critique—not only on the written portion, but also on the data and format of the geodatabase. The authors gratefully acknowledge the dedication of all involved. The combination of ecologists, geographers, botanists, and natural resource professionals in all of the cooperating agencies and organizations allowed for a collaborative work environment that greatly eased the process.

We would specifically like to thank the following people for their efforts: Anne Cully, Southern Colorado Plateau Network, for providing overall leadership to this and other projects and for her time spent reviewing this report; Herschel Schulz, Chief Ranger, and Kayci Cook Collins, Superintendent, El Morro National Monument, for their enthusiasm for and support of the project; Marguerite Hendrie and Kristin Straka, Southern Colorado Plateau Network, for examining the database and making recommendations to the format; Chris Lea, National Park Service, for providing the necessary updates and corrections to the background information on the NVC, NVCS, and the relationship to the vegetation mapping program; Dr. Esteban Muldavin, Natural Heritage New Mexico, for providing state ranks of vegetation types.

Glenn Rink, Northern Arizona University, provided the latest list of vouchered specimens for the park and reviewed this report. We also would like to thank Dan Cogan, National Park Service, and Chris Lea for reviewing the text.

We would also be remiss if we did not also acknowledge the efforts of both Mike Story and Karl Brown, National Vegetation Mapping Program, managers of these park vegetation mapping projects, as well as the many other scientists who produced the original protocols and have been applying these techniques to projects in the field for many years. These previous efforts have raised the bar each time. We have learned much from the earlier projects, and it is our distinct pleasure to have added to them. New technologies and lessons learned have, we hope, produced a finer product.

1 Introduction

1.1 Background

1.1.1 USGS-NPS Vegetation Mapping Program

In 1994, the U.S. Geological Survey (USGS) and National Park Service (NPS) formed a partnership to map U.S. national parks using the National Vegetation Classification (NVC) (TNC and ESRI 1994b). The goals of the USGS-NPS Vegetation Mapping Program (VMP) are to provide baseline ecological data for park resource managers, create data in a regional and national context, and provide opportunities for future inventory, monitoring, and research activities (FGDC 1997, Grossman et al. 1998, http://biology.usgs.gov/npsveg/index.html).

Central to fulfilling the goals of this national program is the use of the NVC as the standard vegetation classification. This classification is based upon current vegetation; uses a systematic approach to classify vegetation communities across environmental continuums; emphasizes natural and existing vegetation; uses a combined physiognomic-floristic hierarchy; identifies vegetation units based on both qualitative and quantitative data; and is appropriate for mapping at multiple scales.

The use of NVC and mapping protocols facilitates effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as well as by other federal and state agencies. These vegetation maps and associated information support a wide variety of resource-assessment, park-management, and planning needs, and provide a structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental processes across the landscape.

The NVC has primarily been developed and implemented by The Nature Conservancy (TNC) and the network of Natural Heritage Programs over the past 20 years (Grossman et al. 1998). Currently, the NVC is maintained and updated by NatureServe. Additional support has come from federal agencies, the Federal Geographic Data Committee (FGDC), and the Ecological Society of America. Refinements to the classification occur in the application process, leading to ongoing proposed revisions that are reviewed both locally and nationally. NatureServe has made available a two-volume publication presenting the standardized classification. This document provides a thorough introduction to the classification, its structure, and the list of vegetation types found across the U.S. as of April 1997 (Grossman et al. 1998). This publication can be found on the Internet at http://www.natureserve.org/publications/library.jsp.

NPS/S. BECKWITH

Sandstone formation, El Morro National Monument.

NatureServe has since superseded Volume II (the classification listing) with an online database server that provides regular updates to ecological communities in the U.S. and Canada. NatureServe Explorer® can be found on the Internet at http://www.natureserve.org/explorer.

1.1.2 El Morro National Monument vegetation mapping project

The decision to map vegetation at El Morro National Monument (ELMO) as part of the VMP was made in response to the NPS Natural Resources Inventory and Monitoring (I&M) Program Guidelines issued in 1992. The vegetation-mapping portion of the I&M program recognizes the need for the parks to spatially analyze vegetation at a scale that is fine enough to facilitate the prediction of outcomes relative to various management issues.

In 2005, the NPS's Southern Colorado Plateau Network (SCPN) initiated this project by requesting the U.S. Bureau of Reclamation (BOR)'s Remote Sensing and Geographic Information Group to undertake mapping of ELMO.

Our objectives were to produce final products consistent with the following standards mandat-

ed by the USGS-NPS National Vegetation Mapping Program:

- National Vegetation Classification Standard (FGDC 1997);
- Spatial Data Transfer Standard (FGDC 1998b);
- Content Standard for Digital Geospatial Metadata (FGDC 1998a);
- United States National Map Accuracy Standards (USGS 1999);
- Integrated Taxonomic Information System; and
- NPS-USGS Program-defined standards for map attribute accuracy and minimum mapping unit (MMU).

The products derived from these efforts include:

Spatial data
- Aerial photography
- Map classification/descriptions
- Spatial database of vegetation communities
- Hard-copy maps of vegetation communities
- Metadata for spatial databases

Vegetation information
- Vegetation classification
- Formal description for each vegetation class
- Ground photos of vegetation classes
- Field data in database format

1.2 Scope of work

Vegetation at ELMO was mapped and classified through a combination of existing plot data (Cully 2002), a field visit in 2005, and photo interpretation of 1:12,000, true-color aerial photography from September 2004. The protocols and standards used are described in the USGS/NPS program documents (TNC and ESRI (1994a) for small parks. In 2005, the SCPN contracted the BOR to map approximately 1,000 ha (2,400 acres) of ELMO and its surrounding environs. The park proper comprises about 420 ha (1,036 acres). Vegetation mapping for ELMO included land inside park boundaries and a 0.5-km environs buffer. Field reconnaissance included only the area within park boundaries.

1.3 The National Vegetation Classification Standard

In 1994, the VMP adopted the U.S. National Vegetation Classification (TNC and ESRI 1994a and 1994b, Grossman et al. 1998) as a basis for the *a priori* definition of vegetation units to be inventoried. The Federal Geographic Data Committee (FGDC) adopted a modified version of the upper (physiognomic) levels as a federal standard (FGDC-STD-005; FGDC 1997), hereafter termed the National Vegetation Classification Standard (NVCS).[†] The NVCS established a federal standard for a complete taxonomic treatment of vegetation in the U.S. at physiognomic levels. It also established conceptual taxonomic levels for the floristic units of alliance and association, largely following the NVC, but did not offer a taxonomic treatment for the floristic levels because of the immense scope of establishing robust floristic units for the entire U.S. Table 1.3 identifies the seven levels of the NVC and depicts their placement in the hierarchical relationship (Maybury 1999).

The FGDC standard requires that federally funded vegetation classification efforts collect data in a manner that enables cross-walking the data to the NVCS (i.e., the physiognomic levels) and sharing among agencies, but does not require that agencies use that standard for internal mission needs. NatureServe maintains a treatment of floristic units (alliances and associations) that, though not a federal standard, are used as classification and mapping units by the VMP whenever feasible. For purposes of this document, the federal standard (FGDC 1997) is denoted as the NVCS; the NVC will refer exclusively to NatureServe's treatment for vegetation floristic units treatment (alliances and associations only).

Alliances and associations are based on both the dominant (greatest-canopy-cover) species in the upper strata of a stand and on diagnostic species (those consistently found in some land-cover types but not others). Associations are the most specific classification, and are hierarchically subsumed in alliances. Typically, each association is included in only one alliance, while each alliance may include many associations. Alliance names are generally based on the dominant/diagnostic species in the uppermost stratum of the vegetation, though up to four species may be used if

[†] The VMP standards refer to the National Vegetation Classification Standard (also NVCS). Because of nomenclatural and acronym confusion with the federal (FGDC) National Vegetation Classification Standard, the VMP no longer uses this term.

Table 1.3. Summary of the National Vegetation Classification Standard hierarchical approach.

Level	Primary basis for classification	Example
Class	Structure of vegetation	Woodland
Subclass	Leaf phenology	Evergreen woodland
Group	Leaf types, corresponding to climate	Temperate or subpolar needle-leaved evergreen woodland
Subgroup	Relative human impact (natural/semi-natural, or cultural)	Natural/semi-natural
Formation	Additional physiognomic and environmental factors, including hydrology	Saturated temperate or subpolar needle-leaved evergreen woodland
Alliance	Dominant/diagnostic species of the uppermost or dominant stratum	Longleaf pine (slash pine, pond pine) saturated woodland alliance
Association	Additional dominant/diagnostic species from any strata	Longleaf pine/little gallberry/carolina wiregrass woodland

Source: Maybury 1999.

necessary to define the type. Associations define distinct plant compositions that repeat across the landscape, and are generally named using both the dominant species in the uppermost stratum of the vegetation and one or more dominant species in lower strata (or a diagnostic species in any stratum). Documentation from NatureServe (2005) describes the naming conventions and syntax for all NVC names:

- A hyphen with a space on either side (-) separates names of species occurring in the same stratum.
- A slash with a space on either side (/) separates names of species occurring in different strata.
- Species that occur in the uppermost stratum are listed first, followed successively by those in lower strata.
- Order of species names generally reflects decreasing levels of dominance, constancy, or indicator value.
- Parentheses around a species name indicate the species is less consistently found either in all associations of an alliance, or in all occurrences of an association.
- Association names include the dominant species of the significant strata, followed by the class in which they are classified (e.g., Forest, Woodland, or Herbaceous).
- Alliance names also include the class in which they are classified (e.g., Forest, Woodland, or Herbaceous), but are followed by the word "Alliance" to distinguish them from associations.

The species nomenclature for all alliances and associations follows Kartesz (1999).

Examples of association names from ELMO:

- *Bouteloua gracilis* Herbaceous Vegetation
- *Bouteloua gracilis - Sporobolus cryptandrus* Herbaceous Vegetation
- *Pinus edulis* - (*Juniperus monosperma*) / *Bouteloua gracilis* Woodland

Examples of alliance names from ELMO:

- *Bouteloua gracilis* Herbaceous Alliance
- *Pinus edulis* - (*Juniperus* spp.) Woodland Alliance

For more information on the NVC, see the USGS-NPS Vegetation Mapping Program standards (http://biology.usgs.gov/npsveg/standards.html) or Grossman et al. (1998).

In addition to the NVC, NatureServe has created a standardized Ecological Systems Classification for describing sites, based on both vegetation and the ecological processes that drive it. Ecological systems are mid-scale biological communities that occur in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding (Comer et al. 2003). They are not conceptually a unit within the NVC, but are rather a vegetation mapping concept. However, NVC associations occur within ecological systems. An association may occur in any number of ecological systems, limited only by the range of ecological settings in which that association occurs. Ecological systems are a broad-scale, and can embody any number of highly specific associations that might be found in a par-

ticular setting.

1.4 Natural Heritage Program methodology and element ranking

New Mexico's Natural Heritage Program (NHNM) is a member of the NatureServe Network of Natural Heritage Programs and Conservation Data Centers. It operates as a division of the Museum of Southwestern Biology at the University of New Mexico. Natural heritage programs (and conservation data centers) are located in all U.S. states and Canadian provinces. Each program serves as that state's biological diversity data center, gathering information and field observations to help develop national and statewide conservation priorities.

The multidisciplinary team of scientists, planners, and information managers at the heritage programs uses a standardized methodology to gather information on the rare, threatened, and endangered species and significant plant communities that occur in each state. The species and plant communities for which each program maintains data are referred to as "elements of natural diversity" or, simply, "elements." Life history, status, and locational data are regularly updated in a comprehensive shared data system. Sources of element data include published and unpublished literature, museum and herbaria labels, and field surveys conducted by knowledgeable naturalists, experts, agency personnel, and the heritage program staff of botanists, ecologists, and zoologists.

1.4.1 The Natural Heritage ranking system

The cornerstone of natural heritage methodology is the use of a standardized element-imperilment ranking system. Ranking species and ecological communities according to their imperilment status provides guidance for where natural heritage programs should focus their information-gathering activities and provides data users with a concise, meaningful decisionmaking tool.

To determine the status of an element within New Mexico, NHNM gathers information on plants, animals, and plant communities. Each of these elements of natural diversity is assigned a rank that indicates its relative degree of imperilment on a five-point scale (1 = critically imperiled, 5 = demonstrably secure). The criteria used to define the element-imperilment rank are number of occurrences, size of population, and quality of population. The primary criterion is the number of occurrences (i.e., the number of known distinct localities or populations). This factor is weighted more heavily than other factors because an element found in only one place is more imperiled than something found in, say, 21 places. Also important are the size of the geographic range, the number of individuals, the trends in both population and distribution, identifiable threats, and the number of protected occurrences.

Element-imperilment ranks are assigned in terms of the element's degree of imperilment both within New Mexico (its state-, or S-rank) and over its entire range (its global-, or G-rank). Taken together, these two ranks indicate an element's degree of imperilment. For example, bunchberry (*Cornus canadensis*), thought to be secure in northern North America, but critically imperiled in New Mexico, is ranked G5 S1 (globally secure, but critically imperiled in this state). The sessile-flower false carrot (*Aletes sessiliflorus*) is ranked G3 S3 (vulnerable both globally and in the state). Further, gypsum necklace (*Sophora gypsophila)* is ranked G1 S1 (critically imperiled both globally and in the state). NHNM actively collects, maps, and electronically processes specific-occurrence information for animal and plant species considered extremely imperiled-to-vulnerable in the state (S1–S3). Certain elements are "watchlisted," meaning that specific occurrence data are periodically analyzed to determine whether more active tracking is warranted. A complete description of each natural heritage rank is provided in Table 1.4.1.

1.5 Project area

1.5.1 Park purpose and significance

A reliable waterhole hidden at the base of a massive sandstone bluff made El Morro ("the bluff") a popular campsite for centuries. Ancestral Puebloans settled on the mesa top more than 700 years ago. Subsequently, Spanish and American travelers rested, drank from the pool, and carved their signatures, dates and messages for hundreds of years. Today, El Morro National Monument protects more than 2,000 inscriptions and petroglyphs, as well as Ancestral Puebloan structures.

1.5.2 Location and regional setting

El Morro National Monument (Figure 1.5.2) lies in west-central New Mexico, within Cibola County roughly 161 km west of Albuquerque.

Table 1.4.1. Definition of natural heritage imperilment ranks.

Rank	Status	Scale/Description
G1/S1	Critically imperiled	Globally/state because of rarity (5 or fewer occurrences in the world/state; or 1,000 or fewer individuals), or because some factor of its biology makes it especially vulnerable to extinction.
G2/S2	Imperiled	Globally/state because of rarity (6–20 occurrences, or 1,000–3,000 individuals), or because other factors demonstrably make it very vulnerable to extinction throughout its range.
G3/S3	Vulnerable	Through its range or found locally in a restricted range (21–100 occurrences, or 3,000–10,000 individuals).
G4/S4	Apparently secure	Globally/state, though it may be quite rare in parts of its range, especially at the periphery. Usually more than 100 occurrences and 10,000 individuals.
G5/S5	Demonstrably secure	Globally/state, though it may be quite rare in parts of its range, especially at the periphery.
GX/SX	Presumed extinct	Globally, or extirpated within the state.
G#?		Indicates uncertainty about an assigned global rank.
GU/SU		Unable to assign rank due to lack of available information.
GQ		Indicates uncertainty about taxonomic status.
GH/SH		Historically known, but usually not verified for an extended period of time.
G#T#		Trinomial rank (T) is used for subspecies or varieties. These taxa are ranked on the same criteria as G1–G5.
SA		Accidental in the state.
SE		Exotic species.
SNR		Needs review.
SR		Reported to occur in the state but unverified.
S?		Unranked. Some evidence that species may be imperiled, but awaiting formal rarity ranking.

Note: Where two numbers appear in a state or global rank (for example, S2S3), the actual rank of the element is uncertain, but falls within the stated range.

The park is wholly surrounded by the Ramah Navajo Indian Reservation. Cibola National Forest lies approximately 10.5 km to the north. El Malpaís National Monument lies about 17.7 km to the east. New Mexico State Highway 53 runs east-to-west through the park. The closest urban areas are Gallup, via Highways 602 and 53 (90.1 km to the northwest) and Grants (67.6 km to the northeast via Highway 53).

1.5.3 Climate and weather

Winters at ELMO are often cold; average snowfall for the area is 101.6 cm (40 in) per year. December and January are typically the coldest months, with average lows of 14–15° F, and average highs of 44–45° F. Summers are hot, with frequent afternoon thundershowers. Average precipitation (snowmelt and rain) for the ELMO area is 14–16" per year (National Climatic Data Center 1991) (Figure 1.5.3). July is historically the warmest month of the year, with an average high of 84° and low of 52° F (www.nps.gov/elmo/planyourvisit/weather.htm).

1.5.4 Topography

At an elevation of 2,200 m (7,219 ft), El Morro National Monument lies on the southern slope of the Zuni Mountains, within the Colorado Plateau, in the mesa country of western New Mexico. Two other physiographic provinces are nearby. The Basin and Range province lies 48 km to the west and 96 km to the south, and the lower part of the southern Rocky Mountain province is located 56 km to the northeast. The Continental Divide (Oso Ridge) skirts the park roughly 48 km to the east. Mt. Taylor, at 3,445 m, figures prominently on the horizon, about 64 km to the east. Within the park, the topography is generally flat, with the exception of Inscription Rock, on the southwest side of the mapping area. Figure 1.5.4 shows the topographic relief of west-central New Mexico.

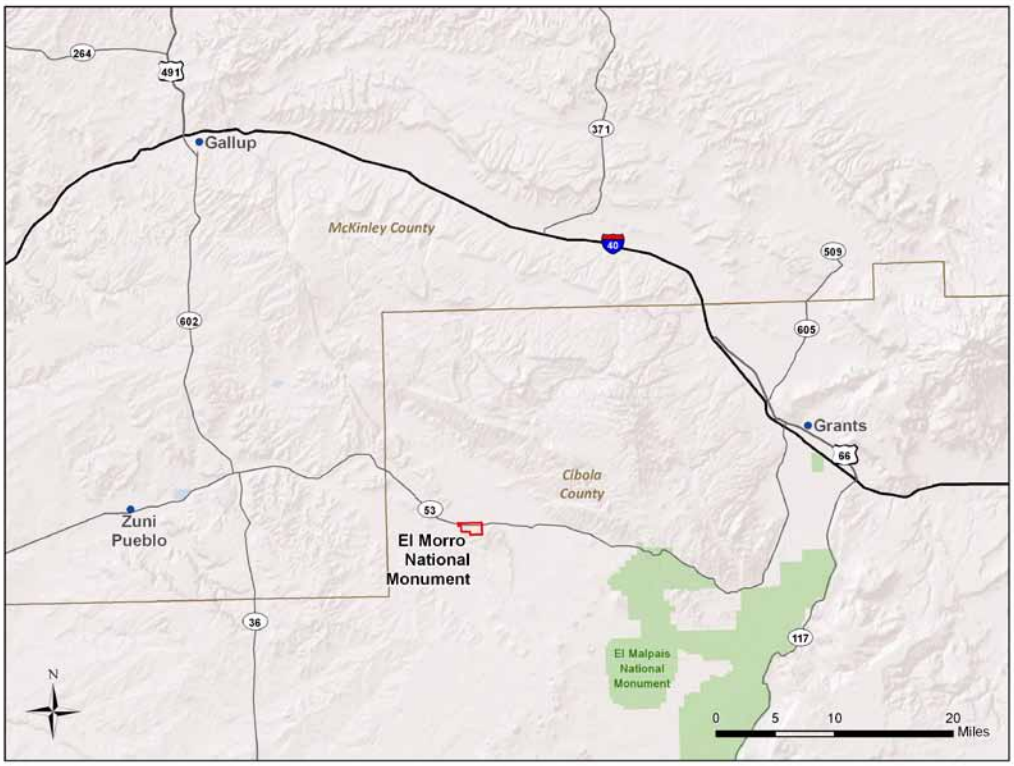


Figure 1.5.2. Location map for El Morro National Monument.

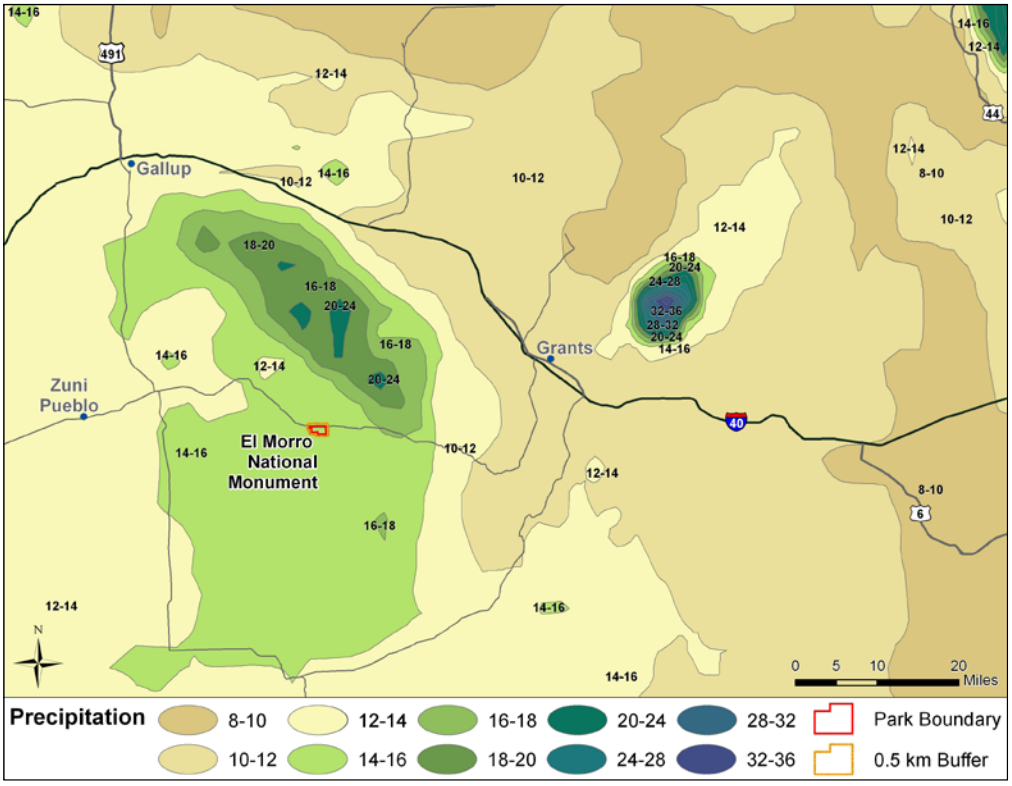


Figure 1.5.3. Precipitation (in.) in west-central New Mexico, 1961–1990.

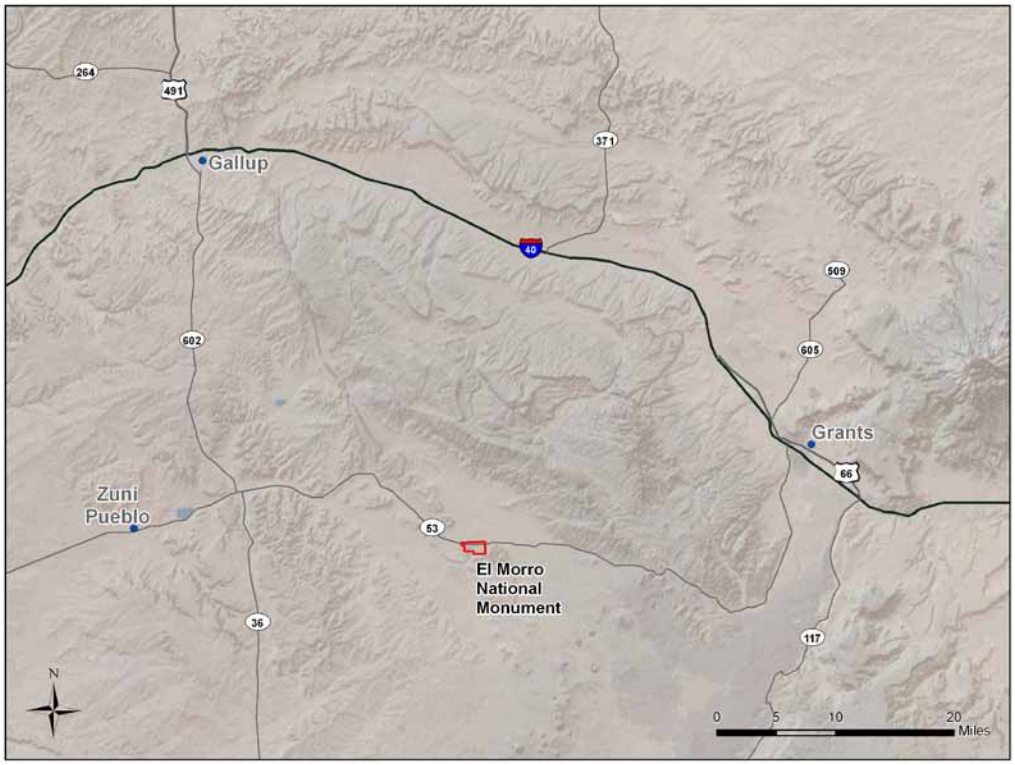


Figure 1.5.4. Topography of ELMO and surrounding area.

1.5.5 Geology

The park intersects with basalt flows, sandstones, and a variety of eolian, alluvium, and colluvial deposits. Quaternary basalt flows (Qb) dominate the northern part of the park. Quaternary alluvium, colluvium, and eolian deposits surround the mesa to the north and east. Cretaceous Dakota Sandstone and Jurrasic Zuni Sandstone make up the bulk of the mesa area. A number of other minor geologic types intersect the mapping area, as well (Figure 1.5.5-1).

The New Mexico Bureau of Geology and Mineral Resources (http://geoinfo.nmt.edu/tour/federal/monuments/el_morro/home.html) provides the following description of geology at ELMO:

> El Morro, which means "bluff" or "headland" in Spanish, is an imposing cliff made of Middle to Late Jurassic (155–165 million years old) Zuni Sandstone capped by Late Cretaceous Dakota (~95–96 million years old) sandstone and shale. El Morro lies on the southern flank of the Zuni Mountains and the rocks dip gently (3°) toward the southwest (Anderson and Maxwell 1991) .The quartz grains that make up the yellow-gray to tan Zuni Sandstone are well-rounded and the sandstone is well sorted (Anderson and Maxwell 1991), which means that the sand grains are all about the same size. Large scale cross-bedding is common in the Zuni Sandstone. These features are characteristic of sand deposited in large wind-blown dunes that can form in an arid (dry) environment. These sand dunes were part of a dune field that covered much of northwestern New Mexico, as well as northeastern Arizona, southeastern Utah, and southwestern Colorado about 150 million years ago. The Zuni Sandstone is stratigraphically equivalent to the Entrada Sandstone and the overlying Bluff (Cow Springs) Sandstone to the northeast (Lucas et al. 2003). The top of the Zuni Sandstone beneath the Dakota Sandstone is bleached white several ft below the contact (Figure 1.5.5-2). The contact represents a time gap on the order of 60 million years and the bleached horizon is a paleo-weathering surface. In places, pieces of the underlying Zuni Sandstone have been incorporated into overlying sandy to gravelly stream deposits (Figure 1.5.5-3) of uncertain age (Late Cretaceous (?), Anderson and Maxwell 1991). The lower and middle part of the main body of the Late Cretaceous Dakota Sandstone is preserved along the trail within the monument. The lower part is cross-bedded

Figure 1.5.5.-1 Geologic formations in the immediate vicinity of ELMO.

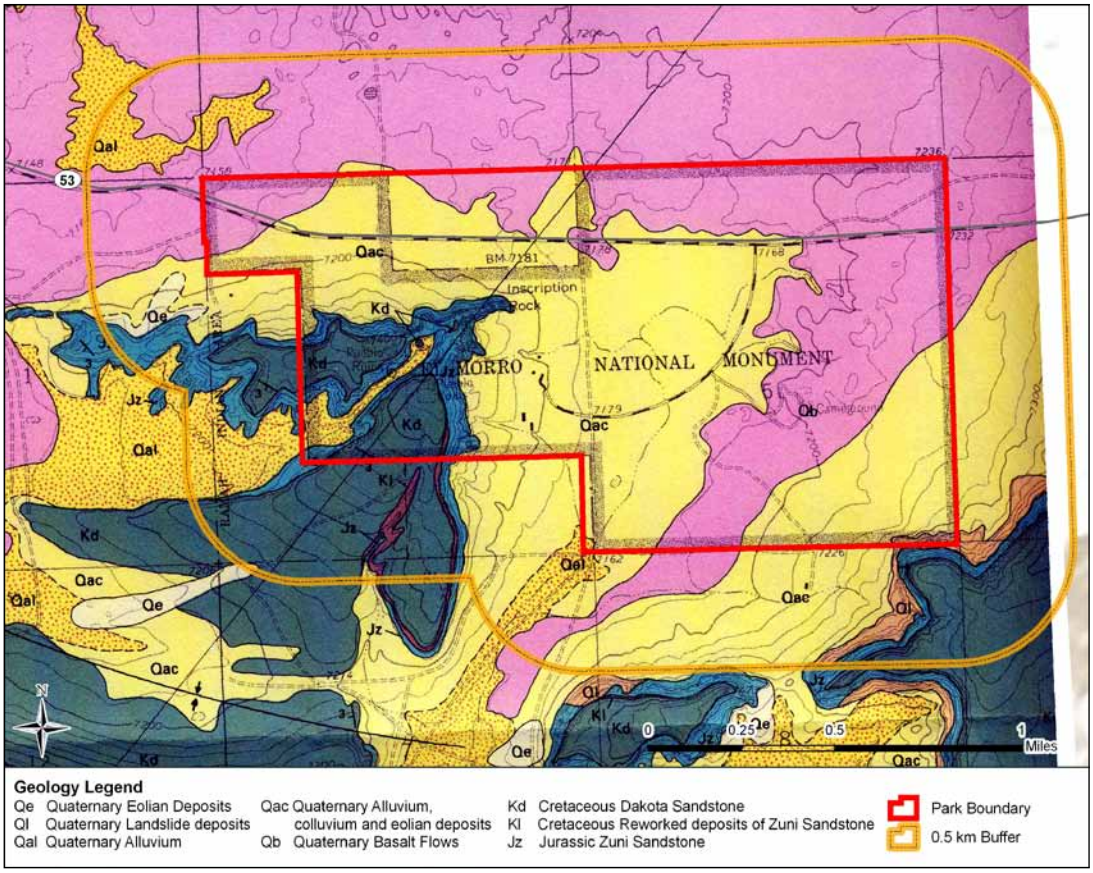


Figure 1.5.5-2. Brown Cretaceous Dakota Sandstone stream channels cut into the top of the Jurassic Zuni Sandstone. Note the white paleo-weathering horizon at the top of the Zuni Sandstone.

Figure 1.5.5-3. Blocks of Zuni Sandstone incorporated into the base of the overlying stream deposits. Black pocket knife, ~10 cm long, shown for scale.

sandstone with lenses of conglomerate containing pebbles of chert and quartzite. The sandstone is overlain by a gray mudstone and shale. The pueblo strucutres are built on the gray mudstone to shale unit. This deposit represents streams flowing across the coastal plain along the shores of the Western Interior Seaway in Late Cretaceous time.

Basalt flows from the Zuni-Bandera volcanic field to the east underlie the low country to the north, northwest, and northeast of the sandstone cliffs. These basalt flows are ~79,000–1.38 million years old (Anderson and Maxwell 1991). An apron of younger Quaternary colluvium (rocks eroded from the cliffs), alluvium (water-laid deposits in arroyos), and wind-blown silt surround the sandstone cliffs.

1.5.6 Soils

Four soil types intersect the mapping area (Figure 1.5.6). The most common type is the Teco-Atarque association, which coincides with the Quaternary basalts and alluviums. The remaining types (Flugle-Goesling loamy fine sands, the Rock outcrop-Vessilla-Mion complex, and Pinitos-Ribera sandy loams) occur on the mesas south of the mapping area. Appendix A includes detailed soils data extracted from the Soil Survey Geographic Database of the U.S. Department of Agriculture Natural Resources Conservation Service (http://soildatamart.nrcs.usda.gov).

1.5.7 Wildlife

Various research has been conducted to document fauna at the local scale. Bogan et al. (2005) reported 13 species of bats, one lagomorph, 11 rodents, and five carnivores. Piñon mice (*Peromyscus truei*) and deer mice (*Peromyscus truei*) were the most common mammals in the park. The most common bat species encountered was little brown bat (*Myotis lucifugus*).

Surveys conducted in 2001–2002 by Johnson et al. (2007) detected 63 different species of birds at ELMO (Figure 1.5.7), including five species of conservation concern: peregrine falcon (*Falco peregrinus*), Lewis's woodpecker (*Melanerpes lewis*), loggerhead shrike (*Lanius ludovicianus*), gray vireo (*Vireo vicinior*), and Grace's warbler (*Dendroica graciae*). The chipping sparrow (*Spizella passerina*) was the most commonly detected bird, followed by the white-throated swift (*Aeronautes saxatalis*) and lark sparrow (*Chondestes grammacus*).

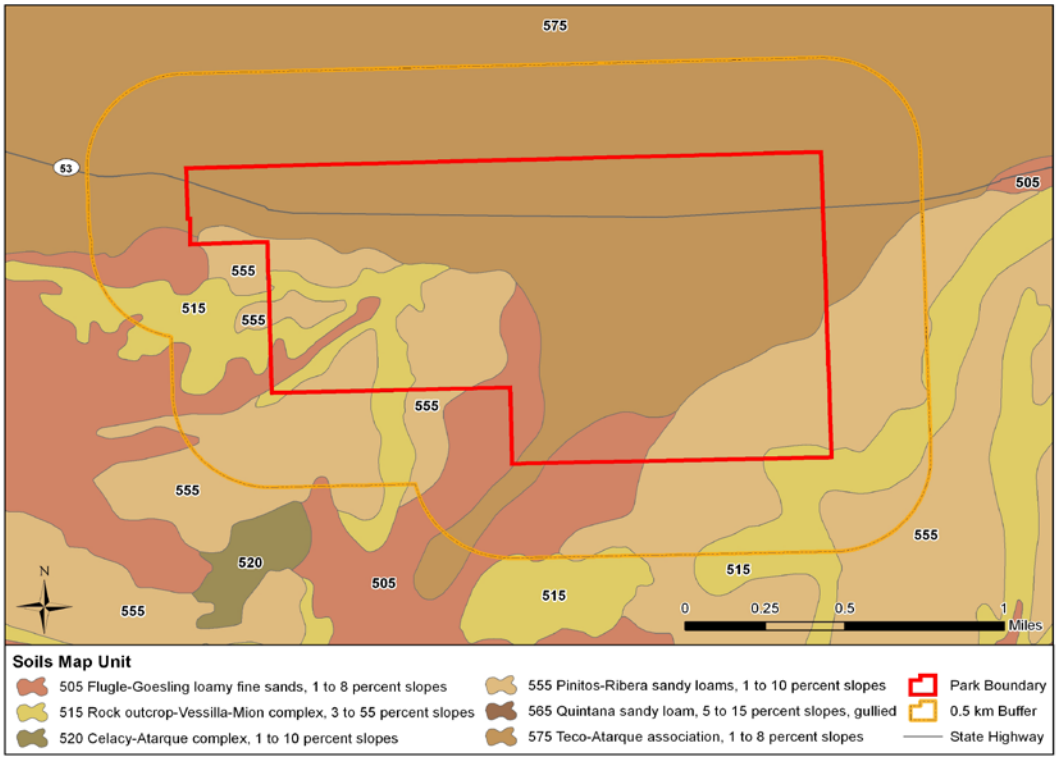


Figure 1.5.6. Soil map units within and adjacent to ELMO mapping area.

USFWS/DAVE MENKE

Figure 1.5.7. The chipping sparrow (*Spizella passerina*) was the bird most commonly detected in ELMO during a 2001–2002 inventory.

A review of the herpetology of the southwestern parks (Persons and Nowak 2008) reported 12 species of lizards and snakes, either from voucher specimens or sightings: tiger salamander (*Ambystoma tigrinum*), Plains spadefoot (*Spea bombifrons*), Mexican spadefoot (*Spea multiplicata*), eastern fence lizard (*Sceloporus undulatus*), ornate tree lizard (*Urosaurus ornatus*), greater short-horned lizard (*Phrynosoma hernandesi*), many-lined skink (*Eumeces multivirgatus*), plateau striped whiptail (*Cnemidophorus velox*), night snake (*Hypsiglena torquata*), gopher snake (*Pituophis catenifer*), western terrestrial garter snake (*Thamnophis elegans*), and western rattlesnake (*Crotalus viridis*).

A more regional description of the fauna surrounding ELMO can be found at the website for the U.S. Forest Service's Colorado Plateau Semi-desert Province [http://www.fs.fed.us/land/ecosysmgmt/colorimagemap/images/313.html (accessed Aug. 18, 2010)]

1.5.8 Vegetation

ELMO lies at the intersection of two ecoregions *sensu* Omernik (1987) (Figure 1.5.8-1) and three ecoregions *sensu* Bailey (1995) (Figure 1.5.8-2). The park falls entirely within Omernik's Arizona/New Mexico Mountains (Ecoregion 23) and Bailey's Colorado Plateau Semi-Desert Province. However, adjacent ecoregions lie within 11.3 km of the park, and may share some floristic characteristics. Adjacent Omernik ecoregions include the Arizona/New Mexico Plateau (Ecoregion 22). Adjacent Bailey ecoregions include the Painted Desert and Navajo Canyonlands section (see Appendix B). Bailey's map was created at a scale of 1:7,500,000; therefore, the boundaries of the

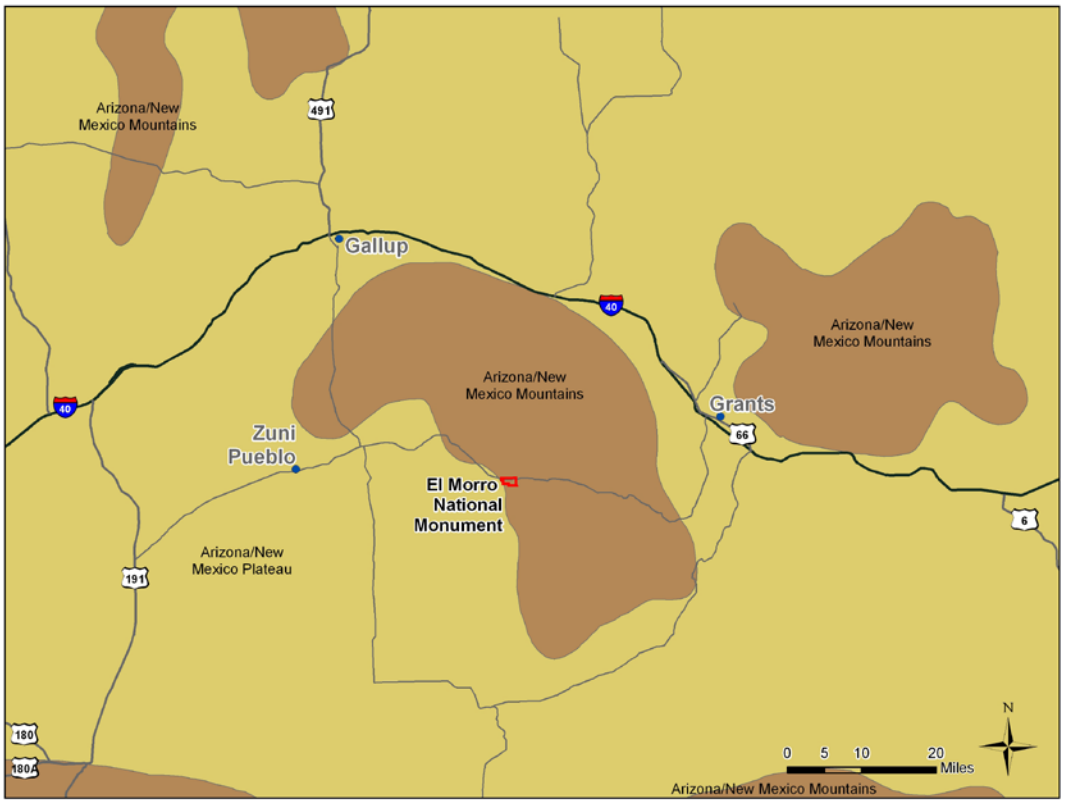


Figure 1.5.8-1. Regional view of Omernik's (1987) ecoregions.

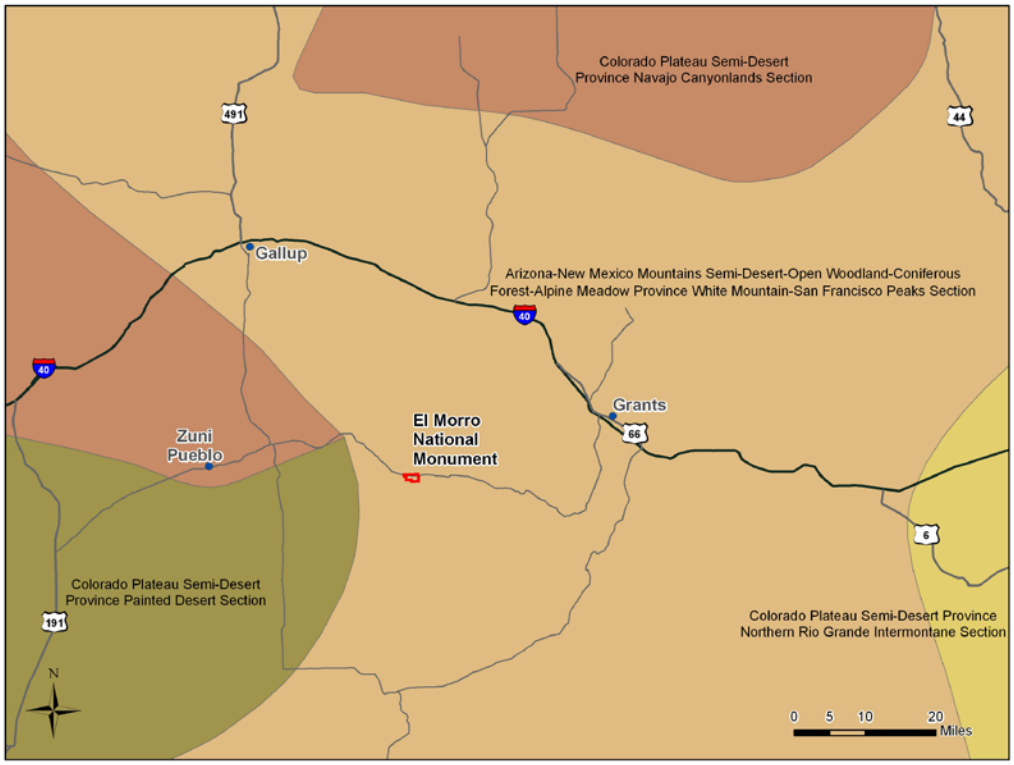


Figure 1.5.8-2. Regional view of Bailey's (1995) ecoregions.

ecoregions at the scale of this project must be considered as estimates. More detailed information at the state level (1:1,000,000-scale paper map by Dr. William Dick-Peddie, New Mexico Geographic Information System Program) shows the park in Plains Mesa Grassland surrounded by Juniper Savannah (Ecotone) (Figure 1.5.8-3). In terms of life zones (Brown 1994; Merriam and Steineger 1890), the area can be described as Upper Sonoran, with a few elements of the transition zone.

Given the limited extent of the park, the floristic variability is limited and continues to be inventoried (Glenn Rink, pers. comm. 2007). The park and buffer area are primarily dominated by *Juniperus monosperma* (one-seed juniper) and *Pinus-Juniperus* spp. (pinyon-juniper) with *Bouteloua gracilis* (blue grama) understories. A few stands of *Pinus ponderosa* (ponderosa pine) with *Quercus gambelii* (Gambel oak) are found on the sheltered north and east side of the mesa. The more common shrubs include *Artemisia* spp. (sagebrush), *Tetradymia* spp. (horsebrush), *Chrysothamnus* spp. (rabbitbrush), *Sarcobatus vermiculatus* (greasewood) and *Gutierrezia sarothrae* (snakeweed). The grasses are dominated by *B. gracilis*, *Pascopyrum smithii* (western wheatgrass), *Pleuraphis* spp. (galleta grass), and *Sporobolus cryptandrus* (sand dropseed).

Two previous flora checklists have been compiled for ELMO. These include McCallum (1981a) and Stolz (1986). In addition, McCallum (1981b) described the vegetation and mapped plant associations. Schackel (1984) provided a photographic history and analysis of vegetation change throughout the monument.

The monument has an herbarium collection, and a list of the collections made at ELMO has been compiled (Rink et al. 2009; Appendix C). Cully (2002) and Rink et al. (2009) conducted plant-species inventories and collected data in ELMO and the surrounding environs. This inventory is preliminary, and does not include collections located in the University of New Mexico herbarium.

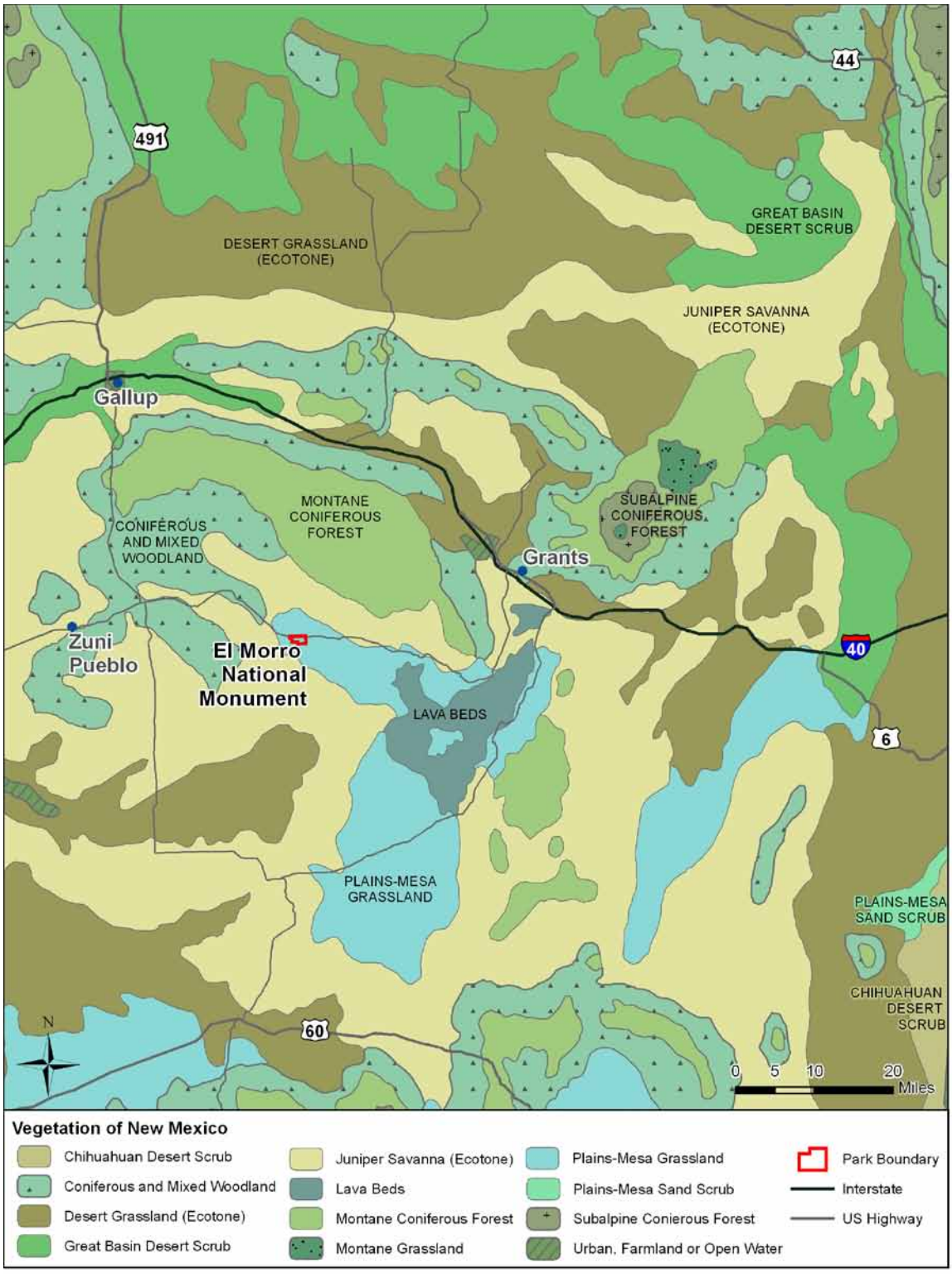


Figure 1.5.8-3. 1:1,000,000-scale vegetation map of New Mexico (Dick-Peddie 1993).

2 Methods

The methods used to produce vegetation maps of parks of restricted size, such as ELMO, are different than those used for larger parks. ELMO falls at the small end of the "medium park" category, defined as 1–100 km^2. For the larger "medium parks," the sampling area is the entire park, with data points collected using a stratified approach. At ELMO, we collected observation points subjectively throughout the park. This is described in more detail below.

2.1 Planning and scoping

On May 11, 2005, a general planning and scoping meeting was held at Hubbell Trading Post National Historic Site to discuss the vegetation-mapping needs of El Morro National Monument, Hubbell Trading Post NHS, and Navajo National Monument. Topics of discussion included:

- Project background
- National program standards
- Unit overviews
- Task overviews
    - Compilation and preparation of existing data
    - Preliminary classification and data review
    - Data collection
    - Map classification
    - Available photographs
    - Information database
    - Local descriptions
    - Metadata
    - Map production
- Field season

2.2 Responsibilities and deliverables

The BOR assumed primary responsibility for all project tasks. Products will include a full report, metadata, and distribution of the data and information to the appropriate NPS offices and websites. The data will ultimately be made available through the USGS website, http://biology.usgs.gov/npsveg/. The data and report have been reviewed and accepted by Anne Cully, Southern Colorado Plateau Network; Herschel Schulz, ELMO Chief Ranger; Esteban Muldavin, New Mexico Natural Heritage Program; and internal BOR peer review.

2.3 Preliminary data collection and review of existing information

This project is not the first to examine, report, and/or map vegetation at ELMO. Schackel (1984) provided an overview of all the previous work done at ELMO. Her report detailed the descriptions of vegetation recorded by many of the early European and American exploratory expeditions to the area. The most recent mapping of the park was done by McCallum (1981b); however, the map has been lost. Cully (2002) sampled the park with 32 plots. These data were examined for this mapping effort and placed within the NVC hierarchy as a reference.

2.4 Field survey

A field survey was conducted on August 27 and 28, 2005, to verify signatures and collect additional data. Given the small size of ELMO, and the subsequent low probability of finding new associations, a formalized data collection was foregone in lieu of an abbreviated data collection. The data collection used an "Observation Point" form identical to the data-collection forms used for accuracy assessment at larger parks. This form collects enough data to assign an existing vegetation association to a given point.

Prior to the field visit, all polygons were assigned a numeric ID. The field crew visited the central area of each polygon and used the polygon ID as the observation point number. Only polygons within the park boundary were visited. At each observation point, one photograph was taken in each of the four cardinal directions from plot center. Not all polygons received a visit. The crew concentrated their time on the polygons that were largest and held the most ecological interest. All data points collected are shown in Figure 2.4.

Cully (2008) conducted field surveys to collect additional information on certain vegetation types. The observation points and data associated with this effort are avalable in databases found on the CD provided with this report.

2.5 Aerial photography

All aerial photography was collected on September 1, 2004, at a scale of 1:12,000, in natural color. The aerial photography collected for ELMO was part of a regionwide USDA-NPS contract for a number of park units within the Southern Colorado Plateau Network. The scanned photography

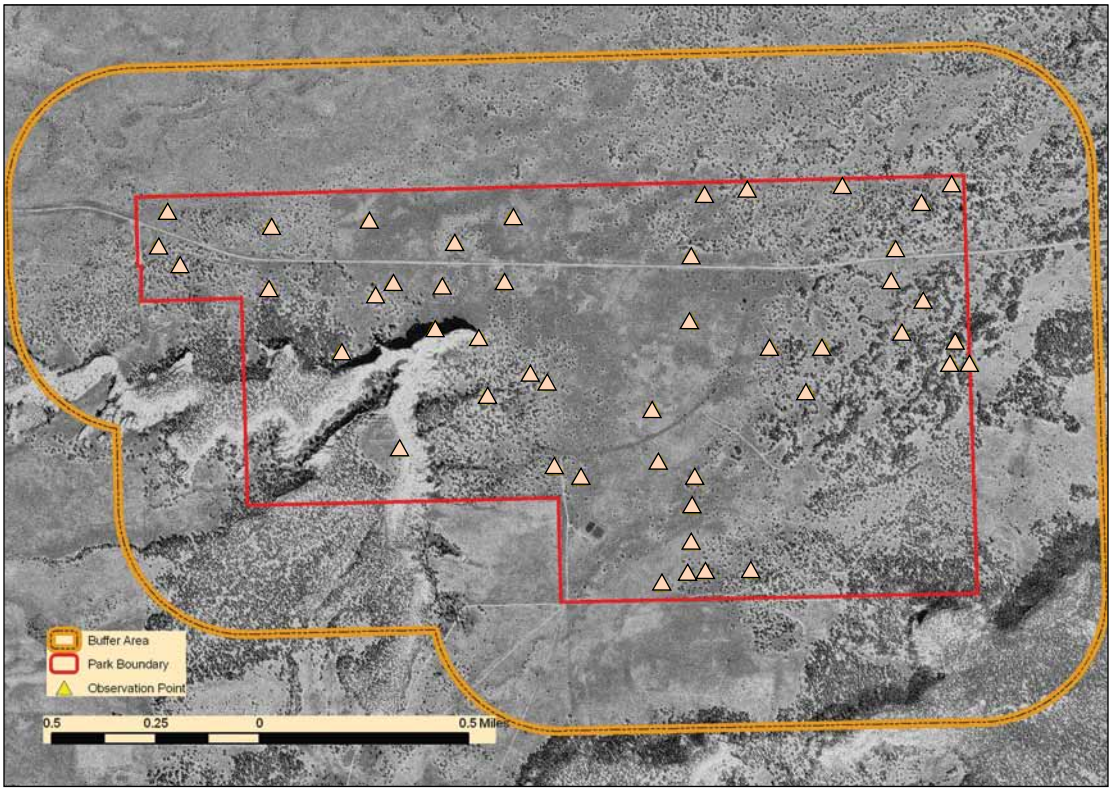


Figure 2.4. Observation point locations for vegetation characterization for ELMO.

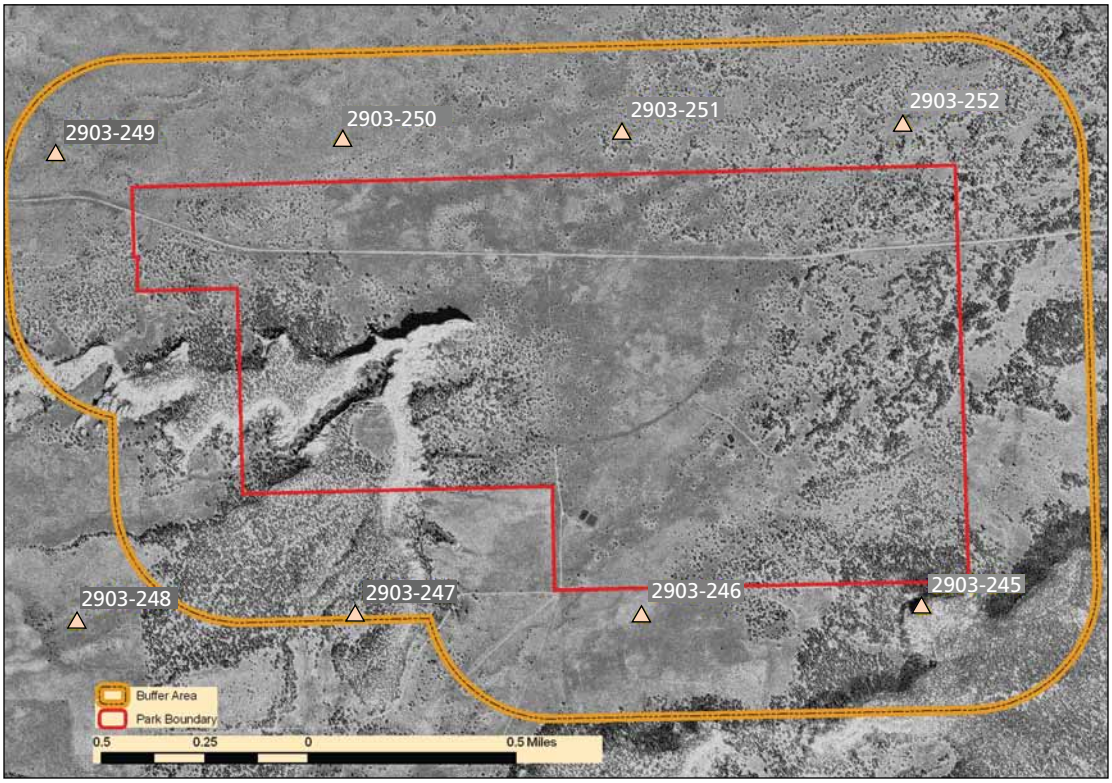


Figure 2.5. Aerial photograph center points.

is included in the CD that accompanies this report. Photo centers are shown in Figure 2.5.

2.6 Photointerpretation

Photointerpretation was done using 9 × 9-in, 1:12,000-scale, true-color photographs. Mylar overlays placed on each aerial photo allowed the project team to make notes and delineate polygons. At this stage of interpretation, a stereoscope was used to help recognize complex photo signatures and three-dimensional features. No attempt was made to label polygons at the initial stage of photointerpretation. Polygons were delineated using homogenous ground features as a mappable unit. These drawn polygons were later revisited after field-data collection in order to assign a map unit and other polygon attributes.

2.7 Map units and polygon attribution

The map units delineated on the orthophotos were derived from the NVC. NatureServe developed a preliminary list of potential vegetation types. These data were combined with existing plot data (Cully 2002) to derive an initial list of potential types. Additional data and information were gleaned from a field visit and incorporated into the final list of map units. Because of the park's small size and the large amount of field data, the map units are equivalent to existing vegetation associations or local associations/descriptions (e.g., Prairie Dog Colony). In addition to vegetation type, vegetation structures were described using three attributes: height, coverage density, and coverage pattern (see Table 2.7).

Table 2.7. Structural categories for vegetation photointerpretation.

Code	Height
1	<1 m
2	1–5 m
3	5–15 m
4	15–30 m
5	>30 m
Code	**Coverage density**
1	Closed canopy/Continuous 75–100%
2	Discontinuous 50–75%
3	Dispersed 25–50%
4	Sparse <25%
Code	**Coverage patterns**
1	Evenly dispersed
2	Clumped/Bunched
3	Gradational/Transitional
4	Alternating

In addition to vegetation structure and context, a number of attributes for each polygon were stored in the associated table within the GIS database. Many of these attributes were derived from the photointerpretation; others were calculated or crosswalked from other classifications. Table 2.6.1-2 shows all of the attributes and their sources. Anderson Level 1 and 2 codes are also included (Anderson et al. 1976). These codes should allow for a more regional perspective on the vegetation types. Look-up tables for the names associated with the codes is included within the geodatabase and in Appendix D.

The look-up tables contain all the NVC formation information as well as alliance names, unique IDs, and the ecological system codes (El_Code) for the associations. These El_Codes often represent a one-to-many relationship; that is, one association may be related to more than one ecological system. The NatureServe conservation status is included as a separate item.

Finally, slope (degrees), aspect, and elevation were calculated for each polygon label point using a digital elevation model and an ArcView script developed by Jenness Enterprises and downloadable from www.jennessent.com. The slope figure will vary if one uses a TIN (triangulated irregular network) versus a GRID (grid-referenced information display) for the calculation (Jenness 2005). A grid was used for the slope figure in this dataset. Acres and hectares were calculated using XTools Pro for ArcGIS Desktop.

2.8 Field photographs

Instrumental to the photointerpretive effort were the GPS-located vegetation plots collected by the field crew. These plots provided an idea of what the signatures of the individual map units should look like. In addition to the tablular data associated with each vegetation plot, four photographs were collected at each plot. These photographs not only helped to identify the immediate area, but also provided a look at surrounding areas that may have been in different map units than the actual plot. These photographs can be hyperlinked within ArcMap to the salient vegetation observa-

Table 2.6.1-2. Polygon attribute items and descriptions used in the ELMO spatial database.

Attribute	Description
AREA*	Surface area of the polygon (m^2)
PERIMETER*	Perimeter of the polygon (m)
ELMO_VEG#*	Unique internal polygon coding
ELMO_VEG-ID*	Unique internal polygon coding
POLYGON_ID	Unique polygon identifier
VEG_NAME	Vegetation (land cover) name associated to each polygon
MAP_UNIT	Final map unit codes (BOR-derived, project specific)
HEIGHT	Height range of the dominant vegetation layer (height classes: <1 m, 1–5 m, 5–15 m, 15–30 m, >30 m)
DENSITY	Density of the tallest strata (density classes: <25%, 25–50%, 50–75%, >75%)
PATTERN	Vegetation pattern within the polygon (vegetation pattern classes: Evenly dispersed, Clumped/bunched, Gradational, Alternating)
SLOPE	Slope of label point within polygon (degrees)
ASPECT	Aspect of label point within polygon
ANDERSON_1	Land Use and Land Cover Classification System (USGS, Anderson et al. 1976) Level 1.
ANDERSON_2	Land Use and Land Cover Classification System (USGS, Anderson et al. 1976) Level 2.
HECTARES	Area in hectares
ACRES	Area in acres
ELEV_M	Elevation (m) for label point
ELEV_FT	Elevation (ft) for label point

*ArcInfo© default items

tion point for a better concept of on-the-ground conditions.

2.9 Digital transfer

Because the park covers a limited area, we used "heads-up digitizing" on an existing USGS digital orthophoto basemap. This technique is ordinarily too time-consuming for larger parks. From the digitized vectors, we created polygons by building topology in the GIS program. Finally, we created labels for each polygon and used these to add the attribute information. Attribution for all the polygons at ELMO included information pertaining to map units, NVC associations, Anderson Land Use Classes (Anderson et al. 1976), and other relevant data. Attribute data were taken directly from the interpreted photos or were added later using the orthophotos as a guide.

2.10 Plot data management and classification analysis

2.10.1 Plot data management

After the field season but prior to data entry, all plot forms were checked to ensure quality control (QC). Particular attention was paid to making sure that the recorded plot location was correct and that all relevant fields were completed. Next, the field data was entered into the VMP PLOTS database, and all plots were subjected to a second QC to eliminate any data-entry errors. During this second QC, the database was examined, sorted, and queried to find missing data, misspellings, duplicate entries, and typographical errors. The species lists were carefully examined to make sure that only USDA PLANTS (NRCS 2005) names and acronyms were used, and that species names and strata assignments were consistent and logical. Plant lists were compared to the assigned association name to ensure correlation.

2.10.2 Vegetation classification

A review of each observation point collected, and comparison to known vegetation associations within the NVC, allowed us to assign a vegetation name to each point and, by proxy, to each polygon that intersected that point. Polygons that did not receive a field visit were assigned to a map unit based upon field notes, review of Cully's plots, and photointerpretation. All polygons outside the park boundary that were not contiguous

with polygons within the park were assigned a map unit based upon field notes and photointerpretation.

2.11 Map verification

For all NPS vegetation mapping projects, some form of map verification is required. The larger parks usually require some sort of stratified random sample to derive a statistically valid statement regarding the accuracy of the entire map and of each map unit. Although ELMO is a medium-sized park by document standards, it is only barely so. Because of its small size, the network and park agreed to forgo the formalized accuracy assessment in lieu of the existing and planned field visits. For the purposes of a park the size of ELMO, a representative sample across the park, in addition to plots collected by Cully (2002 and 2008), will suffice to establish an assumption of 100% accuracy.

3 Results

3.1 Field data collection

Field data collected by Cully (2002) were used as a preliminary estimate of the vegetation present at ELMO. These 32 plots, in addition to the 47 observation points collected during fall 2005, provided the backbone for the vegetation classification. Cully's plots were 100-m^2, circular relevé plots. The observation points collected during 2005 considered a circular area with an estimated 40-m radius. Plot locations are shown in Figure 3.1.

3.2 Vegetation classification

The preliminary classification produced in spring 2005, prior to any field sampling, included 11 vegetation types gleaned from Cully's data (see Table 3.2). The data supporting these types are limited, and were used solely as an initial reference. In addition to Cully's list, NatureServe prepared a report that listed several hundred potential types that might exist in the area. These were types existing in the NVC at the time, and which local experts were reasonably certain would occur in the park. The analysis of the observation points collected for this effort (2005) identified some of those types as well as five others not on the preliminary list compiled from the Cully data. Some of the data collected were only sufficient to classify a type to the alliance level.

Using the methods described above, the vegetation plot data collected in 2002 and observation points of 2005 were classified into 16 distinct vegetation types based on species composition, structure, and environmental characteristics (Table 3.2). The following six additional vegetation types were identified and mapped for the project area, but were not supported by formal plots or observation points:

- False Tarragon Shrubland Alliance
- One-seed Juniper Woodland Alliance
- Winterfat Dwarf-shrubland Alliance
- Two-needle Pinyon - (Juniper species) Woodland Alliance
- Ponderosa Pine Woodland Alliance
- Gambel Oak Shrubland Alliance

These types were either outside the park boundary or recognized after the field visit and added without supporting documentation. Photointerpretation of *Pinus ponderosa* or *P. edulis* associations was tenuous in areas not visited, so an alliance-level map unit was created for these.

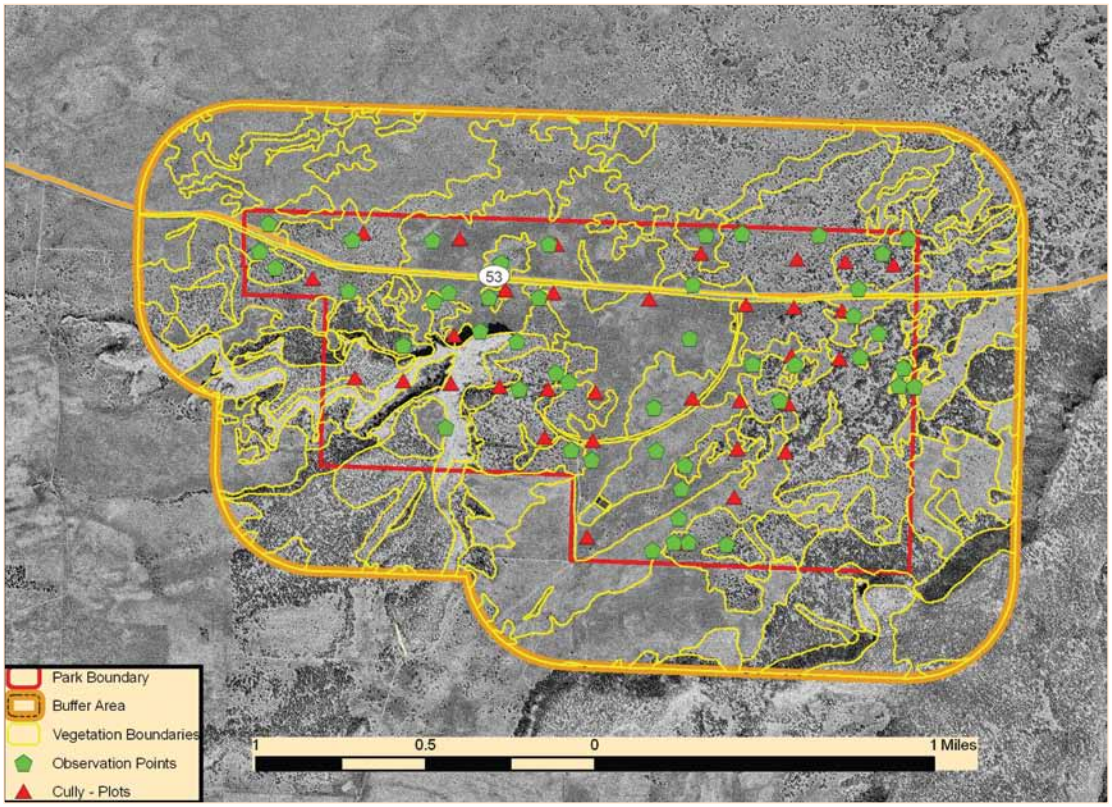


Figure 3.1. Vegetation sample points, El Morro National Monument.

Table 3.2. Vegetation alliances and associations/map units observed in ELMO by field plots and/or observation points, including frequency and area statistics.

		Plots/ Observations			Map-unit details		
Vegetation type	**Alliances and associations/Map-unit names**	**Cully plots**	**Obs. pts.**	**Total**	**Frequency**	**Acres**	**Hectares**
Herbaceous	Blue Grama Herbaceous Vegetation	4	7	**11**	26	346	140
	Blue Grama - Sand Dropseed Herbaceous Vegetation	2	1	**3**	1	6	2
	Cheatgrass Semi-natural Herbaceous Alliance	0	0	**0**	2	2	1
	Needle-and-Thread - Blue Grama Herbaceous Alliance	0	2	**2**	2	34	14
Dwarf-shrubland	Blue Grama Dwarf-shrub Herbaceous Alliance	2	9	**11**	28	302	122
	Winterfat Dwarf-shrubland Alliance	0	0	**0**	1	6	2
Shrub Herbaceous	Rubber Rabbitbrush Shrub Short Herbaceous Alliance	1	0	**1**	0	0	0
	Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation	1	4	**5**	9	191	77
	Sand Dropseed Shrub Herbaceous Alliance	1	0	**1**	0	0	0
Shrubland	False Tarragon Shrubland Alliance*	0	0	**0**	1	1	0
	Fourwing Saltbush / Blue Grama Shrubland	0	1	**1**	3	10	4
	Gambel Oak Shrubland Alliance	0	0	**0**	3	4	2
Woodland	One-seed Juniper Woodland Alliance	0	0	**0**	3	48	20
	One-seed Juniper / Blue Grama Woodland	5	13	**18**	39	554	224
	Two-needle Pinyon - (Juniper species) Woodland Alliance	-	-	-	6	25	10
	Two-needle Pinyon - (One-seed Juniper) / Blue Grama Woodland	12	8	**20**	28	591	239
	Two-needle Pinyon - (One-seed Juniper) / Sparse Woodland [Park Special]	0	0	**0**	1	30	12
	Two-needle Pinyon - Juniper species / Gambel Oak Woodland	2	0	**2**	0	0	0
	Ponderosa Pine Woodland Alliance	0	0	0	6	8	3
	Ponderosa Pine / Blue Grama Woodland	1	0	**1**	0	0	0
	Ponderosa Pine / Gambel Oak Woodland	0	1	**1**	4	21	9
	Two-needle Pinyon / Sparse Understory Forest	0	1	**1**	6	58	23
Other	Unvegetated Surface - Urban	0	0	0	4	29	12
	Weedy Forbs - Prairie Dog Colony	0	0	0	1	62	25
	Zuni Sandstone (Jz)	-	-	-	4	64	26
	Total	**31**	**47**	**78**	**178**	**2,394**	**969**

*not an existing NVCS type

The shrub *Tetradymia canescens* (gray horsebrush) was reported as occurring in high densities (50–75%) by several plots collected by Cully (2002). In addition, up to 25% cover of *T. canescens* was reported to occur at several observation points in 2005. No NVC types dominated by this shrub occur in New Mexico, and only one occurs in the remainder of the United States. After further review of the field data and NVC descriptions, these plots were classified only to the alliance level. The alliance that best describes areas dominated by *T. canescens* in ELMO is the Blue Grama Dwarf-shrub Herbaceous Alliance.

Of the 22 described vegetation types or map units listed in Table 3.2, 20 are recognized NVC types,

while additional vegetation classifications are "local" types (False Tarragon Shrubland Alliance and Two-needle Pinyon - (One-seed Juniper) / Sparse Woodland [Park Special]) specific to the park, but not yet recognized in the NVC. The 20 classified (existing, recognized) types included 11 of the types that were derived from Cully's plots. As a result of the additional field work in 2005, five additional NVC vegetation types were included.

3.3 Map units

Two non-vegetated land-cover types (Unvegetated Surface - Urban and Zuni Sandstone) and a "Weedy Forbs - Prairie Dog Colony" map unit were included with the 18 mapped vegetation associations or alliances, for a total of 21 map units. All alliances and associations in Table 3.2 correspond directly to a map class except for the Rubber Rabbitbrush Short Shrub Herbaceous Alliance, Sand Dropseed Shrub Herbaceous Alliance, Two-needle Pinyon - Juniper species / Gambel Oak Woodland, and Ponderosa Pine/ Blue Grama Woodland. These alliances and associations were not mapped because they typically occurred well below the minimum mapping unit, were difficult to discern, or were not very abundant.

3.4 Vegetation alliances and associations

Descriptions for each vegetation type (i.e., alliance or association) are described in the following sections, orgranized by life form (e.g., herbaceous vegetation, shrubland, woodland). The global descriptions were derived from the NatureServe Explorer website, http://www.natureserve.org/explorer/. These descriptions have been modified to include either local classification comments, local vegetation summaries, or both. These comments and summaries provide new information that may or may not be included in further reviews of the salient types. In some cases, the NatureServe classification confidence is weak, and the only description available is the local description (e.g., Blue Grama - Sand Dropseed Herbaceous Vegetation). Global and state status ranks, when available, indicate conservation status from the NatureServe Explorer website (http://www.natureserve.org/explorer) and from the NHNM ecologist (Dr. Esteban Muldavin, pers. comm.).

Note: *In the descriptions that follow, the only information specific to El Morro National Monument appears under "Local description" and "Plots." All other information is part of a general, "global" description of a given alliance or association. This global information was provided by NatureServe. All photos are courtesy of C Bolen, U.S. Bureau of Reclamation.*

Figure 3.4.1.1. *Bouteloua gracilis* Herbaceous Vegetation.

3.4.1 Herbaceous vegetation

3.4.1.1 Bouteloua gracilis Herbaceous Vegetation

Translated name: Blue Grama Herbaceous Vegetation
Common name: Blue Grama Shortgrass Prairie
Unique identifier: CEGL001760
Classification approach: International Vegetation Classification (IVC)

Summary: This minor plant association is reported from Arizona, Colorado, New Mexico, and Wyoming. Sites are flat-to-gently sloping, and include plains, plateaus, and montane meadows. Substrates are variable and range from coarse-textured soils derived from sand, gravel, 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* (blue grama). Associated grasses are *Bouteloua curtipendula* (sideoats grama), *Elymus elymoides* (squirreltail), *Muhlenbergia* spp. (muhly), *Pascopyrum smithii* (western wheatgrass), *Pleuraphis jamesii (= Hilaria jamesii)* (James' galleta), *Sporobolus cryptandrus* (sand dropseed), and the introduced annual grass *Bromus tectorum* (cheatgrass). Forb cover is sparse. Scattered *Ericameria nauseosa* (rubber rabbitbrush) shrubs and an occasional *Pinus edulis* (two-needle pinyon), *Juniperus* spp. (juniper), or *Pinus ponderosa* (ponderosa pine) tree (in montane stands) may be present.

Classification confidence: 3–Weak
Classification 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.

Vegetation hierarchy		
Formation class	V	Herbaceous Vegetation
Formation subclass	V.A	Perennial graminoid vegetation
Formation group	V.A.5	Temperate or subpolar grassland
Formation subgroup	V.A.5.N	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.e	Short sod temperate or subpolar grassland
Alliance name	*Bouteloua gracilis* Herbaceous Alliance	

Ecological systems placement	
Ecological system unique ID	**Ecological system name**
CES303.672	Western Great Plains Shortgrass Prairie
CES303.817	Western Great Plains Foothill and Piedmont Grassland
CES304.787	Inter-Mountain Basins Semi-Desert Grassland

Global status: G4Q (23Feb1994)
Rounded global status: G4–Apparently Secure
State status: S5 (30Jan2008)

U.S. distribution: AZ, CO, NM?, UT, WY
Global distribution: United States
Global range: This minor plant association occurs in Arizona, Colorado, New Mexico, Utah, and Wyoming.

Dynamics: *Bouteloua gracilis* is an extremely drought- and grazing-tolerant shortgrass species. It is one of the most widely distributed grasses in the interior western U.S., and is present in many different grassland, shrubland, and woodland communities. It evolved with grazing by large herbivores and generally forms a short sod. However, in some stands, ungrazed plants develop the upright physiognomy of a bunchgrass. *Bouteloua gracilis* is a warm-season grass and relatively unaffected by spring grazing while it is dormant. Montane *Bouteloua gracilis*-dominated stands are often seral-to-midgrass associations dominated by species of *Achnatherum* (needlegrass), *Danthonia* (oatgrass), *Festuca* (fescue), *Hesperostipa* (needle and thread), or *Muhlenbergia*, and are the result of inappropriate stocking rates or season of use by large herbivores.

Local description: This association was dominated by the perennial shortgrass *Bouteloua gracilis* (blue grama). The association was described by a total of eleven field plots/observation points for the El Morro project area. The herbaceous stratum was characterized as being low-to-moderate in plant cover (26–65%) and was typically less than 0.5 m (19.7 in) in height (Figure 3.4.1.1). *Bouteloua gracilis* was the dominant species (25–45% cover). *Eriogonum* sp. (buckwheat) was the next most abundant species observed in the field for this association. Common shrubs, such as *Tetradymia canescens* (spineless horsebrush), *Artemisia frigida* (fringed sagewort), and *Chrysothamnus viscidiflorus* (yellow rabbitbrush), were often present in low abundances (<5% cover). In addition, *Pinus edulis* and *Juniperus monosperma* (one-seed juniper) trees may be present within areas mapped as this association. All field plots were located on areas of little-to-no relief. A large portion of bare ground and cryptobiotic crust characterized the field sites. Bare ground estimates ranged from 26 to 45%, and cryptobiotic crust ranged from 5 to 25%. Vegetation associations often found nearby included *Pinus edulis* (*Juniperus monosperma*) / *Bouteloua gracilis* and *Juniperus monosperma* / *Bouteloua gracilis*.

Figure 3.4.1.2. *Bouteloua gracilis - Sporobolus cryptandrus* Herbaceous Vegetation.

3.4.1.2 Bouteloua gracilis - Sporobolus cryptandrus Herbaceous Vegetation

Translated name: Blue Grama - Sand Dropseed Herbaceous Vegetation
Unique identifier: CEGL001761
Classification approach: International Vegetation Classification (IVC)
Classification confidence: 3–Weak

Vegetation hierarchy		
Formation class	V	Herbaceous Vegetation
Formation subclass	V.A	Perennial graminoid vegetation
Formation group	V.A.5	Temperate or subpolar grassland
Formation subgroup	V.A.5.N	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.e	Short sod temperate or subpolar grassland
Alliance name	*Bouteloua gracilis* Herbaceous Alliance	

Ecological systems placement	
Ecological system unique ID	**Ecological system name**
CES302.735	Apacherian–Chihuahuan Semi-Desert Grassland and Steppe

Global status: GNRQ (23Feb1994)
Rounded global status: GNR–Not Yet Ranked

U.S. distribution: NM
Global distribution: Mexico?, United States

Local description: This association was described by a total of one plots and two observation point (Figure 3.4.1.2). *Bouteloua gracilis* and *S. cryptandrus* were the two most abundant species. The herbaceous stratum ranged in cover from 26 to 45%, with a height of less than 1.0 m (39.4 in). *B. gracilis* and *S. cryptandrus* were found as co-dominants. *B. gracilis* ranged in cover from 7 to 10%, and *S. cryptandrus* 5 to 12%. Weedy forbs, such as *Helianthus annuus* (common sun-

flower) and *Lepidium* sp. (pepperweed), represented a significant amount of the herbaceous cover (6–10%). Additional associated species included *Ericameria nauseosa* and *Hesperostipa comata* (needle and thread). Topographic relief was very little-to-none at all (flat). Bare soil accounted for 26–45% of the ground cover, and cryptobiotic crust 5–15%. *Pinus edulis* (*Juniperus monosperma*) / *Bouteloua gracilis* and *Juniperus monosperma* / *Bouteloua gracilis* woodland associations were located nearby.

Figure 3.4.1.3. *Bromus tectorum* Semi-natural Herbaceous Alliance.

3.4.1.3 Bromus tectorum Semi-natural Herbaceous Alliance

Translated name: Cheatgrass Semi-natural Herbaceous Alliance
Unique identifier: A.1814
Classification approach: International Vegetation Classification (IVC)

Summary: This alliance is found throughout much of western North America, from the western Great Plains to the intermountain and southwestern U.S. Elevation ranges from sea level to 2,200 m (7,218 ft). It occurs after disturbance of a natural shrub- or grass-dominated community, resulting in the replacement of the natural vegetation by non-native, annual grass species of *Bromus*. *B. tectorum* typically dominates the community, with more than 80–90% of the total vegetation cover, making it difficult to determine what natural community was formerly present. This alliance also includes grasslands dominated or co-dominated by other Eurasian introduced annual *Bromus* species, such as *B. hordeaceus* (soft brome), *B. madritensis* (compact brome), *B. japonicus* (Japanese brome), *B. rigidus* (ripgut brome), or *B. rubens* (red brome), but is distinct from the annual *Bromus* communities found along the Pacific Coast with Mediterranean or maritime climates.

Classification comments: This alliance is composed of vegetation types dominated by weedy species not native to the western United States. A description can be developed in the future for this alliance, should it prove useful to do so. The only reference presently used for classifying this alliance is Sawyer and Keeler-Wolf (1995). However, numerous references to *B. tectorum* invasion of native vegetation types are available (see individual descriptions, e.g., of alliances in the *Artemisia tridentata* (big sagebrush) complex, *Pinus monophylla* (singleleaf pinyon), *Juniperus osteosperma* (Utah juniper), *Juniperus occidentalis* (western juniper), *Cercocarpus ledifolius* (curl-leaf mountain mahogany), and *Cercocarpus montanus* (alderleaf mountain mahogany).

Vegetation hierarchy		
Formation class	V	Herbaceous Vegetation
Formation subclass	V.D	Annual graminoid or forb vegetation
Formation group	V.D.2	Temperate or subpolar annual grasslands or forb vegetation
Formation subgroup	V.D.2.N	Natural/Semi-natural temperate or subpolar annual grasslands or forb vegetation
Formation name	V.D.2.N.d	Short temperate annual grassland

State status: SE (30Jan2008)

Global distribution: United States
Global range: This alliance is found throughout much of western North America, from the western Great Plains to the intermountain and southwestern U.S.

Dynamics: *Bromus tectorum,* an annual grass, is able to complete its lifecycle in the spring before drying out mid-summer. Its fine structure makes it extremely flammable when dry, and it will increase the fire frequency of a site (FEIS 2001). Frequent fires favor *B. tectorum* because they eliminate competing perennial vegetation but do not kill all the *B. tectorum* seeds, which survive in the unburned organic material (FEIS 2001). This altered ecological process has promoted the spread of *B. tectorum* and other exotic annual bromes at the expense of sagebrush shrublands in large parts of the western U.S. (Daubenmire 1970; Young and Evans 1973; 1978). This type is most common where disturbances have eliminated or largely set back the native vegetation. Where the brome grasses are invading native vegetation, the types may still be tracked as native types, because the native species may still persist. A recent study (Karl et al. 1999) found that despite strong seed and seedling production by the exotic brome grasses (*B. japonicus, B. tectorum*), the large amount of herbaceous biomass produced by the two vegetatively propagating native grasses, *Bouteloua gracilis* and *Pascopyrum smithii*, suggests that these native grasses may well maintain their ecological importance in the stands. In Nevada, Beatley (1976) found dense stands of the introduced winter annual grass *B. tectorum* growing in disturbed *Artemisia* shrublands. *B. rubens* is more common in lower elevation sites, and *B. tectorum* is most common in higher elevation sagebrush and pinyon-juniper communities.

Local description: This alliance was supported by one field plot (Cully 44), in addition to a casual observation (Figure 3.4.1.3). *B. tectorum* (cheatgrass) was observed in areas of disturbance, such as along roads and trails. Large patches of the species were only observed in the box canyon in the park and along the northern extents of the mesa. In these areas, *B. tectorum* was the dominant species occurring alongside native alliances or associations.

Figure 3.4.1.4. *Hesperostipa comata - Bouteloua gracilis* Herbaceous Alliance.

3.4.1.4 Hesperostipa comata - Bouteloua gracilis Herbaceous Alliance

Translated name: Needle-and-Thread - Blue Grama Herbaceous Alliance
Unique identifier: A.1234
Classification approach: International Vegetation Classification (IVC)

Summary: This alliance is widespread across upland sites in the northern Great Plains. Its communities tend to be the climax communities on fertile dry-mesic sites across much of its range (Tolstead 1941; Hansen et al. 1984). It is dominated by mid- and shortgrass species; woody species do not regularly achieve prominence. Few of the species exceed 1 m (3.3 ft), while many, including *Bouteloua gracilis*, do not exceed 50 cm (1.6 ft). The most abundant species are *Hesperostipa comata (= Stipa comata)* and *Bouteloua gracilis*. On more mesic sites, *Hesperostipa comata* is predominant, while on areas that are drier or subject to light grazing, *Bouteloua gracilis* takes precedence. Other graminoid species commonly found in communities of this alliance are *Aristida purpurea var. longiseta (= Aristida longiseta)* (Fendler's threeawn), *Carex duriuscula (= Carex eleocharis)* (spikerush sedge), *Carex filifolia* (threadleaf sedge), *Koeleria macrantha* (Junegrass), *Nassella viridula* (green needlegrass), and *Pascopyrum smithii*. Sites in the southern half of the range of this alliance may have significant amounts of *Bouteloua curtipendula*. Forbs are common but not usually abundant. Forb species regularly found are *Artemisia frigida, Gaura coccinea* (scarlet gaura), *Gutierrezia sarothrae (= Gutierrezia diversifolia)* (snakeweed), *Liatris punctata* (dotted blazing star), *Sphaeralcea coccinea (= Malvastrum coccineum)* (scarlet globemallow), and *Phlox hoodii* (spiny phlox). The clubmoss *Selaginella densa* is present in many stands in this alliance (Coupland 1950; DeVelice and Lesica 1993; Hansen et al. 1984). Scattered shrubs are sometimes present. These include *Prunus virginiana* (chokecherry), *Rhus aromatica* (fragrant sumac), and *Symphoricarpos occidentalis* (western snowberry). In the western and southwestern portions of its range, *Cercocarpus montanus* may be found where this alliance occurs on slopes (Hanson 1955). Communities in this alliance are found on flat-to-moderately steep topography. The soils are sandy loam, loam, or sometimes clay loam. They are often well-developed and derived from either glacial deposits or sometimes limestone or sandstone (Hanson and Whitman 1938; Coupland 1950; Hanson 1955).

Classification comments: Communities in this alliance can be confused with communities of the *Bouteloua gracilis* Herbaceous Alliance (A.1282), especially in Wyoming. More classification work is needed to clarify the conceptual boundaries between stands in this alliance.

Vegetation hierarchy		
Formation class	V	Herbaceous Vegetation
Formation subclass	V.A	Perennial graminoid vegetation
Formation group	V.A.5	Temperate or subpolar grassland
Formation subgroup	V.A.5.N	Natural/Semi-natural temperate or subpolar grassland
Formation name	V.A.5.N.c	Medium-tall sod temperate or subpolar grassland

State status: S4? (30Jan2008)

U.S. distribution: CO, KS, MT, ND, NE, SD, WY
Canadian province distribution: AB, MB, SK
Global distribution: Canada, United States
Global range: This alliance is found in the western Great Plains, from western Kansas to North Dakota, west into Colorado, Wyoming, and Montana. The alliance also extends north into Canada in Saskatchewan, Manitoba, and probably Alberta.

Local classification comments: This alliance is not documented in New Mexico, but is supported by two observation points (76, 78) for the El Morro project area. Neither observation point describes any of the four component associations found within this alliance. The association *Hesperostipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation is the most similar to what is described by the observation points. However, *Carex filifolia* is not documented as occurring either in El Morro National Monument or in the state of New Mexico. For this reason, the observation points were only classified to the alliance level. Two additional alliances were considered during classification: the *Hesperostipa comata* Bunch Herbaceous Alliance and *Bouteloua gracilis* Herbaceous Alliance. The lack of shrubs directed the classification away from the other *Hesperostipa comata* alliance, whereas the large abundance of *H. comata* directed the classification away from the *B. gracilis* alliance.

Vegetation structure summary: This alliance is dominated by mid- and shortgrass species; woody species do not regularly achieve prominence. Few of the species exceed 1 m (3.3 ft), while many do not exceed 50 cm (19.7 in) in height. Perennial and annual forbs are common but are not abundant in most stands.

Environmental summary: Grasslands included in this alliance are common in the west-central and northwestern Great Plains. Elevations range from 600 to 2,350 m (1,969–7,710 ft). Climate is temperate, continental, and semi-arid to subhumid. Mean annual precipitation ranges from 25–50 cm (9.8–19.7 in). The year-to-year variation is great, in both total annual precipitation and the proportion of precipitation occurring in the winter and spring versus summer. Stands typically occur on upland sites in rolling plains, breaks, foothills, plateaus, or xeric montane parklands, and in smaller forest openings in mountains. Sites are flat-to-moderately steep slopes on any aspect. Soils are shallow-to-moderately deep, non-saline, often calcareous and alkaline, with sandy loam, loam, or sometimes clay loam texture. Mountain substrates are typically coarser colluvial soils. Parent materials often include limestone, sandstone, or shale, with glacial deposits in the northern Great Plains, and colluvium derived from granite, gneiss, and schist in the mountains. Adjacent stands are often grasslands dominated by *Pascopyrum smithii* in mesic bottomlands; *Bouteloua gracilis* in the xeric plains; *Festuca idahoensis* (Idaho fescue) in the mountains; shrublands dominated by *Artemisia tridentata, Ribes* spp. or *Rhus trilobata* (three-leaf sumac); or woodlands dominated by *Pinus edulis, Pinus flexilis, Pinus ponderosa,* or *Juniperus* spp.

Dynamics: These mixed grasslands occur in the subhumid/semi-arid steppes of the western Great Plains, where high variability of precipitation, both seasonally and yearly, allows both short and mid grasses to co-exist (Coupland 1992). *Hesperostipa comata* will decline with overgrazing, leaving the more grazing-tolerant *Bouteloua gracilis* to dominate (Laurenroth et al. 1994; Smoliak 1965;

Smoliak et al. 1972). Fire also can change the species composition of these grasslands. Burning generally kills or severely damages *H. comata* plants. After fire, regeneration of this non-rhizomatous bunchgrass is through seed, and may take many years to reach prefire densities (FEIS 1998). Burning *B. gracilis* during the growing season will topkill the plant, but the rhizomes are usually unharmed and quickly regrow (FEIS 1998). *B. gracilis* is usually unharmed by fires in years with above-normal winter and spring precipitation (soil moisture prevents lethal soil temperatures), but it can be severely damaged by fires that occur during drought years (FEIS 1998). Exotic species, such as *Taraxacum officinale* (dandelion), *Medicago sativa* (alfalfa), *Melilotus officinalis* (yellow sweetclover), or *Salsola kali* (Russian thistle), are present in some stands.

Local description: This alliance was characterized by a distinct herbaceous stratum dominated by *Hesperostipa comata* (Figure 3.4.1.4). *H. comata* ranged in cover from 40 to 55%, and ranged in height from 0.5 to 1.0 m (19.7–39.4 in). *Bouteloua gracilis* was the most associated herbaceous species in this alliance, with cover up to 15%. Shrubs common to the area, such as *Ericameria nauseosa,* may be present in small amounts (<5% cover). Observation points were located in areas of flat terrain. Bare soil exposed at field plots ranged from 26 to 45%. Litter and duff accounted for the majority of the remaining ground cover with ranges of 46–65%.

Figure 3.4.2.1. *Bouteloua gracilis* Dwarf-shrub Herbaceous Alliance.

3.4.2 Dwarf-shrubland

3.4.2.1 Bouteloua gracilis Dwarf-shrub Herbaceous Alliance

Translated name: Blue Grama Dwarf-shrub Herbaceous Alliance
Unique identifier: A.1571
Classification approach: International Vegetation Classification (IVC)

Summary: This alliance is reported from the Tularosa Basin of southern New Mexico and the Colorado Plateau in southwestern Utah and northern Arizona. Elevations range from 1,200 to 2,700 m (3,937–8,858 ft). Climate is semi-arid. Sites include valley bottoms, plains, hillslopes, mesa tops, sand sheets, and dunes. Soils range from loamy sand to silt texture and are derived from alluvium and colluvium from sandstone and other parent materials. The vegetation is dominated by a sparse-to-moderately dense graminoid layer of the perennial shortgrass *Bouteloua gracilis,* with an open (10–25% cover) dwarf-shrub layer. *Hesperostipa comata, Pleuraphis jamesii*, or *Sporobolus airoides* (alkali sacaton) may co-dominate the graminoid layer in some stands. Other associated grasses are *Achnatherum hymenoides, Bouteloua curtipendula, Hesperostipa neomexicana* (New Mexico needlegrass), *Muhlenbergia montana* (mountain muhly), *Poa fendleriana*, and *Sporobolus cryptandrus*. *Artemisia bigelovii* (Bigelow's sage) or *Gutierrezia sarothrae* are commonly present and may dominate the open dwarf-shrub layer. Other dwarf-shrubs and shrubs may include *Arctostaphylos patula* (greenleaf manzanita), *Artemisia tridentata, Ephedra torreyana* (Torrey's jointfir), *Ephedra viridis* (Mormon tea), *Ericameria nauseosa, Quercus gambelii* (Gambel oak), *Tetradymia canescens*, and *Yucca* spp. An occasional *Pinus edulis* or *Juniperus* spp. tree may be present in higher elevation stands.

Classification comments: The two associations included in this alliance are described from only two stands on the White Sands Missile Range, 12 plots from Petrified Forest National Park, and 4 plots from Zion National Park. More classification work is needed to clarify how it differs from the similar alliances, especially the stands in the *Artemisia bigelovii* Shrubland Alliance (A.1103).

Vegetation hierarchy		
Formation class	V	Herbaceous Vegetation
Formation subclass	V.A	Perennial graminoid vegetation
Formation group	V.A.8	Temperate or subpolar grassland with a sparse dwarf-shrub layer
Formation subgroup	V.A.8.N	Natural/Semi-natural temperate or subpolar grassland with a sparse dwarf-shrub layer
Formation name	V.A.8.N.a	Short temperate or subpolar lowland grassland with a sparse needle-leaved or microphyllous dwarf-shrub layer

U.S. distribution: **AZ,** NM, UT
Global distribution: United States
Global range: Grasslands in this alliance have been described from the Oscura Mountains in the Tularosa Basin in south-central New Mexico and the Colorado Plateau in southwestern Utah and northern Arizona.

Local description: This alliance characterized areas dominated by the perennial shortgrass *Bouteloua gracilis* and one or more associated dwarf-shrub species (Figure 3.4.2.1). The alliance was described locally by 11 field plots/observation points located throughout the extent of the project area. The only component association for this alliance, *Artemisia bigelovii* / *Bouteloua gracilis* Dwarf-shrub Herbaceous Vegetation, did not fit well due to the lack of *Artemisia bigelovii*. The most common dwarf-shrubs associated with this alliance included *Tetradymia canescens*, *Chrysothamnus viscidiflorus,* and *Artemisia frigida*. Shrub cover ranged from 6 to 25%, often forming dominating patches within classified polygons that were less than the minimum mapping unit of the vegetation map (< 0.5 ha; 1.24 acres). The dwarf-shrubs were most often less than 0.5 m in height, with heights sometimes reaching 1.0 m (39.4 in). The herbaceous cover for this alliance ranged from 26 to 45%. The herbaceous stratum was most often less than 0.5 m (19.7 in) tall, with occasional heights up to 1.0 m (39.4 in). The most common species in the herbaceous stratum was found in the genus *Eriogonum*. Scattered *Juniperus monosperma* and/or *Pinus edulis* trees may be found within areas of this association. Slopes for this association at El Morro were very low-to-none (flat). The percent of bare ground ranged from 16 to 45%; percent cryptobiotic crust present was 5–45%. Associations often found nearby included *Pinus edulis* (*Juniperus monosperma*) / *Bouteloua gracilis* and *Juniperus monosperma* / *Bouteloua gracilis*.

3.4.2.2 Krascheninnikovia lanata Dwarf-shrubland Alliance

Translated name: Winterfat Dwarf-shrubland Alliance
Unique identifier: A.1104
Classification approach: International Vegetation Classification (IVC)

Summary: This minor alliance includes dwarf-shrublands scattered across the interior western U.S. Stands occur on plateaus, plains, mesas, hillslopes, and alkaline flats around playas and along drainages. Some habitats are intermittently flooded wetlands. Sites are typically flat-to-gently sloping and occur on any aspect, but stands have also been reported from moderately steep slopes. Soils are calcareous, moderately alkaline, and sometimes saline. Soil texture is typically stony, sandy loam, but may be coarser-textured. The ground cover is mostly bare soil. Vegetation included in this alliance is characterized by a sparse-to-moderately dense dwarf-shrub layer dominated by *Krascheninnikovia lanata* (winterfat). Other woody species may include scattered *Artemisia frigida, Artemisia nova* (black sagebrush), *Artemisia tridentata, Chrysothamnus* spp., *Gutierrezia sarothrae, Opuntia polyacantha, Rhus trilobata*, and *Yucca glauca* (soapweed yucca). In the Mojave Desert, *Larrea tridentate* (creosote bush), *Lycium andersonii* (water jacket), *Ambrosia dumosa* (burrobush), and *Atriplex polycarpa* (cattle saltbush) may also be present. The herbaceous layer has sparse-to-moderately dense cover dominated by graminoids with scattered perennial forbs. Graminoids, such as *Poa secunda, Hesperostipa comata (= Stipa comata), Pleuraphis jamesii (= Hilaria jamesii), Achnatherum hymenoides (= Oryzopsis hymenoides)*, and *Pseudoroegneria spicata*, are most abundant. Perennial forbs may include *Phlox hoodii, Sphaeralcea coccinea, Sphaeralcea munroana* (Munro's globemallow), *Achillea millefolium* (common yarrow), *Astragalus purshii* (woollypod milkvetch), *Calochortus macrocarpus* (sagebrush mariposa lily), and *Erigeron* (daisy) spp. Annuals may be seasonally present-to-abundant, depending on precipitation and disturbance. Exotic annuals can be abundant. Diagnostic of this alliance is the *Krascheninnikovia lanata*-dominated dwarf-shrub canopy, with more than 25% cover.

Classification comments: The vegetation is sparse in many of these stands, and they would be better classified in a sparsely vegetated alliance. Only stands described by Daubenmire (1970) and DeVelice et al. (1991) have the necessary woody cover to be dwarf-shrublands. One association, *Krascheninnikovia lanata / Phlox* spp. Dwarf-shrubland (CEGL001325), was no longer mentioned in the final report on the Pryor Mountains in Montana by DeVelice and Lesica (1993), and needs further investigation. Stands in California need investigation and association-level description.

Vegetation hierarchy		
Formation class	IV	Dwarf-shrubland
Formation subclass	IV.A	Evergreen dwarf-shrubland
Formation group	IV.A.2	Extremely xeromorphic evergreen dwarf-shrubland
Formation subgroup	IV.A.2.N	Natural/Semi-natural extremely xeromorphic evergreen dwarf-shrubland
Formation name	IV.A.2.N.a	Extremely xeromorphic evergreen subdesert dwarf-shrubland

State status: SNR (30Jan2008)

U.S. distribution: **CA?,** CO, ID, MT, NM, NV, OR, TX, UT, WA
Canadian province distribution: SK?
Global distribution: Canada, United States
Global range: Stands in this minor dwarf-shrubland alliance occur on the Columbia Plateau and Great Basin, and extend east to the northwestern Great Plains and south to the Mojave Desert and Colorado Plateau. It is reported from eastern Washington and Oregon, Idaho, Montana, Nevada, New Mexico, and Colorado, and likely occurs in Utah, California, and Saskatchewan, Canada.

Local classification comments: Casual observations, rather than a formal field plot or observation point, supported this classification in the El Morro project area. Only one polygon was mapped as this alliance for the entire project area. *Krascheninnikovia lanata* Dwarf-shrub Herbaceous

Alliance is the most similar to the chosen classification, but characterizes areas that have a sparser shrub stratum and a more dominant herbaceous stratum than what was observed at El Morro. Of the six component associations for the *Krascheninnikovia lanata* Dwarf-shrubland Alliance, only one has been documented in New Mexico: *Krascheninnikovia lanata / Pleuraphis jamesii Dwarf-shrubland*. Additional potential associations included *Krascheninnikovia lanata / Hesperostipa comata* Dwarf-shrubland and *Krascheninnikovia lanata* Dwarf-shrubland, but these contain distributions outside New Mexico. Due to the lack of supporting field data, only the alliance was described and mapped for this project.

Vegetation structure summary: Vegetation included in this alliance is dominated by a sparse-to-moderately dense evergreen, dwarf-shrub layer, often with scattered shrubs. Also present is a sparse-to-moderately dense herbaceous layer dominated by perennial graminoids with scattered perennial forbs. Annual grasses and forbs are seasonally present to abundant.

Environmental summary: This minor alliance includes dwarf-shrublands scattered across the interior western U.S. Elevations range from 100 to 2,700 m (328–8,858 ft). Climate is mostly temperate and semi-arid, but stands in southern Nevada are arid, with hot summers and mild winters. Stands occur on plateaus, plains, mesas, hillslopes, and alkaline flats around playas and along drainages. Some habitats are intermittently flooded wetlands (Sawyer and Keeler-Wolf 1995). Sites are typically flat-to-gently sloping, and may occur on any aspect. They have also been reported from moderate slopes of 45%. Soils are generally thin to moderately deep, calcareous, moderately alkaline, and sometimes saline. Soil textures are typically stony, sandy loams, but range to silty clays. The ground cover is mostly bare soil. Stands described by Blackburn et al. (1968) and Francis (1986) averaged 77% and 90% bare ground, respectively. Adjacent stands depend on geography of the stand. In the steppe of eastern Washington, adjacent stands are dominated by *Artemisia tridentata*, *Grayia spinosa* (spiny hopsage), or *Pseudoroegneria spicata*. In eastern Montana, there are sharp ecotones with *P. spicata* grasslands. In the Mojave Desert, adjacent vegetation is desert scrub dominated by *Atriplex polycarpa*, *Atriplex confertifolia* (shadscale), *Ambrosia dumosa,* or *Larrea tridentata*.

Dynamics: Stands dominated by *K. lanata* occur locally. They often have sharp ecotones with other vegetation types and were thought to be an edaphic community type by Daubenmire (1970). However, edaphic factors separating these stands from adjacent stands have yet to be found. Soil characteristics, such as excessive amounts of calcium carbonate or lack of the nutrients N, P, K, or S, have been studied and do not appear to control the occurrence of this alliance (Daubenmire 1970; DeVelice et al. 1995). *K. lanata* is important range forage. It is highly palatable in winter and is tolerant of heavy browsing (Daubenmire 1970). Many stands have long histories of grazing impacts, and are thought to be in a degraded state (DeVelice et al. 1995; Francis 1986). These stands often have low perennial herbaceous cover and many have high cover of the exotic annual grass *Bromus tectorum* (Daubenmire 1970; Francis 1986). DeVelice et al. (1995) described stands dominated by *K. lanata* and *Hesperostipa comata*, which they considered to be a seral stage of a *K. lanata / P. spicata* community type that is not currently described in the National Vegetation Classification. Francis predicts that with protection from grazing, *Gutierrezia sarothrae* cover will decrease and *K. lanata*, *Sporobolus airoides,* and *A. hymenoides* will increase in cover.

3.4.3 Shrub Herbaceous Vegetation

3.4.3.1 Ericameria nauseosa Shrub Short Herbaceous Alliance

Translated name: Rubber Rabbitbrush Shrub Short Herbaceous Alliance
Unique identifier: A.1546
Classification approach: International Vegetation Classification (IVC)

State status: SNR (30Jan2008)

Local description: One field plot (Cully 46) was classified to the alliance level in the El Morro project area due to the lack of cohesiveness with component associations. Of the three component associations within this alliance, none adequately describes the vegetation information described by the field plot. The field plot contained a shrub stratum dominated by *Ericameria nauseosa*, with a cover class of 6–24%. The herbaceous stratum was dominated by the graminoids *Stipa* sp. (needle and thread) and *Sporobolus cryptandrus*. Other abundant associated species included *Cryptantha cinerea* var. *jamesii* (James' catseye), *Descurainia* sp. (tansymustard), *Hymenopappus flavescens* (collegeflower), *Aristida purpurea*, *Eriogonum effusum* (spreading buckwheat), *Plantago patagonica*, *Psoralea lanceolata* (lemon scurfpea), *Senecio multilobatus* (lobeleaf groundsel), and *Helianthus* sp. (sunflower).

Figure 3.4.3.2. *Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation.

3.4.3.2 Ericameria nauseosa / *Bouteloua gracilis* Shrub Herbaceous Vegetation

Translated name: Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation
Unique identifier: CEGL003495
Classification approach: International Vegetation Classification (IVC)

Classification confidence: 3–Weak
Classification comments: Former CEGL001738 and CEGL001739 were lumped into this new association; separation of these two types by *Ericameria nauseosa* ssp. was not supported by the data in Francis (1986).

Summary: This shrub herbaceous association occurs on valley floors, swales and alluvial flats in the southern and central part of the Colorado Plateau. Its presence generally indicates disturbance, and it may represent degraded forms of other grassland, shrubland or woodland communities. Stands occupy gentle to moderate slopes (2-13%) between 1635 and 2010 m (5360-6600 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. 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.

Vegetation hierarchy		
Formation class	V	Herbaceous Vegetation
Formation subclass	V.A	Perennial graminoid vegetation
Formation group	V.A.7	Temperate or subpolar grassland with a sparse shrub layer
Formation subgroup	V.A.7.N	Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer
Formation name	V.A.7.N.j	Short temperate or subpolar grassland with a sparse microphyllous evergreen shrub layer
Alliance name	*Ericameria nauseosa* Shrub Short Herbaceous Alliance	

Ecological systems placement	
Ecological system unique ID	**Ecological system name**
CES304.787	Inter-Mountain Basins Semi-Desert Grassland
CES304.788	Inter-Mountain Basins Semi-Desert Shrub-Steppe

Global status: GNR (14Apr2003)
Rounded global status: GNR–Not Yet Ranked
State status: SNR (30Jan2008)

U.S. distribution: AZ, UT
Global distribution: United States

***Local description*:** This association was characterized by a distinct short shrub stratum dominated by *Ericameria nauseosa* and an herbaceous stratum dominated by the perennial short grass *Bouteloua gracilis* (Figure 3.4.3.2) Other grasses, most notably *Hesperostipa comata* and *Sporobolus cryptandrus*, may share dominance or be more abundant than *Bouteloua gracilis*. Four observation points (9, 44, 107, and 126) and seven supplementary observation points (ELMO-WP 26, 27, 39, 41, 43, 45, and 46) described this association for the El Morro project area. The short shrub stratum consisted mainly of *Ericameria nauseosa*, which was present in low abundance (10-15% cover), and was between 1.0 (3.3 ft) and 2.0 (6.6 ft) in height. *Artemisia dracunculus* (false tarragon) was recorded for one of the observation points, with a cover of 2%. Associated dwarf-shrub species included *Artemisia frigida, Tetradymia canescens*, and *Chrysothamnus viscidiflorus*, which ranged in cover from 2 to 20 %. The herbaceous stratum ranged in cover from 16 to about 60%, and was dominated by *Bouteloua gracilis, Hesperostipa comata*, or *Sporobolus cryptandrus*. In places, there may be a significant component of annual species like *Chenopodium* spp. and *Helianthus petiolaris*.

3.4.3.3 ***Sporobolus cryptandrus*** Shrub Herbaceous Alliance

Translated name: Sand Dropseed Shrub Herbaceous Alliance
Unique identifier: A.1525
Classification approach: International Vegetation Classification (IVC)

Summary: Grasslands in this alliance are described from Montana, Idaho, and New Mexico. In New Mexico, the alliance occurs in the northwestern part of the state, on alluvial flats at an elevation of approximately 2,140 m (7,021 ft). Climate is semi-arid with most of the highly variable annual precipitation falling during the summer as high-intensity convectional storms. Sites are nearly level. Soils are calcareous, loamy and shallow (less than 25 cm (9.8 in) deep). Soil surface averages 65% bareground, 17% plant litter with little rock. The vegetation is dominated by the perennial bunchgrass *Sporobolus cryptandrus* with a sparse shrub layer usually dominated by *Artemisia tridentata*. In New Mexico, a stand has been described where total vegetation canopy cover is 22% with *S. cryptandrus, Artemisia tridentata*, and *Eriogonum* spp., a perennial forb, having canopy cover of 13%, 3% and 2%, respectively (Francis 1986). Other common grasses include *Achnatherum hymenoides (= Oryzopsis hymenoides), Pascopyrum smithii, Achnatherum robustum (= Stipa robusta), Sporobolus contractus* (spike dropseed), and *Bouteloua gracilis*. Other shrubs, such as *Ericameria nauseosa (= Chrysothamnus nauseosus), Gutierrezia sarothrae*, and *Atriplex* spp. (saltbush), may also be present. Common forbs, such as *Sphaeralcea coccinea* and *Asteraceae* spp. (sunflower), contribute very little to the total cover.

Classification comments: This alliance is very poorly described in the literature. Vegetation types placed here need to be reviewed. If some of the desert shrublands get moved to shrub herbaceous alliances, the ones with high *S. cryptandrus* cover may fall into this alliance. The graminoid cover is low in the stand described by Francis (1986), and that type may be better classified in sparse vegetation rather than a grassland alliance. Overgrazed stands in the *Sporobolus cryptandrus* Herbaceous Alliance (A.1252) develop a significant shrub layer of *Ericameria nauseosa* and may be better classified in this alliance (Daubenmire 1970).

Vegetation hierarchy		
Formation class	V	Herbaceous Vegetation
Formation subclass	V.A	Perennial graminoid vegetation
Formation group	V.A.7	Temperate or subpolar grassland with a sparse shrub layer
Formation subgroup	V.A.7.N	Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer
Formation name	V.A.7.N.e	Medium-tall temperate or subpolar grassland with a sparse needle-leaved or microphyllous evergreen shrub layer

State status: SNR (30Jan2008)

U.S. distribution: ID, MT, NM, OR
Global distribution: United States
Global range: Grasslands included in this alliance have been described in a semi-arid basin in northwestern New Mexico, in Hells Canyon in the Pryor Mountains in south central Montana, and may occur in the canyons of the upper Columbia River basin.

Vegetation structure summary: Vegetation in this alliance is dominated by medium-tall bunch grasses with a sparse layer of needle-leaved or microphyllous evergreen shrubs. The grass layer can be sparse to moderate, while the shrub layer is typically sparse.

Dynamics: In New Mexico, grazing has significantly impacted much of the vegetation in this region, which has had a long history of settlement and heavy livestock use. With proper livestock management and time, palatable species such as *Achnatherum hymenoides* and *Pascopyrum smithii* may increase, and *Gutierrezia sarothrae* and *Ericameria nauseosa* may decline in abundance (Francis 1986).

Local description: This association was not very abundant in the El Morro project area, and was only described by one field plot (Cully 64). *Sporobolus cryptandrus* was the dominant species. Associated shrubs for this alliance with significant cover included *Artemisia dracunclus* and *Artemisia frigida,* with a cover range of 6–24%. Additional species found in the area included *Gutierrezia sarothrae*, *Stipa* sp., *Corydalis aurea* (scrambled eggs), *Lactuca serriola*, *Monarda* sp. (beebalm), *Oenothera elata* (Hooker's evening-primrose), *Opuntia* sp. (pricklypear), *Senecio multilobatus*, *Sisymbrium altissimum* (tumblemustard), *Sphaeralcea* sp. (globemallow), and *Tradescantia occidentalis* (prairie spiderwort). Scattered *Juniperus monosperma* trees also were present in the area. Two component associations were within this alliance: *Sporobolus cryptandrus* Shrub Herbaceous Vegetation and *Artemisia tridentata* / *Sporobolus cryptandrus - Achnatherum hymenoides* Shrub Herbaceous Vegetation. Due to the lack of field data for this vegetation type in the El Morro project area, the plot was classified only to the alliance level.

Figure 3.4.4.1. *Artemisia dracunculus* Shrubland Alliance.

3.4.4 Shrubland

3.4.4.1 Artemisia dracunculus Shrubland Alliance

Translated name: False Tarragon Shrubland Alliance
Unique identifier: CEGLXXXXX
Classification approach: Local

Summary: This minor shrubland association is reported only for this park, and is considered a local occurrence. There is no description of this type within the NatureServe database; it is included here as it best describes the unit on the ground. This plant is considered invasive (Stubbendieck et al. 1994). The vegetation hierarchy below is tentative and requires review.

Vegetation hierarchy		
Formation class	III	Shrubland
Formation subclass	III.B	Deciduous shrubland
Formation group	III.B.2	Cold-deciduous shrubland
Formation subgroup	III.B.2.N	Natural/Semi-natural cold-deciduous shrubland
Formation name	III.B.2.N.a	Temperate cold-deciduous shrubland

Local description: This alliance is not a recognized NVCS alliance. This occurrence was documented by an observation point (ELMO.20) where *Artemisia dracunculus* was listed as a secondary type option for classification (Figure 3.4.4.3). Given the elevated amount of cover (15% - height class of 0.5–2.0 m) this polygon was mapped as this potential alliance. *Bouteloua gracilis* was the dominant species in the herbaceous stratum. This alliance was observed in several other points in the park, but encompassed an area less than the minimum mapping unit (0.5 ha; 1.24 acres).

Figure 3.4.4.2. *Atriplex canescens* / *Bouteloua gracilis* Shrubland.

3.4.4.2 Atriplex canescens / *Bouteloua gracilis* Shrubland

Translated name: Fourwing Saltbush / Blue Grama Shrubland
Unique identifier: CEGL001283
Classification approach: International Vegetation Classification (IVC)

Summary: This fourwing saltbush type is found in the southern Great Plains of the United States. Stands occur in dry barren flats, slopes, and bluffs. Soils are shallow, rocky, and alkaline. The vegetation is dominated by shrubs between 0.5 (19.7 in) and 1 m (39.4 in) tall. In Kansas, the dominant shrub is *Atriplex canescens* (fourwing saltbush), with associated species being *Rhus aromatica*, *Toxicodendron rydbergii* (western poison ivy) and *Yucca glauca*. The herbaceous layer of short-to-medium-tall grasses includes *Bouteloua gracilis* and *Bouteloua curtipendula*.

Classification confidence: 1–Strong

Vegetation hierarchy		
Formation class	III	Shrubland
Formation subclass	III.A	Evergreen shrubland
Formation group	III.A.5	Extremely xeromorphic evergreen shrubland
Formation subgroup	III.A.5.N	Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation name	III.A.5.N.b	Facultatively deciduous extremely xeromorphic subdesert shrubland
Alliance name	*Atriplex canescens* Shrubland Alliance	

Ecological systems placement	
Ecological system unique ID	**Ecological system name**
CES302.749	Sonora–Mojave Mixed Salt Desert Scrub
CES304.784	Inter-Mountain Basins Mixed Salt Desert Scrub

Global status: G3 (09Nov2005)

Rounded global status: G3–Vulnerable
Reasons: 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.
State status: S3 (30Jan2008)

U.S. distribution: AZ, CO, KS, NM?, TX?, UT
Global distribution: United States
Global range: This saltbush type is found in the southern Great Plains of the United States, from Kansas and Colorado southwest to Arizona and east to Texas.

Local description: This association was described by one observation point for the El Morro project area (Figure 3.4.4.2). The short shrub stratum was co-dominated by two species, represented by a cover class of 26–35% and a stratum height class of 0.5 to 1.0 m (19.7–39.4 in). *Artemisia* sp. was the more dominant of the two shrubs, with an estimated cover of 15%. The other shrub, *Atriplex canescens*, had an estimated cover of 10%. The herbaceous stratum had a cover range of 26–35% and was less than 0.5 m (19.7 in) in height. *Bouteloua gracilis* was the dominant species with a cover of 20%. *Yucca* sp. was the only additional significant species recorded in the field. The observation point was located on top of the mesa in El Morro NM and contained minimal slope (<1%). Litter and duff represented the majority of the ground cover (66–75%). Bare soil represented the majority of the remaining ground cover that was not litter or duff. Other associations nearby (<50 m; 164 ft) included *Pinus edulis* (*Juniperus monosperma*) / *Bouteloua gracilis* woodland.

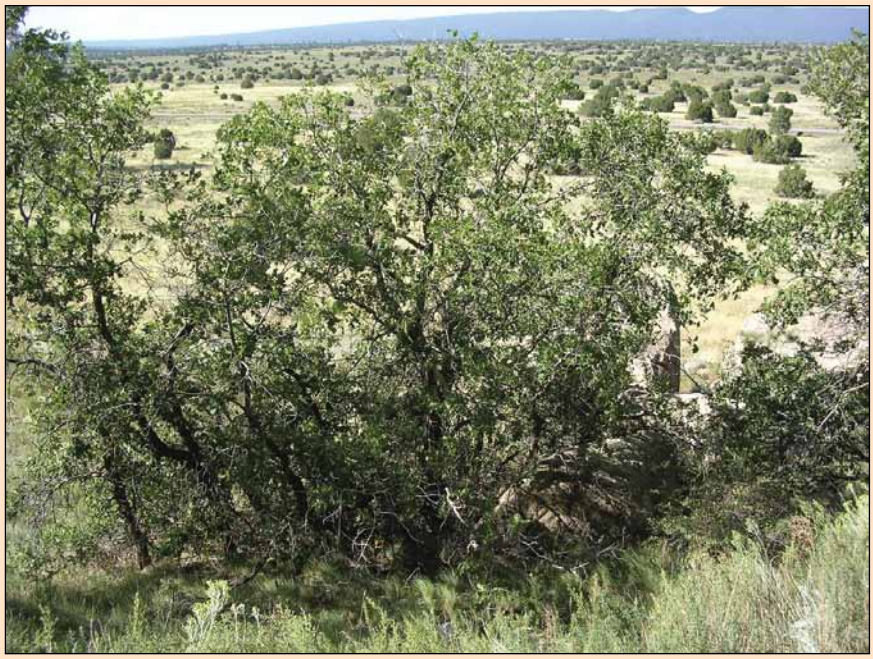


Figure 3.4.4.3. *Quercus gambelii* Shrubland Alliance.

3.4.4.3 Quercus gambelii Shrubland Alliance

Translated name: Gambel Oak Shrubland Alliance
Unique identifier: A.920
Classification approach: International Vegetation Classification (IVC)

Summary: This alliance contains shrublands dominated by *Quercus gambelii*. In western Texas, this alliance includes montane shrublands, 1–2 m (3.3–6.6 ft) tall, often forming dense thickets at the bases of ledges and bordering talus slopes at 1,524–2,530 m (5,000–8,300 ft) elevation. In Texas occurrences, associated species can include *Holodiscus dumosus* (oceanspray) and *Symphoricarpos oreophilus* (mountain snowberry). Additional species found in associations of this alliance include *Cercocarpus montanus*, *Carex geyeri* (Geyer's sedge), *Amelanchier alnifolia* (Saskatoon serviceberry), *Amelanchier utahensis* (Utah serviceberry), *Artemisia tridentata*, *Carex inops* (long-stolon sedge), *Paxistima myrsinites* (Oregon boxleaf), *Robinia neomexicana* (New Mexico locust), and *Symphoricarpos rotundifolius* (roundleaf snowberry).

Vegetation hierarchy		
Formation class	III	Shrubland
Formation subclass	III.B	Deciduous shrubland
Formation group	III.B.2	Cold-deciduous shrubland
Formation subgroup	III.B.2.N	Natural/Semi-natural cold-deciduous shrubland
Formation name	III.B.2.N.a	Temperate cold-deciduous shrubland

State status: SNR (30Jan2008)

Global distribution: Mexico?, United States
Global range: Shrublands included in this alliance occur in lower montane and canyon habitats throughout southern and western Colorado, Utah, Arizona, New Mexico, western Texas, and likely northern Mexico and south-central Wyoming.

Vegetation summary: Shrublands included in this alliance occur in the lower montane zone in

the Southern Rocky Mountains, Wasatch Plateau, and Uinta Mountains; mesas, desert mountains, and canyons in the Chihuahuan and Sonoran deserts and Colorado Plateau; and southern plains. Stands have a moderately dense to dense woody layer typically 2–5 m tall, but can also occur as 1-m-tall clumps to small trees over 5 m tall. The canopy is dominated by the broad-leaved deciduous shrub, *Quercus gambelii*, which occasionally reaches small-tree size. Stands range from dense thickets with little understory to relatively mesic mixed-shrublands with a rich understory of shrubs, grasses and forbs. These shrubs often have a patchy distribution, with grass growing in between. Scattered trees are occasionally present in stands and typically include species of *Pinus* or *Juniperus*. Characteristic shrubs that may co-occur include *Amelanchier alnifolia, Amelanchier utahensis, Artemisia tridentata, Cercocarpus montanus, Ptelea trifoliate* (common hoptree), *Prunus virginiana, Robinia neomexicana, Rosa* spp. (rose), *Symphoricarpos oreophilus*, and *Symphoricarpos rotundifolius*. The herbaceous layer is sparse-to-moderately dense, ranging from 1 to 40% cover. Perennial graminoids are the most abundant species, particularly *Bouteloua curtipendula, Bouteloua eriopoda* (black grama), *Bouteloua gracilis, Aristida* spp. (threeawn), *Carex inops, Carex geyeri, Elymus arizonicus* (Arizona wheatgrass), *Eragrostis* spp. (lovegrass), *Festuca* spp., *Koeleria macrantha, Muhlenbergia* spp., and *Hesperostipa* spp. Many forb and fern species can occur, but none have much cover. Commonly present forbs include *Achillea millefolium, Artemisia* spp. (sagebrush), *Geranium* spp. (geranium), *Maianthemum stellatum* (starry false lily of the valley), *Thalictrum fendleri* (Fendler's meadowrue), and *Vicia americana* (American vetch). Ferns include species of *Cheilanthes* (lipfern) and *Woodsia* (cliff fern). Annual grasses and forbs are seasonally present.

Vegetation structure summary: Vegetation in this shrubland alliance is characterized by a moderately dense cover of broad-leaved deciduous shrubs. The graminoid layer is sparse-to-moderately dense and dominated by medium-tall bunch grasses. The forb layer is generally sparse but may have high species diversity. Annual grasses and forbs are seasonally present.

Environmental summary: Shrublands included in this alliance occur in the foothills and lower slopes of isolated desert mountain ranges, mesas, and canyons from Nevada to western Texas, as well as in the lower montane zone of the southern Rocky Mountains, Uinta Mountains, and Wasatch Plateau. Elevations range from 1,550 to 2,950 m (5,085–9,678 ft). Climate is semi-arid. Summers are generally hot, and winters range from mild with cold periods and occasional snows in the southern part of its range to extended periods of freezing temperatures in the northern part of its range. The seasonality of precipitation varies, but most of the 35–70-cm (13.4–27.6-in) mean annual precipitation occurs during the growing season. Stands typically occur on nearly level-to-steep (to 80%), rocky slopes on upper slopes and ridgetops, but some stands occur in canyon bottoms and along drainages. Aspect does not seem important except in the southern range extent, where stands are restricted to the more mesic north slopes. Soils are generally deep, coarse-textured, and well-drained. Soil texture is typically a cobbly, gravelly, loamy sand and gravelly loams, but the alliance also occurs on well-drained clay soil. Parent materials are varied, and include quartzite, monzonite, shale, and alluvium. Adjacent vegetation at higher elevations is typically conifer woodlands or forests dominated by *Pinus ponderosa, Pinus contorta* (lodgepole pine), or *Pseudotsuga menziesii* (Douglas-fir), but *Populus tremuloides* (quaking aspen) forests are also common in the northern part of its range. Adjacent vegetation below these stands is often medium-tall grasslands in southeastern Colorado or shrublands dominated by *Artemisia* spp. in western Colorado.

Dynamics: The distribution of *Quercus gambelii* was studied by Neilson and Wullstein (1983) in respect to climatic patterns. They found the species to be limited by seedling mortality from severe spring frosts and summer drought. The northern extent of the species is in alignment with the winter polar front that runs along the boundary between southern Wyoming and Colorado and Utah. Its western range limit aligns with the westward extent of summer moisture from the Arizona monsoon, which approximates the western Arizona border. Reproducing stands in northern Utah that exist north of the summer monsoon moisture are restricted to more mesic sites. Seedling recruitment is more common in the southern part of its range than the northern (Neilson and Wullstein 1983). *Q. gambelii* is a fire-adapted species (Clary 1992). The root systems are well-developed and draw moisture from a large volume of soil allowing for rapid re-sprouting after fire. Muldavin et al. (1998b) reported that, in the Organ Mountains in southwestern New Mexico, after a severe fire, *Q.*

gambelii re-sprouted into a dense thicket that excluded both herbaceous understory and conifer species. They suggested frequent small cool fires would favor the establishment of conifers and maintain an herbaceous understory. *Q. gambelii* shrubs also re-sprout vigorously after stems are killed with almost all herbicides or removed by chaining or cut for firewood (Clary 1992). Altered fire regimes, fuelwood harvest, and grazing by livestock have significant impacts to the quality of sites. More study is needed to understand and manage these shrublands ecologically.

Local description: This alliance was relatively sparse in the El Morro project area, and was not supported by any field plots or observation points. *Quercus gambelii* (Gambel oak) dominated the shrub stratum, most often ranging in height from 2 to 5 m (6.6–16.4 ft) (Figure 3.4.4.1). The alliance was commonly found along the base of the mesa at El Morro. *Q. gambelii* was also a significant species in two additional alliances that fell within the project area. Within the *Pinus ponderosa* woodland alliance, the *Pinus ponderosa* / *Quercus gambelii* Woodland association was characterized by a tall shrub stratum dominated by the oak species. The second alliance was within the *Pinus edulis* - *Juniperus monospema* / *Quercus gambelii* Woodland association, characterized with oak species as a tall shrub, but in lesser quantities and found on mesa tops within the El Morro project area.

Figure 3.4.5.1. *Juniperus monosperma* Woodland Alliance.

3.4.5 Woodland

3.4.5.1 Juniperus monosperma Woodland Alliance

Translated name: One-seed Juniper Woodland Alliance
Unique identifier: A.504
Classification approach: International Vegetation Classification (IVC)

Summary: Woodlands in this alliance are dominated by *Juniperus monosperma*, and occur in the southern Rocky Mountains of Colorado, Arizona, and New Mexico, east to the northern Trans-Pecos and High Plains of Texas and Oklahoma. Common associates include *Quercus gambelii, Quercus pungens* (pungent oak), *Quercus mohriana* (Mohr oak), *Rhus trilobata*, *Agave lechuguilla* (lechuguilla), *Cercocarpus montanus*, *Dalea formosa* (featherplume), *Artemisia bigelovii*, *Artemisia tridentata, Andropogon hallii* (sand bluestem), *Bouteloua eriopoda, Bouteloua curtipendula, Sporobolus* spp., *Aristida* spp., and *Tridens* spp. In Texas, these woodlands occur over shallow soils on slopes.

Vegetation hierarchy		
Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland

State status: SNR (30Jan2008)

U.S. distribution: AZ, CO, NM, OK, TX, UT?
Global distribution: United States

Global range: Woodlands included in this alliance occur on dry sites on mesas, mountains, foothills, canyons, plateaus, and plains from eastern Arizona to western Texas, the Oklahoma panhandle, and north into southern Colorado. They may also occur in southern Utah.

Vegetation summary: Woodlands included in this alliance occur on dry sites in the foothills of the southern Rocky Mountains and in desert mountains, plateaus, mesas, canyons, and breaks from eastern Arizona to the southwestern Great Plains. Stands typically have a moderately sparse-to-moderately dense tree canopy, typically 2–7 m (6.6–23 ft) tall. Mature individuals range from 2 to 3-m (6.6–9.8-ft) tall scrub to large trees up to 12 m (39.4 ft) tall. Moderately sparse stands have an open canopy with trees distributed in patches, resembling a savanna, whereas the tree crowns touch in the moderately dense stands. The upper canopy is often solely dominated by the evergreen scale-leaved tree *Juniperus monosperma*, but one of two broad-leaved species, *Quercus gambelii* and *Quercus mohriana*, may co-dominate. Occasional *Pinus edulis* trees may also be present. At higher elevations, *Juniperus scopulorum* (Rocky Mountain juniper) may be present and, in the southern extent, Madrean evergreen woodland elements such as *Juniperus deppeana* (alligator juniper) and *Juniperus coahuilensis (= Juniperus erythrocarpa)* (redberry juniper) may be present, but not co-dominant. The understory ranges from a relatively rich mixture of evergreen and/or deciduous shrubs to a sparse or moderately dense herbaceous layer dominated by perennial grasses (with or without shrubs), to no vegetation at all. Most commonly, the understory is sparse and has a patchy distribution. Characteristic shrubs and dwarf-shrubs include *Agave lechuguilla, Artemisia bigelovii, Artemisia tridentata, Cercocarpus montanus, Dasylirion wheeleri* (common stool), *Fallugia paradoxa* (Apache plume), *Gutierrezia sarothrae, Krascheninnikovia lanata, Larrea tridentata, Nolina microcarpa* (sacahuista), *Opuntia* spp., *Quercus turbinella* (scrub oak), *Quercus X pauciloba* (wavyleaf oak), *Rhus trilobata*, and *Yucca* spp., depending on geography. The herbaceous layer is sparse to moderately dense, ranging from 1 to 40% cover. Perennial graminoids are the most abundant species, particularly *Bouteloua curtipendula, Bouteloua eriopoda, Bouteloua gracilis, Bouteloua hirsuta, Aristida* spp., *Erioneuron pilosum* (hairy woollygrass), *Pleuraphis jamesii (= Hilaria jamesii), Muhlenbergia* spp., *Achnatherum hymenoides (= Oryzopsis hymenoides), Piptatherum micranthum (= Oryzopsis micrantha)* (little-seed mountain ricegrass), *Schizachyrium scoparium* (little bluestem), *Sporobolus* spp., and *Hesperostipa* spp. *Andropogon hallii* occurs with *Artemisia filifolia* (sand sagebrush) as the understory in rare, deep sands habitats. Many forb species can occur, but few have much cover. Commonly present forbs include species of *Artemisia, Dalea* (prairieclover), *Eriogonum, Heterotheca* (false goldenaster), *Hymenoxys* (rubberweed), *Mirabilis* (four o'clock), *Penstemon* (penstemon), *Phlox* (phlox), *Physalis* (groundcherry), *Pediomelum (= Psoralea)* (breadroot), and *Zinnia*. Annual grasses and forbs are seasonally present.

Vegetation structure summary: Vegetation included in this alliance has a moderately sparse-to-moderately dense tree canopy that is typically 2–7 m (6.6–23 ft) tall (Figure 3.4.5.1). Stands are solely dominated by scale-leaved evergreen trees. Broad-leaved and needle-leaved evergreen trees may be present but do not co-dominate. A sparse-to-moderately dense shrub layer (0.5–3 m; 1.6–9.8 ft tall) may be present as a diverse mixture of broad-leaved and microphyllous deciduous or evergreen shrubs that are usually less than 3 m (9.8 ft) tall. Cacti and stem succulents are often present. A sparse-to-moderate layer that is dominated by perennial graminoids is usually present. Perennial forbs may be scattered. Annual forbs and grasses may be seasonally present.

Environmental summary: Stands included in this woodland alliance occur from eastern Arizona to western Texas and Oklahoma panhandle, and in the foothills in the southern Rocky Mountains. Stands also occur in the mountains, mesas, plateaus, piedmonts, canyons, escarpments, and other geographic breaks in the southern Great Plains. Elevations range from 1,200 to 2,100 m (3,937–6,890 ft). Climate is semi-arid, with drought not uncommon. Summers are generally hot, and winters range from mild with cold periods and occasional snows in southern New Mexico and Arizona, to cold with extended periods of freezing temperatures. The mean annual precipitation ranges from 30 to 48 cm (11.8–18.9 in). Stands occur from nearly level surfaces to steep, rocky slopes in canyons, on hillsides, and on mesa tops, but also occur on stream terraces and on deep sands. Aspect does not seem important except in elevational extremes for a given latitude. Low-elevation stands are restricted to the more mesic north slopes, whereas high-elevation stands

occur on south aspects. Sites are typically dry, with shallow, rocky, calcareous, alkaline soils. Soil textures range from sandy loam to clay soils typically derived from limestone, sandstone, or shale. Other parent materials include basalt, granite, dolomite, siltstone, and mixed alluvium. Adjacent vegetation at higher elevations is typically woodlands or forests dominated by *Pinus* and *Quercus* spp. Adjacent vegetation at lower elevations includes *Juniperus* savannas or *Artemisia*-dominated shrublands or grasslands.

Dynamics: *Juniperus monosperma* is extremely drought-tolerant. It is also non-sprouting and may be killed by fire (Wright et al. 1979). The effect of fire on a stand is largely dependent on the tree height and density, fine fuel load on the ground, weather conditions, and season (Wright et al. 1979, Dwyer and Pieper 1967). Trees are more vulnerable in open stands where fires frequently occur in the spring, the relative humidity is low, wind speeds are over 10–20 mph, and adequate fine fuels exist to carry fire (Fischer and Bradley 1987, Wright et al. 1979). Under other conditions, burns tend to be spotty, with low tree mortality. Large trees are generally not killed unless fine fuels, such as tumbleweeds, have accumulated beneath the tree to provide ladder fuels for the fire to reach the crown. Closed-canopy stands rarely burn because they typically do not have enough understory or wind to carry a fire. Altered fire regimes, tree-cutting for fencing, and improper grazing by livestock have significant impacts on the quality of sites. Livestock grazing can modify the fire regime by removing the fine fuels that carry fire. *J. monosperma* invasion into grasslands has occurred in places. Control efforts by chaining and prescribed burning have mixed results. More study is needed to understand and manage these woodlands ecologically.

Figure 3.4.5.2. *Juniperus monosperma* / *Bouteloua gracilis* Woodland.

3.4.5.2 Juniperus monosperma / *Bouteloua gracilis* Woodland

Translated name: One-seed Juniper / Blue Grama Woodland
Unique identifier: CEGL000710
Classification approach: International Vegetation Classification (IVC)
Classification confidence: 2–Moderate

Vegetation hierarchy		
Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	*Juniperus monosperma* Woodland Alliance	

Ecological systems placement	
Ecological system unique ID	**Ecological system name**
CES303.664	Southwestern Great Plains Canyon
CES304.767	Colorado Plateau Pinyon-Juniper Woodland
CES304.782	Inter-Mountain Basins Juniper Savanna
CES306.834	Southern Rocky Mountain Juniper Woodland and Savanna
CES306.835	Southern Rocky Mountain Pinyon-Juniper Woodland

Global status: G5 (23Feb1994)
Rounded global status: G5–Secure
State status: S5 (30Jan2008)

U.S. distribution: AZ, CO, NM
Global distribution: United States

Local description: This association was very common across the entire El Morro project area. A total of 5 field plots and 13 observation points described this association. The *Pinus edulis* (*Juniperus monosperma*) / *Bouteloua gracilis* association was also considered as a possible association during the classification process. In this association, *J. monosperma* and *P. edulis* are co-dominants, where *P. edulis* may be present with a small cover in some instances (Figure 3.4.5.2). The field plots classified as the *Juniperus monosperma* / *Bouteloua gracilis* association had either no *P. edulis* trees reported or *P. edulis* was present with less than or equal to 1% cover. In El Morro, the woodland stratum was found to be in the cover range of 16–25%, with heights ranging from 3 to 7 m. *J. monosperma* was the dominant tree species, ranging in cover from 5 to 20%. Additional trees found within this association included *P. edulis*, *Pinus ponderosa,* and *Juniperus scopulorum,* all found in sparse quantities (<1% cover). This association was highly variable in the structure of the understory species. Five of the eighteen field observations contained a distinct dwarf-shrub stratum (7–20% cover). Common dwarf-shrub species included *Tetradymia canescens*, *Chyrsothamnus viscidiflorus*, *Artemisia frigida,* and *Gutierrezia sarothrae*. Two observation points were dominated by *Hesperostipa comata* (15 and 20%), with *Bouteloua gracilis* as a subordinate species (10 and 7%). One plot had very little total herbaceous cover (3%). The remaining two plots were dominated by *B. gracilis* and seemed more typical of this association. Overall, the herbaceous stratum ranged in cover from 3 to 45%. *B. gracilis* was the most common grass species. Other grasses observed include *Hesperostipa comata*, *Bromus tectorum,* and *Sporobolus crpytandrus*. Common forb species included *Eriogonum* sp. and *Phlox gracilis*. All plots were located on terrain of little relief. Bare ground ranged from 25 to 65%. Cryptobiotic crust was also present in large amounts for all of the plots and ranged in cover from 10 to 45%. Vegetation types found nearby (<50 m; 164 ft) included *Bouteloua gracilis* Herbaceous Vegetation, *Bouteloua gracilis* Dwarf-Shrub Herbaceous Alliance, and *Hesperostipa comata - Bouteloua gracilis* Herbaceous Alliance.

3.4.5.3 Pinus edulis - (*Juniperus* spp.) Woodland Alliance

Translated name: Two-needle Pinyon - (Juniper species) Woodland Alliance
Unique identifier: A.516
Classification approach: International Vegetation Classification (IVC)

Summary: *Pinus edulis*-dominated woodlands occur in the mountains of Colorado, Utah, Arizona, and New Mexico, in the westernmost tip of the Oklahoma panhandle, and possibly in western Texas. Associated species can include *Juniperus monosperma, Juniperus osteosperma, Juniperus deppeana, Juniperus coahuilensis (= Juniperus erythrocarpa), Quercus arizonica* (Arizona white oak), *Cercocarpus montanus, Cercocarpus ledifolius, Arctostaphylos pungens* (pointleaf manzanita), *Artemisia tridentata, Rhus trilobata, Bouteloua gracilis, Andropogon hallii, Festuca arizonica* (Arizona fescue), *Muhlenbergia dubia* (pine muhly), and others.

Classification comments: *Pinus edulis* forest stands are not well differentiated from woodland stands. They occur on less-xeric sites within woodlands such as on north aspects and at higher elevation sites. Only one association currently exists, and more work is needed to clarify the differences between these two alliances.

The literature often describes *P. edulis* and *Juniperus* spp. vegetation types as one woodland type (P/J woodland). Both *P. edulis*-dominated associations and those co-dominated with *Juniperus* spp. are included in this alliance. More work is needed to clarify boundaries between this alliance and the *Juniperus* spp. alliances that may have scattered *P. edulis* trees. Also, a sparsely vegetated alliance may need to be developed because some *P. edulis* stands do not have enough cover to be classified as woodlands. See Francis (1986) for examples.

Comments: Forest stands are similar to the woodland stands except for a higher density of trees and typically a sparser understory. *Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) stands are separated from stands in the similar *Juniperus* spp. woodland alliances by the dominance or co-dominance of *P. edulis*. Associations placed in the alliances defined for *Juniperus* spp. do not have significant cover of *P. edulis* trees.

Vegetation hierarchy		
Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland

Global distribution: United States
Global range: Stands included in this woodland alliance are common on the Colorado Plateau and extend north into the Uinta Mountains, south in the northern mountains of the Sonoran and Chihuahuan deserts, and east to the lower montane zone of the southern Rocky Mountains. The alliance is also found on mesas and breaks of the southern Great Plains as far as the Oklahoma panhandle and into western Texas.

Vegetation summary: Woodlands included in this alliance occur on dry sites in the lower montane zone in the southern Rocky Mountains; mountains, mesas and canyons in the Chihuahuan and Sonoran deserts, and the Colorado Plateau; and breaks in the southern Great Plains. Stands have a moderately sparse-to-moderately dense tree canopy typically 3–12 m tall. Mature individuals range from 2–3-m-tall scrub to large trees up to 21 m tall. Moderately sparse stands have an open canopy with trees distributed in patches, whereas the tree crowns touch in the moderately dense stands. The upper canopy may be solely dominated by the evergreen needle-leaved tree *Pinus edulis*, but more commonly is co-dominated by one of several species of *Juniperus* or *Quer-*

cus, depending on geography. On the Colorado Plateau, *Juniperus osteosperma* may co-dominate, whereas *Juniperus monosperma* co-dominates in the eastern part of the woodland's range. At higher elevations, *Juniperus scopulorum* may be present and in the far southern extent, Madrean evergreen woodland species co-occur. These species include *Juniperus deppeana, Juniperus coahuilensis* (= *Juniperus erythrocarpa*) and the encinals, *Quercus arizonica, Quercus grisea* (gray oak), *Quercus X pauciloba*. The understory ranges from a relatively rich mixture of evergreen and/or deciduous shrubs, to a sparse-to-moderately dense herbaceous layer dominated by perennial grasses (with or without shrubs), to no vegetation at all. Most commonly, the understory is sparse and has a patchy distribution. Characteristic shrubs and dwarf-shrubs include *Artemisia tridentata, Cercocarpus montanus, Cercocarpus ledifolius, Coleogyne ramosissima* (blackbrush), *Ephedra viridis, Gutierrezia sarothrae, Lycium pallidum* (pale wolfberry), *Opuntia* spp., *Purshia mexicana* (Mexican cliffrose), *Purshia tridentata* (antelope bitterbrush), *Rhus trilobata*, and *Quercus gambelii*. Shrubs restricted to warmer southern latitudes include *Agave* spp. (agave), *Arctostaphylos pungens, Dasylirion wheeleri, Garrya* spp. (silktassel), *Nolina microcarpa, Quercus turbinella*, and *Yucca baccata* (banana yucca). The herbaceous layer is sparse to moderately dense, ranging from 1 to 30% cover. Perennial graminoids are the most abundant species, particularly *Bouteloua curtipendula, Bouteloua gracilis, Bouteloua hirsuta, Aristida* spp., *Festuca arizonica, Koeleria macrantha, Muhlenbergia* spp., *Achnatherum hymenoides (= Oryzopsis hymenoides), Piptatherum micranthum (= Oryzopsis micrantha), Poa fendleriana, Pseudoroegneria spicata*, and *Hesperostipa* spp. *Andropogon hallii* occurs as an understory species in rare, deep-sands habitats. Many forb species occur, but few have much cover. Commonly present forbs include species of *Artemisia, Eriogonum, Heterotheca, Mirabilis, Penstemon, Phlox, Senecio*, and *Zinnia*. Annual grasses and forbs are seasonally present.

Vegetation structure summary: Vegetation included in this alliance has a moderately sparse-to-moderately dense tree canopy that is typically 3–10 m (9.8–32.8 ft) tall. Stands are either solely dominated by evergreen needle-leaved trees or may be co-dominated by broad-leaved or scale-leaved evergreen trees. A sparse-to-moderately dense shrub layer (0.5–3 m) (1.6–9.8 ft) tall may be present. If present, the shrub layer ranges from a single species to a diverse mixture of broad-leaved and microphyllous deciduous or evergreen shrubs that are usually less than 3 m tall. A sparse-to-moderate ground layer dominated by perennial graminoids is usually present. Perennial forbs and cacti are often scattered throughout the stands. Annual forbs and grasses may be seasonally present.

Figure 3.4.5.4. *Pinus edulis* - (*Juniperus monosperma*) / *Bouteloua gracilis* Woodland.

3.4.5.4 Pinus edulis - (*Juniperus monosperma*) / *Bouteloua gracilis* Woodland

Translated name: Two-needle Pinyon - (One-seed Juniper) / Blue Grama Woodland
Unique identifier: CEGL002151
Classification approach: International Vegetation Classification (IVC)

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 1,525 to 2,444 m (5,000–8,000 ft), but may be higher in stands in southern New Mexico. Stands occur 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 vegetation is characterized by an open-to-moderately dense tree canopy (10–60% cover) co-dominated by *Pinus edulis* and *Juniperus monosperma,* with a grassy understory dominated by *Bouteloua gracilis*. *P. edulis* may be present with relatively small cover in some stands. *Juniperus deppeana* or *Juniperus coahuilensis* may replace *J. monosperma* in southern stands. Other species of *Juniperus,* such as *Juniperus scopulorum,* may be present at upper elevations. The shrub layer is sparse. If *Quercus gambelii* is present, it has less than 5% cover. Scattered *Agave* spp., *Cercocarpus montanus, Dasylirion wheeleri, Gutierrezia sarothrae, Opuntia* spp., or *Yucca* spp. may be present. The herbaceous layer is moderately dense to dense and is dominated by the warm-season, perennial shortgrass *B. gracilis*. Associated graminoids include *Aristida* spp., *Achnatherum hymenoides (= Oryzopsis hymenoides), Elymus elymoides, Koeleria macrantha, Hesperostipa comata (= Stipa comata), Hesperostipa neomexicana (= Stipa neomexicana), Muhlenbergia torreyi* (ring muhly), 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* (James' buckwheat), *Hymenopappus filifolius*, and *Mentzelia* spp. (blazingstar) are common.

Classification confidence: 2–Moderate
Classification 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, Chihuahuan Desert floristic affinities in *Pinus edulis* - (*Juniperus monosperma*) / *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 co-dominated by *Juniperus deppeana* in their southern extent. Stuever and Hayden (1997a) also described a *J. deppeana* phase (recognized by its dominance in the stand) and hillslope phase, which occurs on slopes of >15% and may have low grass cover (<5% cover). More survey is needed to fully understand the distribution and ecological relationships between these three species of *Juniperus*.

Vegetation hierarchy		
Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	

Ecological systems placement	
Ecological system unique ID	**Ecological system name**
CES304.767	Colorado Plateau Pinyon-Juniper Woodland
CES306.835	Southern Rocky Mountain Pinyon-Juniper Woodland

Global status: G5? (15Dec1994)
Rounded global status: G5–Secure
State status: S5 (30Jan2008)

U.S. distribution: AZ?, CO, NM, OK, TX?
Global distribution: United States
Global range: Southern Colorado, western Oklahoma, New Mexico, and possibly Texas and east-central Arizona.

Dynamics: *Pinus edulis* is extremely drought-tolerant and slow-growing (Powell 1988, Little 1987, Muldavin et al. 1998a). It is also non-sprouting and may be killed by fire (Wright et al. 1979). The effect of a fire on a stand is largely dependent on the tree height and density, fine fuel load on the ground, weather conditions, and season (Wright et al. 1979, Dwyer and Pieper 1967). Trees are more vulnerable in open stands where fires frequently occur in the spring, when the relative humidity is low, wind speeds are over 10–20 mph, and adequate fine fuels exist to carry fire (Wright et al. 1979). Under other conditions, burns tend to be spotty, with low tree mortality. Large trees are generally not killed unless fine fuels, such as tumbleweeds, have accumulated beneath the tree to provide ladder fuels for the fire to reach the crown (Jameson 1962). Closed-canopy stands rarely burn because they typically do not have enough understory or wind to carry a fire (Wright et al. 1979). Altered fire regimes, tree-cutting for fencing, and improper grazing by livestock have significant impacts on the quality of sites. Livestock grazing can modify the fire regime by removing the fine fuels that carry fire. Fire, livestock grazing, and trampling by recreationalists and vehicles disturb cryptogamic soil crusts that help maintain soil structure, reduce soil erosion, provide habitat for plants, and preserve biological diversity (Ladyman and Muldavin 1996). More study is needed to understand and manage these woodlands ecologically.

Local description: This association was the most frequent, and represents the greatest proportion

of the area, in the El Morro project area. A total of 20 field plots/observation points described this association. *Pinus edulis* and *Juniperus monosperma* co-dominated the tree canopy (Figure 3.4.5.4). *P. edulis,* at times, may account for a small percentage of the overall canopy cover (as low as 2% observed). Tree canopy cover ranged from 6 to 45%, with heights ranging from 3 to 7 m (9.8–23 ft). Scattered shrubs (<0.5 m; 1.6 ft) were sometimes present, ranging in cover from 0 to 15% among plots. Common shrubs included *Tetradymia canescens*, *Atriplex canescens*, *Chyrsothamnus viscidiflorus*, *Gutierrezia sarothrae,* and *Artemisia frigida*. The herbaceous stratum ranged in cover from 5 to 35%, and was dominated by *Bouteloua gracilis*. Associated species in the herbaceous stratum included *Sporobolus cryptandrus*, *Hesperostipa comata*, *Poa fendleriana*, *Eriogonum* sp., and *Tradescantia occidentalis*. Percent bare soil ranged from 10 to 50% and cryptobiotic crust 10–60%.

Figure 3.4.5.5. *Pinus edulis* – (*Juniperus monosperma*) / Sparse Woodland [Park Special]

3.4.5.5 Pinus edulis – (Juniperus monosperma) / Sparse Woodland [Park Special]

Translated name: Two-needle Pinyon – (One-seed Juniper) / Sparse Woodland [Park Special]
Unique identifier: A.516
Classification approach: International Vegetation Classification (IVC)

Summary: Data are not available.

Classification confidence: 3–Weak

Classification comments: This park special was identified on one polygon. It is documented with 7 supplementary observation points.

Vegetation hierarchy		
Formation class	II.	Woodland
Formation subclass	II.A	Evergreen Woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needleleaved
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name		

Ecological systems placement	
Ecological system unique ID	**Ecological system name**
CES304.767	Colorado Plateau Pinyon-Juniper Woodland

Global status: Not applicable
Rounded global status: Not applicable
State status: Not applicable

U.S. distribution: Not applicable
Global distribution: Not applicable
Global range: Not applicable

El Morro National Monument— This type occurs at its greatest extent on the top of the mesa that forms Inscription Rock, on the western side.

Local distribution: This park special was documented by eight supplementary observation points, ELMO WP-8, 10, 11, 12, 15, 16, 17, and 18. The canopy is dominated by *Pinus edulis* and J*uniperus monosperma* in the upper stratum, ranging from around 15-35%; there were no tall (> 1m) shrubs and the herbaceous understory was sparse (<1-3%). *Bouteloua gracilis* occured in many of the samples, but, rather being the dominant species in the understory, was co-dominant with *Aristida longiseta* and herbaceous broadleaf plants like *Eriogonum jamesii.* Low shrubs including *Gutierrezia sarothrae* and *Yucca baccata* occurred occasionally (ranging from <1-12%). Biotic crust was abundant in the samples, up to 75%.

3.4.5.6 Pinus edulis - Juniperus spp. / *Quercus gambelii* Woodland

Translated name: Two-needle Pinyon - Juniper species / Gambel Oak Woodland
Unique identifier: CEGL000791
Classification approach: International Vegetation Classification (IVC)

Summary: This widespread woodland association is known from the Colorado Plateau and southern Rocky Mountains, occurring from south-central Colorado to south-central New Mexico, west along the Mogollon Rim of Arizona, and north into Utah and western Colorado. Elevations normally range from 1,580 to 2,440 m (5,184–8,005 ft), but may be higher in stands in southern New Mexico. Sites are variable, but generally are relatively mesic. Stands occur on flat-to-moderate slopes along drainages and on mesa tops, and on moderate-to-steep, rocky slopes of foothills, mountains, and canyons, especially in draws where soil moisture is concentrated, on northern aspects or where shaded by upper canyon walls. Stands may occur on any aspects, but are less common on hot, south-facing slopes. The soils are variable and range from deep to shallow, silty clay to sandy loam, and often gravelly. Litter from *Quercus gambelii* and other shrubs is often extensive (over 50% cover). Parent materials include sandstone, limestone and rhyolite. The vegetation is characterized by an open-to-moderately dense tree canopy (10–60% cover) co-dominated by *Pinus edulis* and *Juniperus* spp. The species of *Juniperus* varies with geography and elevation. *J. monosperma* is common in north-central New Mexico and southern Colorado. *J. deppeana* is common in southern New Mexico, and *J. osteosperma* is common in northwestern New Mexico, northern Arizona and in Utah. *J. scopulorum* is more common in higher elevation stands. An occasional *Pinus ponderosa* tree may be present in some stands. *Q. gambelii* dominates the often patchy, moderately dense tall-shrub layer with at least 5% cover, but often over 25% cover. *Amelanchier utahensis, Cercocarpus montanus, Symphoricarpos oreophilus*, or species of *Yucca* and *Opuntia* are common shrub associates. Herbaceous cover is variable, ranging from sparse to moderately dense, but generally dominated by graminoids (>5% cover) with scattered forbs. Associated graminoids include *Achnatherum hymenoides (= Oryzopsis hymenoides), Bouteloua gracilis, Carex geyeri, Carex rossii* (Ross' sedge), *Elymus elymoides, Festuca arizonica, Koeleria macrantha, Muhlenbergia montana, Poa fendleriana*, and *Schizachyrium scoparium*. Common forbs may include *Artemisia frigida, Balsamorhiza sagittata* (arrowleaf balsamroot), *Geranium caespitosum* (pineywoods geranium), *Packera neomexicana* (New Mexico groundsel), *Thalictrum fendleri*, or *Vicia americana*.

Classification confidence: 2–Strong

Vegetation hierarchy		
Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland

Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	

State status: S5 (30Jan2008)

U.S. distribution: **AZ,** CO, NM, UT
Global distribution: United States
Global range: This woodland association occurs in foothills and mesas from southern Colorado to south-central New Mexico, west along the Mogollon Rim of Arizona, and north into Utah and western Colorado.

Dynamics: *Quercus gambelii* is adapted to fire and will re-sprout profusely after a burn, forming a dense thicket (Wright 1972). *Pinus edulis, Juniperus monosperma, J. osteosperma*, and *J. scopulorum* are killed or severely damaged by fire and do not re-sprout after burning (Wright et al. 1979). When burned, these woodlands will convert to oak shrublands. However, because *J. deppeana* re-sprouts after burning, it will not be eliminated from the site (Bassett 1987, Wright 1972). Frequent burning will reduce cover of both *Quercus gambelii* and *J. deppeana* (Erdman 1970, Kallender 1959).

Local description: This association was relatively sparse in the El Morro project area. A total of two field plots described this association, both occurring on the mesa top. *Pinus edulis* and *Juniperus monosperma* co-dominated the tree canopy. *Pinus ponderosa* was observed in one of the plots. Other species of significant cover included *Yucca baccata*, *Hymenopappus filifolius* (fineleaf hymenopappus), *Gutierrezia sarothrae*, *Muhlenbergia* sp., and *Opuntia erinacea* (grizzlybear pricklypear).

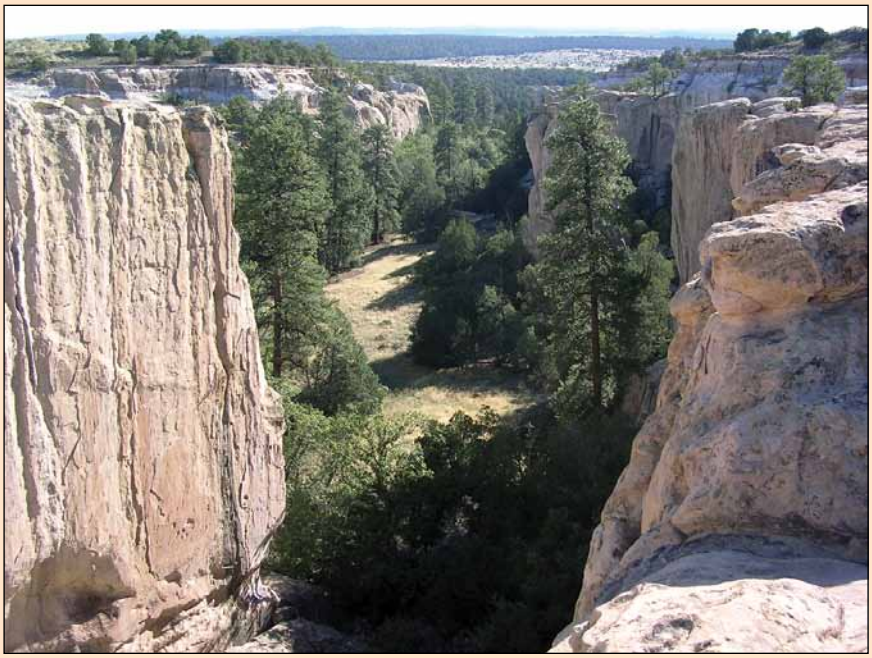


Figure 3.4.5.7. *Pinus ponderosa* Woodland Alliance.

3.4.5.7 Pinus ponderosa Woodland Alliance

Translated name: Ponderosa Pine Woodland Alliance
Unique identifier: A.530
Classification approach: International Vegetation Classification (IVC)

Summary: This alliance is one of the most widespread wooded alliances in the western United States; there are currently more than 50 plant associations in this alliance. The alliance is found throughout the western half of the U.S. and southwestern Canada, as well as the Trans-Pecos of Texas and the western portions of the Great Plains, such as in western Oklahoma and the Dakotas. Sites are dry/dry-mesic to xeric, and soils are generally well-drained and coarse-textured. *Pinus ponderosa* often dominates these woodlands, but co-dominant species may include *Pseudotsuga menziesii*, other *Pinus* species, and species of *Juniperus, Abies* (fir), or *Picea* (spruce). The understory ranges from dense shrub or graminoid layers to barren rock. The associated plant species vary with changes in geography and environmental conditions. Associated trees include species of *Pinus, Quercus, Juniperus, Abies, Pseudotsuga* (Douglas-fir), *Populus* (cottonwood), and *Picea*. Shrubs can include species of *Arctostaphylos* (manzanita), *Artemisia, Cercocarpus* (mahogany), *Ceanothus* (ceanothus), *Symphoricarpos* (snowberry), *Physocarpus* (ninebark), *Rosa, Purshia* (cliffrose), and others. Important graminoids include species of *Carex* (sedge), *Elymus* (wildrye), *Poa* (bluegrass), *Festuca, Muhlenbergia, Piptochaetium* (needlegrass), and many others.

Classification comments: Taxonomists (Kartesz 1999) recognize two varieties of *Pinus ponderosa*: a Pacific form, *Pinus ponderosa var. ponderosa*, and an interior form, *Pinus ponderosa var. scopulorum*. Associations dominated by either variety are included in this alliance. The classification status of all associations currently placed in the *Pinus ponderosa* Forest Alliance (A.124) should be reviewed and verified.

Comments: The *Pinus ponderosa* Woodland Alliance (A.530) is distinguished by the singular dominance of *P. ponderosa* in open stands (25–60% cover) occurring in non-wetland habitats and exhibiting an obvious woodland physiognomy. The presence of significant amounts of *Pseudotsuga menziesii* may make it difficult to separate some stands from communities in the II.A.4.N.a *Pinus*

ponderosa - Pseudotsuga menziesii Woodland Alliance (A.533). The abundance of graminoids typically found in dry and dry-mesic prairies is one diagnostic feature to separate many elements within this woodland alliance from those within the *Pinus ponderosa* Forest Alliance (A.124). However, some woodland elements are relatively mesic and contain mesophytic shrubs. The classification status and diagnostic characteristics for these elements need to be further elucidated.

Vegetation hierarchy		
Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	

U.S. distribution: AZ, CA, CO, ID, MT, ND, NE, NM, NV, OK, OR, SD, TX, UT, WA, WY
Canadian province distribution: BC
Global distribution: Canada, Mexico, United States

Global range: These woodlands occur in every state west of the Great Plains, as well as in British Columbia, Canada. East of the Rocky Mountains, they extend locally into North and South Dakota, Nebraska, Oklahoma, and Texas. The alliance is also found in northern Mexico.

Vegetation summary: This alliance includes woodlands dominated by *Pinus ponderosa*. Structurally, these are open woodlands or savannas with large, open growth-form *P. ponderosa* trees (generally) as the only canopy dominant (Figure 3.4.5.6). Average tree canopy cover ranges from 20 to 70%. The understory may include dense stands of shrubs or be dominated by grasses, sedges, or herbaceous species, although many of the associations are named for shrub species. Existing stands usually have younger cohorts of *P. ponderosa* present and may be less open than in the past. Associated trees and understory species vary widely across the range of this alliance. In the southern Rocky Mountains and the mountains of southern Arizona and New Mexico, associated trees include *Pseudotsuga menziesii, Abies concolor* (white fir), *Picea pungens* (blue spruce), *Pinus strobiformis* (southwestern white pine), *P. edulis, P. discolor* (border pinyon), *P. cembroides* (Mexican pinyon), *P. flexilis, Juniperus scopulorum*, and *Populus tremuloides*. In far southern stands, *Juniperus deppeana* may also be common. In the interior Pacific Northwest as far east as northwestern Montana, associated tree species may include *Pseudotsuga menziesii, Abies grandis* (giant fir), *Cercocarpus ledifolius, Pinus contorta, Larix occidentalis* (mountain larch), *Juniperus occidentalis*, or *Quercus garryana* (Oregon white oak). As in the southern Rockies, none of these trees are ever abundant in the canopy, but in some stands one or more may be successfully regenerating, particularly *A. grandis* or *P. menziesii*. A shrub layer may be prominent or nearly absent, depending on location and disturbance history. Common species include *Arctostaphylos uva-ursi* (kinnikinnick), *A. patula, A. pungens, A. nevadensis* (pinemat manzanita), *Artemisia tridentata, A. arbuscula* (little sagebrush), *A. nova, Amelanchier alnifolia, Cercocarpus montanus, C. ledifolius, Ceanothus greggii* (desert ceanothus), *C. fendleri* (Fendler's ceanothus), *C. velutinus* (snowbrush ceanothus), *Juniperus communis* (common juniper), *Purshia mexicana, P. tridentata*, and species of *Quercus, Ribes*, and *Symphoricarpos*. The herbaceous layer tends to vary inversely with shrub cover, but is composed primarily of graminoids. Important species include *Bouteloua gracilis, Carex geyeri, C. rossii, C. pensylvanica* (Pennsylvania sedge), *Koeleria macrantha, Leucopoa kingii (= Festuca kingii)* (spike fescue), *Muhlenbergia virescens* (screwleaf muhly), *M. montana, Achnatherum hymenoides (= Oryzopsis hymenoides), A. occidentale (= Stipa occidentalis)* (western needlegrass), *Pseudoroegneria spicata, Poa secunda, Elymus elymoides, Festuca idahoensis, F. arizonica*, and *Hesperostipa comata (= Stipa comata)*. Important or diagnostic forb species include *Aspidotis densa* (Indian's dream), *Wyethia mollis* (woolly mule-ears), *Balsamorhiza sagittata, Achillea millefolium, Sedum stenopeta-*

lum (wormleaf stonecrop), *Maianthemum racemosum (= Smilacina racemosa)* (feathery false lily of the valley), *Vicia americana*, and species of many other genera, such as *Erigeron, Lupinus* (lupine), *Fragaria* (strawberry), *Lathyrus* (pea), *Heterotheca, Arenaria* (sandwort), and *Antennaria* (pussytoes). In western Texas and Oklahoma, other associated species include *Piptochaetium fimbriatum* (pinyon ricegrass), *P. pringlei* (Pringle's speargrass), *Achnatherum lobatum (= Stipa lobata)* (littleawn needlegrass), *Bothriochloa barbinodis (= var. barbinodis)* (cane bluestem), *Schizachyrium scoparium var. scoparium (=* ssp. *neomexicanum), Muhlenbergia rigida* (purple muhly), and *Panicum bulbosum* (bulb panicgrass). Woodlands of the Black Hills and the surrounding region have somewhat unique species assemblages not found elsewhere. Tree associates include *Picea glauca* (Black Hills spruce), *Quercus macrocarpa* (bur oak), *Populus tremuloides, Betula papyrifera* (paper birch), and *Juniperus scopulorum*. Characteristic shrubs in these eastern stands include *Rhus trilobata, Physocarpus monogynus* (mountain ninebark), *Symphoricarpos albus* (common snowberry), *S. occidentalis, Shepherdia canadensis* (russet buffaloberry), *Arctostaphylos uva-ursi*, and *Rosa* spp. Many stands have an herbaceous understory composed of species from the adjacent mixed-grass prairie, including *Carex filifolia, Hesperostipa comata, Andropogon gerardii* (big bluestem), *Calamovilfa longifolia* (prairie sandreed), *Danthonia* spp., and *Schizachyrium scoparium*. In southwestern North Dakota, communities within this alliance do not cover large contiguous tracts. They are interrupted by other types of vegetation, usually grasslands (Potter and Green 1964). In the far west, these woodlands occur in summer dry valleys and foothills from southern Oregon to central California. Typical tree associates include *Calocedrus decurrens* (incense cedar), *Pinus sabiniana* (California foothill pine), *P. lambertiana* (sugar pine), *P. attenuate* (knobcone pine), *Pseudotsuga menziesii, Quercus* spp., and *Aesculus californica* (California buckeye). The understory typically contains shrub species from adjacent chaparral communities, including *Arctostaphylos patula, A. viscida* (sticky whiteleaf manzanita), *Ceanothus cuneatus* (buckbrush), *Toxicodendron diversilobum* (Pacific poison oak), *Frangula californica (= Rhamnus californica)* (California buckthorn), and *Symphoricarpos* spp. The herbaceous layer is typically sparse due to litter accumulation and is dominated by xerophytic forbs and grasses.

Vegetation structure summary: These are open woodland stands of needle-leaved evergreen trees 10–50 m (32.8–164 ft) in height. Pacific and southwestern stands often contain taller trees, whereas stands in the northern Great Plains are typically less than 15 m (49.2 ft) in height. Associated trees are primarily needle-leaved evergreen species, but cold-deciduous and broad-leaved evergreen trees may form a subcanopy. The understory is often shrubby, with either tall or short layers, and sclerophyllous or cold-deciduous species dominate. Where there is no shrub layer, grassy understories are common, but perennial forbs are important in some stands. Mosses and lichens can be conspicuous in some stands; thick litter and duff layers occur, as do rock outcrops on steep slopes.

Environmental summary: These woodlands typically occur at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forest. They occur across 20 degrees of latitude, from Canada well into northwestern Mexico. The quantity and timing of precipitation vary greatly across the range of the alliance, ranging from 25 to 60 cm (9.8–23.6 in) annually, with at least some seasonal drought. East of the Continental Divide and in the Southwest, summer precipitation predominates, whereas western stands receive most of their precipitation from westerly winter storms. Monsoonal summer rains can contribute a substantial proportion to the annual precipitation totals in the Southwest. Elevations decrease with increasing latitude, from less than 1,000 m (3,280 ft) in eastern Washington to over 2,750 m (9,022 ft) in southern Arizona and New Mexico. Stands occur at low elevations (<1,000 m; 3,280 ft) in the eastern Great Plains and west of the Cascade–Sierra axis. Fire is a key factor in maintaining the open canopies characteristic of these woodlands, but soil drought or infertility may be equally important in some areas. Soils are derived from igneous, metamorphic, and sedimentary materials and are characterized by good aeration and drainage, coarse textures, circumneutral to slightly acid pH, an abundance of mineral material, and periods of drought during the growing season. Some stands may occur as edaphic climax communities on very skeletal, infertile, and/or excessively drained soils, such as pumice, cinder or lava fields, and scree slopes. All slopes and aspects are represented, but moderately steep-

to-very steep slopes or ridgetops are the most common sites. Adjacent vegetation is highly varied, but most commonly these woodlands grade into semi-arid steppe grasslands or shrublands at the lower elevation margins and closed forests of *Abies grandis*, *Abies concolor*, *Pseudotsuga menziesii*, or *Populus tremuloides* at the upper-elevation margins or adjacent more mesic sites. Adjacent drier sites can be dominated by *Juniperus scopulorum* or *Juniperus occidentalis* woodlands.

Dynamics: *Pinus ponderosa* is a drought-resistant, shade-intolerant conifer that usually occurs at lower treeline in the major ranges of the western United States. Historically, ground fires and drought were influential in maintaining open-canopy conditions in these woodlands. With settlement and subsequent fire suppression, stands have become more dense. Presently, many stands contain understories of more shade-tolerant species, such as *P. menziesii* and/or *Abies* spp., as well as younger cohorts of *P. ponderosa*. These altered stand structures have affected fuel loads and altered fire regimes. Presettlement fire regimes were primarily frequent (5–15-year return intervals), low-intensity ground fires triggered by lightning strikes or deliberately set fires by Native Americans. With fire suppression and increased fuel loads, fires are now less frequent and often become intense crown fires which can kill mature *P. ponderosa*. Establishment is erratic and believed to be linked to periods of adequate soil moisture and good seed crops, as well as fire frequencies which allow seedlings to reach sapling size. Longer fire intervals have resulted in many stands having dense subcanopies of overstocked and unhealthy young *P. ponderosa*.

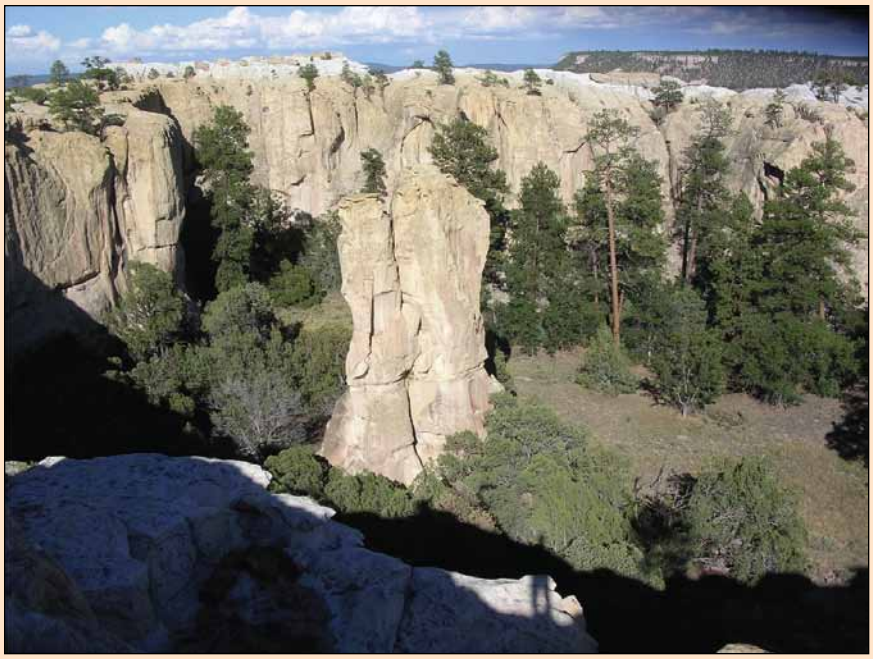


Figure 3.4.5.8. *Pinus ponderosa* / *Bouteloua gracilis* Woodland.

3.4.5.8 Pinus ponderosa / *Bouteloua gracilis* Woodland

Translated name: Ponderosa Pine / Blue Grama Woodland
Unique identifier: CEGL000848
Classification approach: International Vegetation Classification (IVC)

Summary: This widespread woodland occurs at foothill and lower montane elevations from the southern Rocky Mountains, extending east on 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 on 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. The vegetation is characterized by an open-to-moderately dense evergreen, needle-leaved tree canopy, 10–30 m (32.8–98.4 ft) tall, that is either dominated by *Pinus ponderosa* or co-dominated by *P. ponderosa* and *P. edulis*. Species of *Juniperus* may be important subdominants. The typically moderately dense herbaceous layer has greater cover than the shrub layer, and is dominated by graminoids. *Bouteloua gracilis*, the warm-season, sod-forming, shortgrass, dominates the herbaceous layer. Common graminoid associates include *Aristida* spp., *Bouteloua hirsuta, Carex geophila* (White Mountain sedge), *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%). Other shrubs may include scattered *Artemisia tridentata, Ceanothus fendleri, Cercocarpus montanus, Ericameria nauseosa, Purshia tridentata, Rhus trilobata*, and *Tetradymia canescens*. Forb cover is typically sparse.

Classification confidence: 1–Strong

Classification comments: This ponderosa pine woodland is a broadly defined plant association. Stuever and Hayden (1997b) report six phases: the *Bouteloua gracilis, Schizachyrium scoparium, Andropogon hallii, Artemisia tridentata, Quercus grisea*, and *Quercus gambelii* phases. Hanks et al. (1983) described four phases of the *Pinus ponderosa* / *Bouteloua gracilis* habitat type from north-

ern 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.

Vegetation hierarchy		
Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	*Pinus ponderosa* Woodland Alliance	

State status: S5 (30Jan2008)

U.S. distribution: AZ, CO, NM, OK, TX?, UT, WY?
Global distribution: United States
Global range: 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.

Dynamics: Both diagnostic species are tolerant of ground fire. *Pinus ponderosa* develops thick, fire-resistant bark that protects it from ground fires (Bradley et al. 1992). *Bouteloua gracilis* resprouts after burning and is unharmed by fires in years with above-normal winter and spring precipitation, but can be severely damaged during drought years (Wright and Bailey 1980). Most *P. ponderosa* stands have relatively frequent fires (every 3–20 years), but fires are less frequent in dry, rocky stands, where ground fire is limited by lack of continuous fine fuels (Stuever and Hayden 1997b). Fire-return interval has generally increased because of active fire suppression and historic livestock grazing, which has reduced the fine fuels needed to carry ground fires (Madany and West 1980, Savage and Swetnam 1990). Absence of fire has led to large accumulations of ground fuel and has likely resulted in denser stands and invasion of less fire-adapted, shade-tolerant species such as *Pseudotsuga menziesii*. This has likely increased the risk of severe, stand-replacing crown fires.

Local description: This alliance was described by one field plot (Cully 43). The plot is located within one of the box canyons in the El Morro project area (Figure 3.4.5.7). The tree canopy was dominated by *Pinus ponderosa,* with *Pinus edulis* in the subcanopy. *Bouteloua gracilis* was the dominant understory species.

Figure 3.4.5.9. *Pinus ponderosa* / *Quercus gambelii* Woodland.

3.4.5.9 Pinus ponderosa / *Quercus gambelii* Woodland

Translated name: Ponderosa Pine / Gambel Oak Woodland
Unique identifier: CEGL000870
Classification approach: International Vegetation Classification (IVC)

Summary: This major 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 1,830 to 2,800 m (6,000–9,200 ft). 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. High litter cover (70–90%) about 5 cm (2 in) 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).

The *Pinus ponderosa* / *Quercus gambelii* Woodland type is characterized by a sparse-to-moderately dense evergreen needle-leaved tree canopy dominated by *Pinus ponderosa*, or sometimes co-dominated by *Pinus edulis* with scattered *Juniperus scopulorum, Juniperus monosperma*, or *Juniperus osteosperma*. In southern stands, *Juniperus deppeana* and *Pinus strobiformis* may be present to co-dominant. *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 *Q. gambelii*, but there is frequently more than 25%. At higher elevations, the *Q. 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, P. edulis*, and *J. osteosperma* are often present. Other common shrub species may include *Arctostaphylos patula, Amelanchier* spp., *Cercocarpus montanus, Juniperus communis, Mahonia repens, Robinia neomexicana, Rosa woodsii*,

and *Shepherdia rotundifolia* (roundleaf buffaloberry). 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* (longtongue muhly), *Muhlenbergia montana, Poa fendleriana, Schizachyrium scoparium*, and *Carex* spp., especially *Carex geyeri* and *Carex rossii*. Scattered forbs include *Artemisia ludoviciana* (white sagebrush), *Balsamorhiza sagittata, Eriogonum* spp., *Erigeron* spp., *Hymenoxys* spp., *Lithospermum multiflorum* (manyflowered stoneseed), *Packera multilobata* (lobeleaf groundsel), and *Wyethia amplexicaulis* (mule-ears).

Classification confidence: 1–Strong
Classification 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.

Vegetation hierarchy		
Formation class	II	Woodland
Formation subclass	II.A	Evergreen woodland
Formation group	II.A.4	Temperate or subpolar needle-leaved evergreen woodland
Formation subgroup	II.A.4.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation name	II.A.4.N.a	Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance name	*Pinus ponderosa* Woodland Alliance	

Ecological systems placement	
Ecological system unique ID	**Ecological system name**
CES306.032.784	Southern Rocky Mountain Ponderosa Pine Woodland

Global status: G5 (01Feb1996)
Rounded global status: G5–Secure
State status: S5 (30Jan2008)

U.S. distribution: AZ, CO, NM, NV, TX, UT
Global distribution: United States
Global range: 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.

Dynamics: *Pinus ponderosa* is a drought-resistant, shade-intolerant conifer that, when mature, has thick bark that allows it to withstand ground fires (Bradley et al. 1992). Natural fire frequency is estimated to be 3–20 years for this community (Youngblood and Mauk 1985). *Quercus gambelii* is a fire-adapted species with a well-developed root system that draws moisture from a large volume of soil, and allows for rapid re-sprouting after fire (Clary 1992). Both species are well-adapted to relatively frequent ground fires that prevent *Pseudotsuga menziesii* or *Abies concolor* from regenerating. These woodlands grade into *Abies concolor* / *Quercus gambelii* Forest (CEGL000261) or *Pseudotsuga menziesii* / *Quercus gambelii* Forest (CEGL000452) as sites become cooler and wetter (DeVelice et al. 1986). Mosaics of *P. ponderosa* stands with grass- or oak-dominated understories occur in response to different substrates with *Q. gambelii* dominating the rocky sites and grass understory woodland types (*Festuca* spp., *Muhlenbergia montana*) in areas with deeper soils (DeVelice et al. 1986, Peet 1981).

Local description: This association was rare and seemingly associated with the mesa area, includ-

ing the box canyon. Only one field observation described this association for the El Morro project area (Figure 3.4.5.9). The woodland canopy was dominated by *Pinus ponderosa* (25% cover), which ranged from 10 to 15 m (32.8–49.2 ft) in height. The subcanopy or tall shrub stratum was composed of *Quercus gambelii*. Several unknown graminoid species made up the herbaceous stratum (6–15%). Litter/duff accounted for the majority of the ground cover (86–95%).

Figure 3.4.5.10. *Pinus edulis* / Sparse Understory Forest.

3.4.5.10 Pinus edulis / Sparse Understory Forest

Translated name: Two-needle Pinyon / Sparse Understory Forest
Unique identifier: CEGL000795
Classification approach: International Vegetation Classification (IVC)

Summary: These forests and woodlands occur in foothills, mesas, plateaus and mountains of New Mexico, Arizona, and Utah. Sites are flat-to-moderately sloping, at elevations ranging from 1,980 to 2,290 m (6,500–7,500 ft). Stands frequently occur on less xeric northern and eastern exposures, but can occur on all aspects. Substrates are variable but often include eroded, shallow or coarse-textured substrates such as cinder (but not rock outcrops) that limit the growth of understory shrubs and herbaceous plants. Cover of tree litter is dense in some stands (Kennedy 1983). A moderately dense (more than 25% cover)-to-dense tree canopy with little or no understory characterizes the vegetation. The tree canopy is dominated by *Pinus edulis*. Other trees may co-dominate, especially one or more of several species of *Juniperus* that vary with geography. If other species of *Pinus* are present, they do not co-dominate. The sparse understory (<10% cover and usually <2%) may include scattered shrubs, dwarf-shrubs, succulents, grasses, and forbs, such as *Ageratina herbacea* (fragrant snakeroot), *Cercocarpus montanus, Fallugia paradoxa, Rhus trilobata, Gutierrezia sarothrae, Achnatherum hymenoides*, and species of *Poa, Opuntia, Yucca, Penstemon*, and *Phlox*.

Classification confidence: 1–Strong

Classification comments: The original concept of this association was of a nearly closed, *P. edulis*-dominated tree canopy that shaded out understory vegetation and often occurred on relatively mesic sites with high tree growth potential. However, the association also now includes fire-suppressed stands, woodlands growing on eroded or "badlands" substrates, and/or overgrazed stands that lack understory vegetation. These forests may actually be a product of fire suppression, fine-fuel reduction due to livestock grazing, and/or soil erosion, and may be present in degraded examples of other *Pinus edulis* associations (Stuever and Hayden 1997a). The association concept has been expanded to include more open-growing stands by Muldavin et al. (2000), who included stands under 20% tree cover.

Vegetation hierarchy		
Formation class	I	Forest
Formation subclass	I.A	Evergreen forest
Formation group	I.A.8	Temperate or subpolar needle-leaved evergreen forest
Formation subgroup	I.A.8.N	Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest
Formation name	I.A.8.N.b	Rounded-crowned temperate or subpolar needle-leaved evergreen forest
Alliance name	*Pinus edulis* Forest Alliance	

Ecological systems placement	
Ecological system unique ID	**Ecological system name**
CES304.767	Colorado Plateau Pinyon-Juniper Woodland
CES306.835	Southern Rocky Mountain Pinyon-Juniper Woodland

Global status: G5 (01Feb1996)
Rounded global status: G5–Secure
State status: S5 (30Jan2008)

U.S. distribution: AZ, NM, UT
Global distribution: United States

Global range: These woodlands are found locally on the Colorado Plateau, but likely are more widespread and occur throughout the range of *Pinus edulis*.

Dynamics: *Pinus edulis* is extremely drought-tolerant and slow-growing (Little 1987, Powell 1988, Muldavin et al. 1998a). It is also non-sprouting and may be killed by fire. However, fire frequency is relatively low because of the lack of continuous fine fuels needed to spread ground fire. When fire occurs, it will likely be severe, occurring under the extreme conditions (high winds) needed to carry a crown fire (Wright et al. 1979, Bradley et al. 1992). Active fire suppression and historic grazing by livestock, which have removed the fine fuels that carry fire, have likely altered fire regimes and may have contributed to the conversion of open woodlands to closed tree canopies with sparse understories. Subsequent erosion of bare soil can be expected to reduce site productivity (Baker et al. 1995).

Local description: This association was not well documented in the El Morro project area. Only one field observation point was located in the project area, describing one of the few forest associations for the project. The observation point was located on top of a small knoll, dominated by *Pinus edulis* with very little understory species (Figure 3.4.6.10). The forest canopy was estimated to be 45% cover. *Juniperus monosperma* was present at 3% cover. The tree canopy ranged from 2 to 5 m (6.6–16.4 ft) in height. *Bouteloua gracilis* was the most dominant understory species (1% cover). Ground cover was dominated by litter/duff and lichen-covered rocks. Litter/duff accounted for 56–65% of the ground cover, and lichen-covered rocks 36–45%. This association was surrounded by the *Pinus edulis* (*Juniperus monosperma*)/*Bouteloua gracilis* association. This association may be more prevalent outside of the park boundaries on the adjacent slopes. In the park, a lack of ladder fuels found in this vegetative class would make crown fire unlikely. If fire did occur, it would most likely be carried into this vegetative class from a neighboring vegetative class, and could be very severe (Andy Bundshuh, pers. comm., 2008).

3.5 Exotics/Non-native plants

Cully (2002) reported a total of six species that are considered either exotic or non-native to ELMO:

- *Bromus tectorum* (cheatgrass)
- *Erodium cicutarium* (filaree)
- *Sisymbrium altissimum* (tumblemustard)
- *Lactuca* sp. (lettuce)
- *Tragopogon* sp. (goatsbeard)
- *Verbascum thapsus* (common mullein)

A more recent species list for ELMO, compiled by Rink et al. (2009), has additional exotic and/or non-native species documented as occurring in the ELMO vicinity. This species list is included in Appendix C.

3.6 Cryptobiotic soils

Cryptobiotic crusts were pervasive throughout the park. The presence of such a continuous establishment of cryptobiotic crust may be due to the lack of grazing in ELMO over the last several decades. Of the 47 observation points collected, only two had no recorded occurrence of cryptograms. These two points (33 and 58) are on the mesa top, immediately north of the main butte adjacent to the cliff.

3.7 Photography

The digital photographs taken at each observation point, looking in each of the four cardinal directions from the center of the plot, were labeled with the observation point number and the direction in which they were taken. In addition, three extra photographs provided landscape views of ELMO. A total of 180 digital photographs were supplied with the database accompanying this project.

3.8 Photointerpretation and map units

When mapping vegetation in larger parks, it is common for several associations to be combined into one map unit, due to the difficulty of distinguishing similar associations on an aerial photograph. At ELMO, however, almost all delineated polygons within the park were visited and classified in situ. Therefore, at ELMO there was a one-to-one relationship of vegetation associations to map units. We mapped using 21 map units, of which 18 were vegetated (see Table 3.2).

3.9 Vegetation map

A total of 969 ha comprising ELMO and its environs were mapped. The area mapped within the park boundary was 419 ha. Twenty-one map units were used to describe the landscape. Of these, three were unvegetated map units. The most frequently mapped unit within the entire mapping area was One-seed Juniper / Blue Grama Woodland, occurring 39 times, ranging in size from 0.14 ha to 98.4 ha. The most abundant map unit in terms of area was Two-needle Pinyon - (One-seed Juniper) / Blue Grama Woodland, covering 239 ha, or about 26% of the project area, and 60% of the park. Polygon size ranged from <0.1 ha to 98.4 ha; mean polygon size was 5.4 ha.

Several vegetation codes described each polygon; project-specific vegetation codes, developed for this mapping effort, included considerable local detail. These project-specific vegetation codes were also cross-walked to several other codes, which will allow for analysis at various other scales and perspectives. These included two Anderson type land-cover codes (levels 1 and 2) and ecological system codes. Using these items, one can link to external databases that may supplement the information provided here.

This map (Figure 3.9) can be used at several different levels of complexity. A basic application of the vegetation map is to determine how much area a specific map class represents under certain topographical constraints, in order to identify potential habitat for a certain species of concern. Such a question could easily and quickly be answered through a combination of spatial queries. An example of a more sophisticated application of the vegetation map could be its use as an input into landscape models of fuel loadings or invasive species. These more advanced investigations may require the services of a GIS analyst.

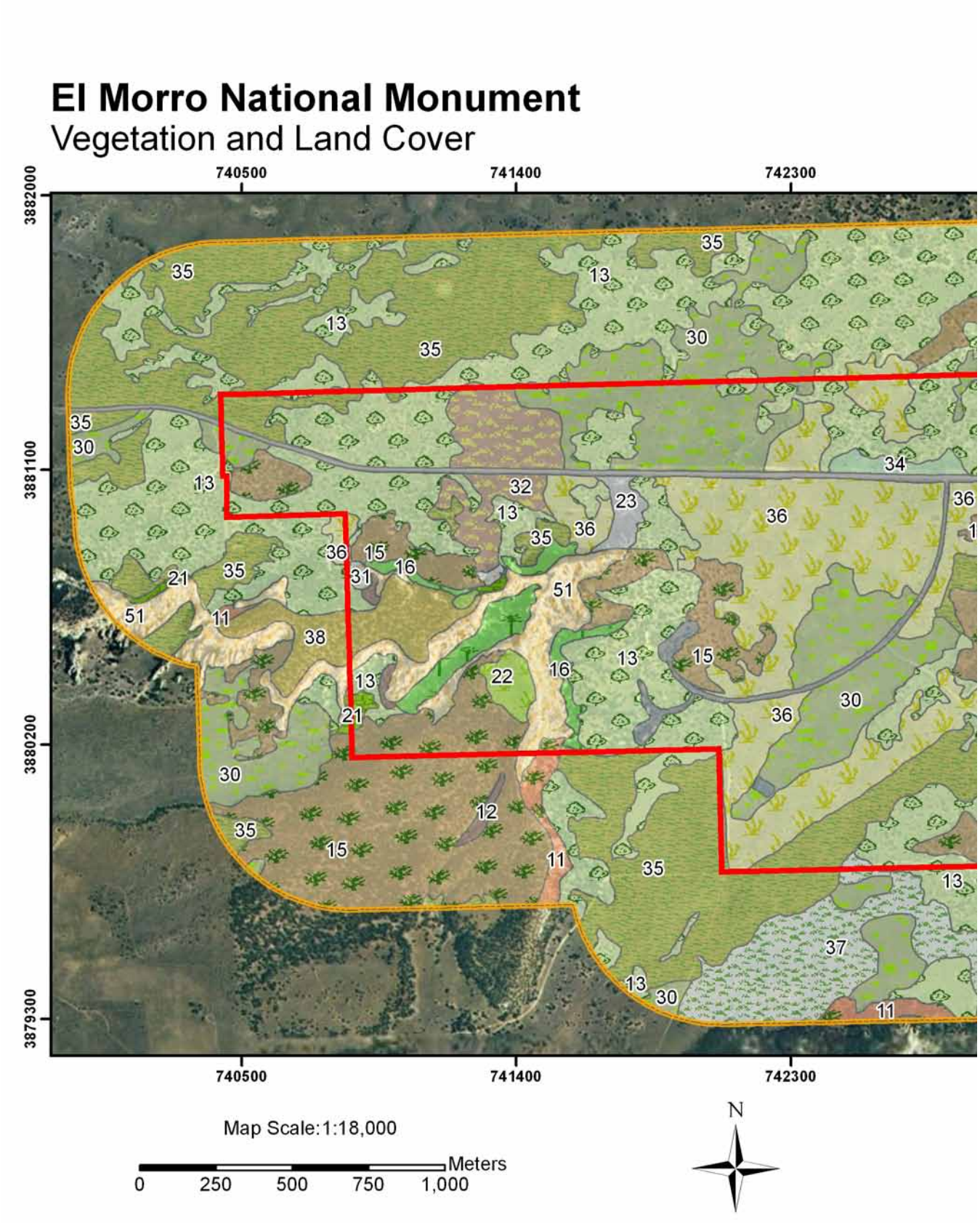
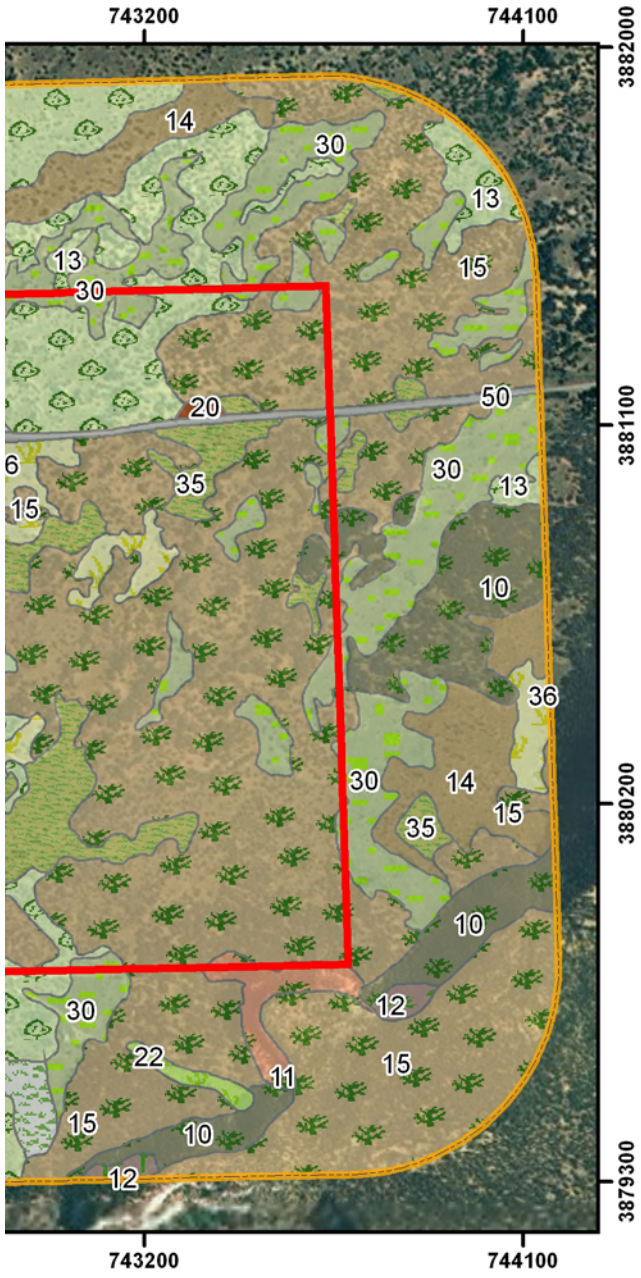


Figure 3.9. El Morro National Monument vegetation map.



Projection UTM
Datum NAD 83
Zone 12
Images - ESRI I3 Aerial Photography

Vegetation Type

Map Unit Code, Map Unit Name

- 10, Two-needle Pinyon / Sparse Understory Forest
- 11, Two-needle Pinyon - (Juniper species) Woodland Alliance
- 12, Ponderosa Pine Woodland Alliance
- 13, One-seed Juniper / Blue Grama Woodland
- 14, One-seed Juniper Woodland Alliance
- 15, Two-needle Pinyon - (One-seed Juniper) / Blue Grama Woodland
- 16, Ponderosa Pine / Gambel Oak Woodland
- 20, False Tarragon Shrubland Alliance
- 21, Gambel Oak Shrubland Alliance
- 22, Fourwing Saltbush / Blue Grama Shrubland
- 23, Winterfat Dwarf-shrubland Alliance
- 30, Blue Grama Dwarf-shrub Herbaceous Alliance
- 31, Cheatgrass Semi-natural Herbaceous Alliance
- 32, Needle-and-Thread - Blue Grama Herbaceous Alliance
- 34, Blue Grama - Sand Dropseed Herbaceous Vegetation
- 35, Blue Grama Herbaceous Vegetation
- 36, Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation
- 37, Weedy Forbs - Prairie Dog Colony
- 38, Two-needle Pinyon - (One-seed Juniper) / Sparse Woodland [Park Special]
- 50, Unvegetated Surface - Urban
- 51, Zuni Sandstone (Jz)
- Monument Boundary
- Buffer Area

Participating Agencies

4 Discussion

4.1 NVC classification

The vegetation at ELMO is fairly restricted, given the park's small size and minimal ecological amplitude (i.e., variability in environmental gradients, for instance, elevation, aspect, and slope). Prior to this effort, only a limited amount of vegetation work had occurred in the park (McCallum 1981a; McCallum 1981b; Stolz 1986; Cully 2002, Rink et al. 2009), the major focus of which was the inventorying of plant species, rather than the mapping of vegetation communities.

Using the NatureServe list and the field plots collected by Cully (2002) (see Section 3.2), a preliminary list of NVC vegetation types was created. An additional five vegetation types were documented as consistently occurring in ELMO as a result of the field work conducted in 2005. The different sampling schemes employed between the two collection efforts may have contributed to the observance of additional vegetation communities. Cully's plots were distributed systematically across the park, while the observation points were placed opportunistically, with the help of preliminary vegetation maps illustrating polygon boundaries (which help to guide the field crew to the representative types).

The data collected from plots during this project were fairly extensive, and observation points covered the majority of the area inside the monument boundary. Pinyon and juniper vegetation types outside the park seemed to be different than those in the park, based on aerial photo signatures. Areas such as these have been identified only to the alliance level, and remain tentative, subject to further field inquiries.

During the course of this investigation, no unexpected alliances or associations were encountered. However, the classification of some types was difficult, as not all plots or observation points fit neatly into predefined associations. It is for this reason that we classified many types only to the alliance level, rather than force them into dubious associations. Indeed, of the 22 described vegetation types or map units listed in Table 3.2, 12 remain at the alliance level and 10 are described to the association level. Of the alliance types, the False Tarragon Shrubland Alliance is not an existing type, and was created specifically for ELMO vegetation mapping project.

The NVC is a dynamic classification system, constantly being updated as additional field data are collected, local expertise is shared, and the vegetation community characteristics of more geographic regions are explored. The field data representing provisional vegetation types not represented by the NVC may eventually be used to create a preliminary vegetation alliance or association. In addition, documenting these vegetation types may encourage future vegetation-community inventories to focus on them. As additional data describing preliminary vegetation types are collected, the associated NVC descriptions will evolve.

Finally, it is important to recognize that although no NVC types dominated by the shrub, *Tetradymia canescens*, have been documented as occuring in New Mexico—and only one occurs in the entire U.S.—*T. canescens* may be the dominant shrub in some vegetation types in ELMO. All of the plots and observation points observed in ELMO contained *Bouteloua gracilis*. Common shrubs often found as codominates included *Artemisia frigida* and *Chrysothamnus viscidiflorus*. Due to the minimum mapping unit requirements and our ability to identify the shrub only from aerial photography, these plots were classified only to the alliance level. The alliance that best describes areas dominated by *T. canescens* is the Blue Grama Dwarf-shrub Herbaceous Alliance.

Certainly, not all investigators will agree with some of the vegetation designations described within this project; we invite all to submit their comments to NatureServe, which will ultimately decide upon inclusion, exclusion, or modification to the NVC.

4.2 Global rarity

Only designations given by NatureServe associations were matched to a global rarity. Of these, all but one were either G5 (Secure) or G4 (Apparently secure). The only exception was the Fourwing Saltbrush / Blue Grama Shrubland, identified on the mesa top adjacent to the Pueblo ruins. This type is ranked as G3 (Vulnerable), and represented only one polygon of the vegetation map. This polygon was sampled only with an observation point, and would benefit from a confirmation plot to firmly establish the association and ranking at ELMO.

4.3 Non-native species

Non-native species were abundant throughout the monument, and were characterized by *Bromus tectorum*, *Lactuca serriola*, *Verbascum thapsus*, *Sisymbrium altissimum*, and *Tragopogon* sp. Occurrences within plots or observation points were documented in the plot or observation data, and remain to be evaluated for possible management action.

4.4 Photointerpretation and map units

One of the benefits of mapping a small park, such as ELMO, is that one has the luxury of visiting almost every polygon within the park boundary. This enhances the potential to maintain a one-to-one relationship between map units and vegetation associations. In larger, more diverse parks, it is extremely costly (both temporally and monetarily) to visit each polygon, and map units may include a number of associations. At ELMO, all vegetated map units have a complete description that includes national characteristics and the local variations of vegetation types. There are areas outside the park that have aerial photo signatures different from those within and could probably be assigned to an association rather than just the alliance if permission could be obtained for a field visit.

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Appendix A: Soil Types

Map Unit 505: Flugle-Goesling loamy fine sands, 1–8% slopes

Flugle soils make up 55% of the map unit. The runoff class is medium. The depth to a restrictive feature is greater than 152 cm (60 in). This soil is well drained. The slowest soil permeability within a depth of 152 cm (60 in) is moderate. Available water capacity to a depth of 152 cm (60 in) is moderate, and shrink-swell potential is moderate. Annual flooding is none, and annual ponding is none. The minimum depth to a water table is greater than 1.8 m (6 ft). The maximum calcium carbonate equivalent within a depth of 102 cm (40 in) is 5%. The assigned Kw erodibility factor is 0.20. This component is not a hydric soil.

Typical profile

A: 0–5 in; loamy fine sand; neutral.
Bt: 5–41 in; sandy clay loam; slightly alkaline.
Bk: 41–61 in; sandy loam; moderately alkaline.

Goesling soils make up 25% of the map unit. The runoff class is high. The depth to a restrictive feature is greater than 152 cm (60 in). This soil is well drained. The slowest soil permeability within a depth of 152 cm (60 in) is moderately slow. Available water capacity to a depth of 152 cm (60 in) is moderate, and shrink-swell potential is low. Annual flooding is none, and annual ponding is none. The minimum depth to a water table is greater than 1.8m (6 ft). The maximum calcium carbonate equivalent within a depth of 102 cm (40 in) is 10%. The assigned Kw erodibility factor is 0.20. This component is not a hydric soil.

Typical profile

None provided

Map Unit 515: Rock outcrop-Vessilla-Mion complex, 3–55% slopes

Vessilla soils make up 20% of the map unit. The runoff class is medium. The depth to a restrictive feature is 15–51 cm (6 to 20 in) to bedrock (lithic). This soil is well drained. The slowest soil permeability within a depth of 152 cm (60 in) is moderately rapid. Available water capacity to a depth of 152 cm (60 in) is very low, and shrink-swell potential is low. Annual flooding is none, and annual ponding is none. The minimum depth to a water table is greater than 1.8 m (6 ft). The maximum calcium carbonate equivalent within a depth of 102 cm (40 in) is 10%. The assigned Kw erodibility factor is 0.24. This component is not a hydric soil.

Typical profile

A: 0–3 in; sandy loam; slightly alkaline.
C: 3–15 in; sandy loam; moderately alkaline.
R: 15–19 in; bedrock.

Mion soils make up 20% of the map unit. The runoff class is very high. The depth to a restrictive feature is 25–59 cm (10–20 in) to bedrock (paralithic). This soil is well drained. The slowest soil permeability within a depth of 152 cm (60 in) is impermeable. Available water capacity to a depth of 152 cm (60 in) is very low, and shrink-swell potential is high. Annual flooding is none, and annual ponding is none. The minimum depth to a water table is greater than 1.8 m (6 ft). The maximum calcium carbonate equivalent within a depth of 102 cm (40 in) is 5%. The assigned Kw erodibility factor is 0.32. This component is not a hydric soil.

Typical profile

None provided

Map Unit 555: Pinitos-Ribera sandy loams, 1–10% slopes

Pinitos soils make up 50% of the map unit. The runoff class is medium. The depth to a restrictive feature is greater than 152 cm (60 in). This soil is well drained. The slowest soil permeability within a depth of 152 cm (60 in) is moderate. Available water capacity to a depth of 152 cm (60 in) is high, and shrink-swell potential is low. Annual flooding is none, and annual ponding is none. The minimum depth to a water table is greater than 1.8 m (6 ft). The maximum calcium carbonate equivalent within a depth of 102 cm (40 in) is 10%. The assigned Kw erodibility factor is 0.32. This component is not a hydric soil.

Typical profile

A: 0–2 in; sandy loam; neutral.
Bt: 2–24 in; sandy clay loam; neutral.
Bk: 24–60 in; sandy loam; slightly alkaline.

Ribera soils make up 30% of the map unit. The runoff class is medium. The depth to a restrictive feature is 51–102 cm (20–40 in) to bedrock (lithic). This soil is well drained. The slowest soil permeability within a depth of 152 cm (60 in) is moderate. Available water capacity to a depth of 152 cm (60 in) is moderate, and shrink-swell potential is low. Annual flooding is none, and annual ponding is none. The minimum depth to a water table is greater than 1.8 m (6 ft). The maximum calcium carbonate equivalent within a depth of 102 cm (40 in) is 10%. The assigned Kw erodibility factor is 0.32. This component is not a hydric soil.

Typical profile

None provided

Map Unit 575: Teco-Atarque association, 1–8 % slopes

Teco soils make up 60% of the map unit. The runoff class is medium. The depth to a restrictive feature is greater than 152 cm (60 in). This soil is well drained. The slowest soil permeability within a depth of 152 cm (60 in) is moderately slow. Available water capacity to a depth of 152 cm (60 in) is high, and shrink-swell potential is moderate. Annual flooding is none, and annual ponding is none. The minimum depth to a water table is greater than 1.8 m (6 ft). The maximum calcium carbonate equivalent within a depth of 102 cm (40 in) is 10%. The assigned Kw erodibility factor is 0.37. This component is not a hydric soil.

Typical profile

A: 0–5 in; fine sandy loam; neutral.
Bt: 5–24 in; clay; moderately alkaline.
Bk: 24–60 in; gravelly very fine sandy loam; moderately alkaline.

Atarque soils make up 25% of the map unit. The runoff class is high. The depth to a restrictive feature is 20–51 cm (8–20 in) to bedrock (lithic). This soil is well drained. The slowest soil permeability within a depth of 152 cm (60 in) is moderate. Available water capacity to a depth of 152 cm (60 in) is very low, and shrink-swell potential is moderate. Annual flooding is none, and annual ponding is none. The minimum depth to a water table is greater than 1.8 m (6 ft). The assigned Kw erodibility factor is 0.32. This component is not a hydric soil.

Typical profile

A: 0–3 in; fine sandy loam; neutral.

Appendix B: Ecoregions of El Morro National Monument and Adjacent Lands

Ecoregions of El Morro National Monument

Ecoregions (Omernik 1987)

Ecoregion code: 23
Name: Arizona/New Mexico Mountains

Description: The Arizona/New Mexico Mountains are distinguished from neighboring mountainous ecoregions by their lower elevations and an associated vegetation indicative of drier, warmer environments, which is also due in part to the region's more southerly location. Forests of spruce, fir, and Douglas-fir, common in the southern Rockies and the Uinta and Wasatch Mountains, are only found in a few high-elevation parts of this region. Chaparral is common on the lower elevations, pinyon-juniper and oak woodlands are found on lower and middle elevations, and the higher elevations are mostly covered with open to dense ponderosa pine forests.

Ecoregions (Bailey 1995)

Domain: Dry Domain
Division: Tropical/Subtropical Regime Mountains
Province: Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province

Land-surface form: This area consists mostly of steep foothills and mountains, but includes some deeply dissected high plateaus. Elevations range from 1,370 to 3,000 m (4,500–10,000 ft), with some mountain peaks reaching as high as 3,840 m (12,600 ft). In many areas, the relief is higher than 900 m (3,000 ft). Isolated volcanic peaks rise to considerable heights in the northwest.

Vegetation: Vegetation zones resemble those of the Rocky Mountains but occur at higher elevations. The foothill zone, which reaches as high as 2,100 m (7,000 ft), is characterized by mixed grasses, chaparral brush, oak-juniper woodland, and pinyon-juniper woodland. At about 2,100 m (7,000 ft), open forests of ponderosa pine are found, although pinyon and juniper occupy south-facing slopes. In Arizona, the pine forests of this zone are strongly infused with Mexican species, including Chihuahuan and Apache pine. Pine forest is replaced at about 2,400 m (8,000 ft) on north-facing slopes (a little higher elsewhere) by Douglas-fir. Aspen is common in this zone, and limber pine grows in places that are rockier and drier.

Section: White Mountain-San Francisco Peaks Section

Ecoregions adjacent to ELMO

Ecoregions (Omernik 1987)

Ecoregion code: 22
Name: Arizona/New Mexico Plateau

Description: The Arizona/New Mexico Plateau represents a large transitional region between the semiarid grasslands and low relief tablelands of the Southwestern Tablelands ecoregion in the east, the drier shrublands and woodland covered higher-relief tablelands of the Colorado Plateau in the north, and the lower, hotter, less-vegetated Mojave Basin and Range in the west and Chihuahuan Deserts in the south. Higher, more forest-covered, mountainous ecoregions border the region on the northeast and southwest. Local relief in the region varies from a few meters on plains and mesa tops to well over 300 m along tableland side slopes.

Ecoregions (Bailey 1995)

Domain: Dry Domain
Division: Tropical/Subtropical Steppe Division
Province: Colorado Plateau Semi-Desert Province

Land-surface form: The Colorado Plateau Province consists of tablelands with moderate-to-considerable relief in Arizona, New Mexico, and Utah. Elevations of the plateau tops range from 1,500 to 2,100 m (5,000–7,000 ft), with local relief ranging from 150 to more than 900 m (500–3,000 ft) in some of the deeper canyons that dissect the plateaus (such as the Grand Canyon of the Colorado River). In some areas, volcanic mountains rise 300–900 m (1,000–3,000 ft) above the plateau surface. Stream valleys are narrow and widely spaced. The Colorado River, which crosses the northern part of the province, is the region's only large stream. Many other streams flow year-round, but the volume of water fluctuates considerably.

Vegetation: Vegetation zones are conspicuous but lack uniformity. In the lowest zone, there are arid grasslands, but the shortgrass sod seldom covers the ground completely, leaving many bare areas. Xeric shrubs often grow in open stands among the grasses, and sagebrush is dominant over extensive areas. A profusion of annuals and perennials blooms during the summer rainy season. At low elevations in the south, several kinds of cactus and yucca are common. Cottonwoods and, more rarely, other trees grow along some of the permanent streams. The woodland zone is the most extensive, dominated by open stands of two-needle pinyon pine and several species of juniper, often termed a pygmy forest. Between the trees the ground is sparsely covered by grama, other grasses, herbs, and various shrubs, such as big sagebrush and alderleaf cercocarpus. The montane zone extends over considerable areas on the high plateaus and mountains, but it is much smaller in area than the pinyon-juniper zone. Vegetation in the montane zone varies considerably from area to area. In the south, especially in Arizona, ponderosa pine is the dominant forest tree. Douglas-fir is associated with ponderosa pine or else grows in more sheltered locations or at higher elevations. In Utah, by contrast, lodgepole pine and aspen are dominant.

Appendix C. Plant Species List, El Morro National Monument*

Scientific name	Common name	Nativity**
Abronia fragrans Nutt. ex Hook.	sweet sand verbena	N
Achillea millefolium var. *occidentalis* DC.	common yarrow	N
Achnatherum hymenoides (Roemer & J.A.Schultes) Barkworth	Indian ricegrass	N
Achnatherum scribneri (Vasey) Barkworth	Scribner's needlegrass	N
Agastache pallidiflora ssp. *neomexicana* (Briq.) Lint & Epling	New Mexican giant hyssop	
Ageratina herbacea (Gray) King & H.E. Robins.	fragrant snakeroot	N
Agropyron cristatum (L.) Gaertn.	crested wheatgrass	E
Agrostis scabra Willd.	rough bentgrass	N
Alyssum minus (L.) Rothm.	European alyssum	E
Amaranthus hybridus L.	smooth pigweed	N
Amaranthus palmeri S. Wats.	Palmer's pigweed	
Amaranthus powellii S. Wats.	Powell's pigweed	N
Amaranthus torreyi (Gray) Benth. ex S. Wats.	Torrey's amaranthus	N
Ambrosia acanthicarpa Hook.	annual bursage	N
Ambrosia artemisiifolia L.	common ragweed	N
Ambrosia psilostachya DC.	perennial ragweed	N
Amelanchier utahensis Koehne	Utah serviceberry	N
Andropogon gerardii Vitman	big bluestem	N
Androsace occidentalis Pursh	western rockjasmine	N
Androsace septentrionalis ssp. *glandulosa* (Woot. & Standl.) St. John	pygmyflower rockjasmine	N
Androsace septentrionalis ssp. puberulenta (Rydb.) G.T. Robbins	pygmyflower rockjasmine	N
Antennaria marginata Greene	whitemargin pussytoes	N
Antennaria parvifolia Nutt.	little-leaf pussytoes	N
Antennaria rosea Greene	rose pussytoes	N
Arabis fendleri var. *fendleri* (S. Wats.) W.A. Weber	Fendler's rockcress	N
Arabis perennans (S. Wats.) W.A. Weber	perennial rockcress	N
Arenaria fendleri var. *brevifolia* (Maguire) Maguire	Fendler's sandwort	N
Arenaria fendleri var. *fendleri* Gray	Fendler's sandwort	N
Arenaria lanuginosa ssp. *saxosa* (Gray) Maguire	spreading sandwort	N
Aristida arizonica Vasey	Arizona threeawn	N
Aristida divaricata Humb. & Bonpl. ex Willd.	poverty threeawn	N
Aristida purpurea var. *longiseta* Nutt. (Steud.) Vasey	Fendler threeawn	N

* taken from Rink et al. 2009

**Nativity: N = native plant species, E = exotic, or not from the North American continent, H = horticultural (planted).

Scientific name	Common name	Nativity
Aristida schiedeana var. *orcuttiana* (Vasey) Allred & Valdés-Reyna	Orcutt's threeawn	N
Artemisia campestris var. *scouleriana* (Hook.) Cronq.	field sagewort	N
Artemisia carruthii Wood ex Carruth.	Carruth's sagewort	N
Artemisia dracunculus Pursh	false tarragon	N
Artemisia filifolia Torr.	sand sagebrush	N
Artemisia frigida Willd.	fringed sagebrush	N
Artemisia ludoviciana ssp. *albula* (Woot.) Keck	white sagebrush	N
Artemisia ludoviciana ssp. *sulcata* (Rydb.) Keck	Louisiana wormwood	N
Artemisia tridentata Nutt.	big sagebrush	N
Asclepias subverticillata (Gray) Vail	horsetail milkweed	N
Astragalus mollissimus var. *matthewsii* (S. Wats.) Barneby	Matthews' woolly milkvetch	N
Atriplex canescens (Pursh) Nutt.	fourwing saltbush	N
Bahia dissecta (Gray) Britt.	ragleaf bahia	N
Besseya arizonica Pennell	Arizona coraldrops	N
Bothriochloa ischaemum (L.) Keng	yellow bluestem	E
Bouteloua curtipendula (Michx.) Torr.	sideoats grama	N
Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	blue grama	N
Brickellia californica (Torr. & Gray) Gray	California brickellbush	N
Brickellia grandiflora (Hook.) Nutt.	mountain brickellbush	N
Bromus ciliatus L.	fringed brome	N
Bromus commutatus Schrad.	hairy brome	E
Bromus inermis Leyss.	smooth brome	E
Bromus japonicus Thunb. ex Murr.	Japanese brome	E
Bromus lanatipes (Shear) Rydb.	wooly brome	N
Bromus tectorum L.	cheatgrass	E
Camelina microcarpa DC.	littleseed falseflax	E
Carex duriuscula C.A. Mey.	spikerush sedge	N
Carex geophila Mackenzie	White Mountain sedge	N
Carex obtusata Lilj.	blunt sedge	N
Carex occidentalis Bailey	western sedge	N
Carex rossii Boott	Ross' sedge	N
Castilleja integra Gray	wholeleaf Indian paint-brush	N
Cenchrus echinatus L.	burgrass	N
Chaetopappa ericoides (Torr.) Nesom	smallflower aster	N
Chamaebatiaria millefolium (Torr.) Maxim.	fernbush	N
Chamaesyce micromera (Boiss. ex Engelm.) Woot. & Standl.	desert spurge	N
Chamaesyce serpyllifolia (Pers.) Small	thymeleaf sandmat	N
Chamaesyce serpyllifolia ssp. serpyllifolia (Pers.) Small	thymeleaf sandmat	N
Chenopodium fremontii S. Wats.	Fremont's goosefoot	N
Chenopodium graveolens Willd.	fetid goosefoot	N

Scientific name	Common name	Nativity
Chenopodium leptophyllum (Moq.) Nutt. ex S. Wats.	narrowleaf goosefoot	N
Chenopodium neomexicanum Standl.	New Mexico goosefoot	N
Chloris verticillata Nutt.	windmill grass	N
Chorispora tenella (Pallas) DC.	blue mustard	E
Chrysothamnus depressus Nutt.	dwarf rabbitbrush	N
Chrysothamnus greenei (Gray) Greene	Green's rabbitbrush	N
Chrysothamnus viscidiflorus ssp. *lanceolatus* (Nutt.) Hall & Clements	yellow rabbitbrush	
Cirsium neomexicanum Gray	New Mexico thistle	N
Cirsium undulatum (Nutt.) Spreng.	wavyleaf thistle	N
Cleome serrulata Pursh	Rocky Mountain beeplant	N
Commelina dianthifolia var. *longispatha* (Torr.) Brashier	birdbill dayflower	N
Convolvulus arvensis L.	European bindweed	E
Conyza canadensis (L.) Cronq.	horseweed	N
Cordylanthus wrightii Gray	Wright's bird's beak	N
Coreopsis tinctoria Nutt.	golden tickseed	N
Corydalis aurea ssp. *aurea* Willd.	golden corydalis	N
Corydalis curvisiliqua ssp. *occidentalis* (Engelm. ex Gray) W.A. Weber	curvepod fumewort	N
Cosmos parviflorus (Jacq.) Pers.	southwestern cosmos	N
Crassula aquatica (L.) Schoenl.	water pygmyweed	N
Crepis runcinata ssp. *glauca* (Nutt.) Babcock & Stebbins	fiddleleaf hawksbeard	N
Cryptantha cinerea var. jamesii Cronq.	James' cryptantha	
Cryptantha fendleri (Gray) Greene	Fendler's cryptantha	N
Cuscuta leptantha Engelm.	slender dodder	N
Cymopterus bulbosus A. Nels.	bulbous springparsley	N
Cymopterus multinervatus (Greene)	Jepson wild parsnip	N
Cyperus esculentus L.	yellow nutsedge	N
Cyperus fendlerianus Boeckl.	Fendler's flatsedge	N
Cyperus squarrosus L.	bearded flatsedge	N
Dalea candida var. *oligophylla* (Torr.) Shinners	white prairie clover	N
Dalea polygonoides Gray	sixweeks prairieclover	N
Descurainia californica (Gray) O.E. Schulz	Sierra tansymustard	N
Descurainia incana ssp. *viscosa* (Rydb.) Kartesz & Gandhi	(Rydb.) Kartesz & Gandhi	N
Descurainia obtusa ssp. *adenophora* (Greene) O.E. Schulz	blunt tansymustard	N
Descurainia obtusa ssp. *obtusa* (Greene) O.E. Schulz	blunt tansymustard	N
Descurainia pinnata ssp. *halictorum* (Cockerell) Detling	desert tansymustard	N
Descurainia sophia (L.) Webb ex Prantl	flixweed tansymustard	E
Dimorphocarpa wislizenii (Engelm.) Rollins	spectaclepod	N
Draba aurea Vahl ex Hornem.	golden whitlowgrass	N
Dracocephalum parviflorum Nutt.	American dragonhead	N
Drymaria glandulosa K. Presl	drymary	N
Drymaria leptophylla (Cham. & Schlecht.) Fenzl ex Rohrb.	canyon drymary	N

Scientific name	Common name	Nativity
Echeandia flavescens (J.A. & J.H. Schultes) Cruden	amberlily	N
Echinocereus coccineus Engelm.	scarlet hedgehog cactus	N
Echinocereus fendleri (Engelm.) F. Seitz	Fendler's hedgehog cactus	N
Echinochloa muricata var. *microstachya* Wieg.	rough barnyard grass	N
Elymus elymoides ssp. *brevifolius* (J.G. Sm.) Barkworth, comb. nov. ined.	squirreltail	N
Elymus trachycaulus (Link) Gould ex Shinners	slender wheatgrass	N
Elymus trachycaulus ssp. *trachycaulus* (Link) Gould ex Shinners	slender wheatgrass	N
Engelmannia peristenia Gray ex Nutt.	Engelmann's daisy	
Ephedra cutleri Peebles	Cutler's jointfir	
Eragrostis cilianensis (All.) Vign. ex Janchen	lovegrass	E
Eragrostis lehmanniana Nees Lehmann's	lovegrass	E
Eragrostis mexicana ssp. *mexicana* (Hornem.) Link	Mexican lovegrass	N
Eragrostis mexicana ssp. *virescens* (Hornem.) Link	Mexican lovegrass	N
Eragrostis pectinacea (Michx.) Nees ex Steud.	purple lovegrass	N
Ericameria nauseosa var. bigelovii (Gray) Nesom & Baird	rubber rabbitbrush	N
Ericameria nauseosa var. *glabrata* (Gray) Nesom & Baird	rubber rabbitbrush	N
Ericameria nauseosa var. *oreophila* (A. Nels.) Nesom & Baird	rubber rabbitbrush	N
Erigeron canus Gray	hoary fleabane	N
Erigeron concinnus (Hook. & Arn.) Torr. & Gray	spreading fleabane	N
Erigeron divergens Torr. & Gray	spreading fleabane	N
Erigeron flagellaris Gray	trailing fleabane	N
Erigeron speciosus (Lindl.) DC.	aspen fleabane	N
Eriogonum alatum L.	winged buckwheat	N
Eriogonum annuum Nutt.		
Eriogonum cernuum Nutt.	nodding buckwheat	N
Eriogonum jamesii var. *jamesii* Benth.	James' buckwheat	N
Eriogonum microthecum var. *laxiflorum* Hook.	slender buckwheat	N
Eriogonum microthecum var. *simpsonii* (Benth.) Reveal	Simpson's buckwheat	N
Eriogonum polycladon Benth.	sorrel buckwheat	N
Eriogonum racemosum Nutt.	redroot buckwheat	N
Erodium cicutarium (L.) L'Hér. ex Ait.	filaree	E
Erysimum capitatum (Dougl. ex Hook.) Greene	western wallflower	N
Erysimum repandum L.	spreading wallflower	
Escobaria vivipara var. *radiosa* (Engelm.) D.R. Hunt	spinystar	
Escobaria vivipara var. *vivipara* (Nutt.) Buxbaum	spinystar	N
*Euphorbia brachycer*a Engelm.	horned spurge	N
Fallugia paradoxa (D. Don) Endl. ex Torr.	Apache plume	N
Festuca arizonica Vasey	Arizona fescue	N
Festuca idahoensis Elmer	Idaho fescue	N
Fragaria virginiana ssp. *virginiana* Duchesne	Virginia strawberry	
Froelichia arizonica Thornb. ex Standl.	Arizona snakecotton	N
Gaillardia aristata Pursh	common gaillardia	

Scientific name	Common name	Nativity
Gaura coccinea Nutt. ex Pursh	scarlet guara	N
Gaura hexandra ssp. *gracilis* (Woot. & Standl.) Raven & Gregory	harlequinbush	N
Gaura mollis James	velvetweed	N
Geranium caespitosum var. *parryi* (Engelm.) W.A. Weber	Parry's geranium	N
Gilia ophthalmoides Brand	eyed gilia	N
Glandularia wrightii (Gray) Umber	Wright verbena	
Grindelia nuda var. *aphanactis* (Rydb.) Nesom	curlytop gummyweed	N
Gutierrezia sarothrae (Pursh) Britt. & Rusby	snakeweed	N
Hedeoma oblongifolia (Gray) Heller	false pennyroyal	N
Helianthus annuus L.	common sunflower	
Helianthus anomalus Heiser	western sunflower	
Helianthus petiolaris Nutt.	prairie sunflower	N
Heliomeris multiflora var. *multiflora* Nutt.	showy goldeneye	N
Hesperostipa comata (Trin. & Rupr.) Barkworth	needle and thread	
Hesperostipa comata ssp. *intermedia* (Scribn. & Tweedy) Barkworth	needle and thread	N
Heterosperma pinnatum Cav.	wingpetal	N
Heterotheca canescens (DC.) Shinners	hoary false goldenaster	N
Heterotheca villosa (Pursh) Shinners	hairy false goldenaster	N
Heuchera parvifolia Nutt. ex Torr. & Gray	littleaf alumroot	N
Hieracium fendleri Schultz-Bip.	yellow hawksbeard	N
Hoffmanseggia drepanocarpa Gray		
Holcus lanatus L.	velvetgrass	E
Hordeum jubatum L.	foxtail barley	N
Hordeum murinum ssp. *glaucum* (Steud.) Tzvelev	smooth barley	E
Hymenopappus filifolius var. *cinereus* (Rydb.) I.M. Johnston	fineleaf hymenopappus	N
Hymenopappus flavescens var. *canotomentosus* Gray	collegeflower	N
Hymenoxys richardsonii (Hook.) Cockerell	pingue	N
Ipomoea hederifolia L.	scarlet creeper	N
Ipomopsis longiflora (Torr.) V. Grant	white-flowered gilia	N
Ipomopsis multiflora (Nutt.) V. Grant	manyflowered ipomopsis	N
Juncus interior Wieg.	inland rush	N
Juncus saximontanus A. Nels.	Rocky Mountain rush	
Juniperus deppeana Steud.	alligator juniper	H (N)?
Juniperus monosperma (Engelm.) Sarg.	one-seed juniper	N
Juniperus scopulorum Sarg.	Rocky Mountain juniper	H (N)?
Kochia scoparia (L.) Schrad.	common kochia	E
Koeleria macrantha (Ledeb.) J.A. Schultes	prairie Junegrass	N
Krascheninnikovia lanata (Pursh) A.D.J. Meeuse & Smit	winterfat	N
Lactuca serriola L.	prickly lettuce	E
Laennecia schiedeana (Less.) Nesom	pineland marshtail	N
Lappula occidentalis var. *cupulata* (S. Wats.) Greene	flatspine stickseed	N

Scientific name	Common name	Nativity
Lappula occidentalis var. *occidentalis* (S. Wats.) Greene	flatspine stickseed	N
Lepidium densiflorum Schrad.	common pepperweed	N
Leptodactylon pungens (Torr.) Torr. ex Nutt.	common prickly gilia	N
Lesquerella rectipes Woot. & Standl.	straight bladderpod	N
Linum australe Heller	southern flax	N
Linum neomexicanum Greene	New Mexico yellow flax	N
Lithospermum incisum Lehm.	fringed puccoon	N
Lolium perenne ssp. *multiflorum* Lam.	Italian ryegrass	E
Lotus wrightii (Gray) Greene	Wright's deervetch	N
Lupinus kingii S. Wats.	King's lupine	N
Lycium pallidum Miers	pale wolfberry	N
Lycurus setosus (Nutt.) C.G. Reeder	bristly wolfstail	N
Machaeranthera canescens (Pursh) Gray	hoary aster	N
Machaeranthera gracilis (Nutt.) Shinners	slender goldenweed	N
Machaeranthera tanacetifolia (Kunth) Nees	tanseyleaf aster	N
Mahonia repens (Lindl.) G. Don	creeping barberry	N
Malva neglecta Wallr.	cheeseweed	E
Mammillaria wrightii Engelm.	Wright's pincushion cactus	N
Marrubium vulgare L.	horehound	E
Medicago lupulina L.	black medick	E
Medicago polymorpha L.	toothed medick	E
Melilotus alba Medikus	white sweetclover	E
Menodora scabra var. *scabra* Engelm. ex Gray	rough menodora	N
Mentzelia albicaulis (Dougl. ex Hook.) Dougl. ex Torr. & Gray	white blazingstar	N
Mirabilis decipiens (Standl.) Standl.	broadleaf four o'clock	N
Mirabilis glabra (S. Wats.) Standl.	smooth four o'clock	N
Mirabilis linearis (Pursh) Heimerl	narrowleaf four o'clock	N
Mirabilis multiflora (Torr.) Gray	Colorado four o'clock	N
Mirabilis oxybaphoides (Gray) Gray	spreading four o'clock	N
Monarda pectinata Nutt.	horsemint	N
Monarda punctata var. lasiodonta Gray	spotted beebalm	N
Muhlenbergia brevis C.O. Goodding	short muhly	N
Muhlenbergia dubia Fourn. ex Hemsl.	pine muhly	N
Muhlenbergia minutissima (Steud.) Swallen	annual muhly	N
Muhlenbergia montana (Nutt.) A.S. Hitchc.	mountain muhly	N
Muhlenbergia pauciflora Buckl.	New Mexico muhly	N
Muhlenbergia repens (J. Presl) A.S. Hitchc.	creeping muhly	N
Muhlenbergia richardsonis (Trin.) Rydb.	mat muhly	N
Muhlenbergia sinuosa Swallen	marshland muhly	N
Muhlenbergia torreyi (Kunth) A.S. Hitchc. ex Bush	ring muhly	N
Muhlenbergia wrightii Vasey ex Coult.	spike muhly	N
Nama dichotomum (Ruiz & Pavón) Choisy	nama	N

Scientific name	Common name	Nativity
Oenothera albicaulis Pursh	white-stem evening-primrose	N
Oenothera caespitosa ssp. *caespitosa* Nutt.	tufted evening-primrose	N
Oenothera coronopifolia Torr. & Gray crownleaf	evening-primrose	N
Oenothera elata ssp. *hirsutissima* (Gray ex S. Wats.) W. Dietr.	Hooker's evening-primrose	N
Oenothera flava (A. Nels.) Garrett	yellow evening-primrose	N
Oenothera pallida ssp. *trichocalyx* (Nutt.) Munz & W. Klein	pale evening-primrose	N
Opuntia imbricata (Haw.) DC.	walkingstick cholla	N
Opuntia phaeacantha Engelm.	brownspine pricklypear	N
Opuntia whipplei Engelm. & Bigelow	Whipple's cholla	N
Orobanche fasciculata Nutt.	tufted broomrape	N
Oxalis L.	woodsorrel	
Oxalis violacea L.	violet woodsorrel	
Packera multilobata (Torr. & Gray ex Gray) W.A. Weber & A. Löve	lobeleaf groundsel	N
Panicum bulbosum Kunth	bulb panicgrass	N
Panicum capillare L.	annual witchgrass	N
Panicum miliaceum ssp. *miliaceum* L.	broomcorn panic	E
Panicum virgatum L.	switchgrass	N
Pascopyrum smithii (Rydb.) A. Löve	western wheatgrass	N
Pennellia micrantha (Gray) Nieuwl.	mountain mock thelypody	N
Penstemon barbatus ssp. *torreyi* (Benth.) Keck	Torrey's penstemon	N
Penstemon barbatus ssp. *trichander* (Gray) Keck	beardlip penstemon	N
Penstemon crandallii ssp. *glabrescens* (Pennell) Keck	Crandall's beardtongue	N
Penstemon jamesii Benth.	James' beardtongue	N
Penstemon ophianthus Pennell	Arizona beardtongue	N
Penstemon virgatus Gray	upright blue beardtongue	N
Phacelia alba Rydb.	white scorpionweed	N
Phlox gracilis ssp. *gracilis* (Hook.) Greene	slender phlox	N
Phoradendron juniperinum Engelm. ex Gray	juniper miseltoe	N
Physalis hederifolia var. *fendleri* (Gray) Cronq. (cordifolia)	ivyleaf groundcherry	N
Physalis subulata var. *neomexicana* (Rydb.) Waterfall ex Kartesz & Gandhi	New Mexican groundcherry	N
Pinus edulis Engelm.	two-needle pinyon	N
Pinus ponderosa P.& C. Lawson	ponderosa pine	N
Piptatherum micranthum (Trin. & Rupr.) Barkworth	little-seed mountain rice-grass	N
Plantago argyraea Morris	saltmeadow plantain	N
Plantago patagonica Jacq.	woolly plantain	N
Poa annua L.	annual bluegrass	E
Poa bigelovii Vasey & Scribn.	Bigelow's bluegrass	N
Poa fendleriana (Scribn. & Williams) Soreng (*Poa longiligula*)	muttongrass	N
Poa fendleriana ssp. *longiligula* (Scribn. & Williams) Soreng (*Poa longiligula*)	muttongrass	N

Scientific name	Common name	Nativity
Poa pratensis L.	Kentucky bluegrass	E
Polygonum aviculare L.	prostrate knotweed	E
Polygonum convolvulus L.	climbing knotweed	E
Polygonum douglasii Greene	Douglas' knotweed	N
Polygonum erectum L.	erect knotweed	N
Polygonum ramosissimum Michx.	bushy knotweed	N
Portulaca halimoides L.	silkcotton purslane	N
Portulaca oleracea L.	common purslane	N
Potentilla pensylvanica L.	Pennsylvania cinquefoil	N
Pseudocymopterus montanus (Gray) Coult. & Rose	false springparsley	N
Pseudognaphalium pringlei (Gray) A. Anderb.	Pringle's cudweed	N
Psoralidium lanceolatum (Pursh) Rydb.	lemon scurfpea	N
Quercus gambelii Nutt.	Gambel oak	N
Quercus X pauciloba Rydb. (pro sp.)	wavyleaf oak	N
Ratibida columnifera (Nutt.) Woot. & Standl.	upright prairie coneflower	N
Ratibida tagetes (James) Barnh.	shortray prairie coneflower	N
Rhus trilobata var. *anisophylla* (Greene) Jepson	three-leaf sumac	N
Ribes cereum Dougl.	wax currant	N
Ribes cereum var. *pedicellare* Brewer & S. Wats.	whisky currant	
Rosa spinosissima L.	Scotch rose	E
*Rosa woodsi*i Lindl.	Woods' rose	
Rumex crispus L.	curly dock	E
Salsola collina Pallas	slender Russian thistle	E
Salsola tragus L.	Russian thistle	E
Salvia reflexa Hornem.	blue sage	N
Salvia subincisa Benth.	sawtooth sage	N
Sanvitalia abertii Gray	sanvitalia	N
Schedonorus pratensis (Huds.) S.J. Darbyshire	meadow ryegrass	E
Schizachyrium scoparium (Michx.) Nash	little bluestem	N
Schkuhria multiflora Hook. & Arn.	false threadleaf	N
Schoenocrambe linearifolia (Gray) Rollins	slimleaf plains mustard	N
Scorzonera laciniata L	cutleaf vipergrass	E
Senecio spartioides var. *multicapitatus* (Greenm. ex Rydb.) Welsh	ragwort groundsel	N
Setaria viridis (L.) Beauv.	bottlegrass	E
Setaria vulpiseta (Lam.) Roemer & J.A. Schultes (macrostachya)	plains bristlegrass	N
Silene laciniata Cav.	cardinal catchfly	N
Silene scouleri ssp. *pringlei* (S. Wats.) C.L. Hitchc. & Maguire	simple campion	
Sisymbrium altissimum L.	tumblemustard	E
Solanum jamesii Torr.	wild potato	N
Solanum physalifolium Rusby	ground-cherry nightshade	N
Solanum triflorum Nutt.	cutleaf nightshade	N

Scientific name	Common name	Nativity
Sorghastrum nutans (L.) Nash	Indian grass	N
Spergularia salina J.& K. Presl	salt sandspurry	N
Sphaeralcea coccinea (E.G. Baker) Kearn.	scarlet globemallow	N
Sphaeralcea digitata ssp. *digitata* (Greene) Rydb.	juniper globemallow	N
Sphaeralcea digitata ssp. *tenuipes* (Woot. & Standl.) Kearney	juniper globemallow	N
Sphaeralcea fendleri ssp. *fendleri* Gray	Fendler's globemallow	N
Sphaeralcea grossulariifolia ssp. pedata (Torr. ex Gray) Kearney	gooseberryleaf globemallow	
Sphaeralcea incana ssp. *cuneata* (Kearney) Kearney	soft globemallow	N
Sporobolus airoides (Torr.) Torr.	alkali sacaton	N
Sporobolus contractus A.S. Hitchc.	spike dropseed	N
Sporobolus cryptandrus (Torr.) Gray	sand dropseed	N
Stuckenia filiformis ssp. *filiformis* (Pers) Boerner	fineleaf pondweed	N
Symphoricarpos oreophilus var. *utahensis* (Rydb.) A. Nels.	Utah snowberry	N
Syringa vulgaris L.	common lilac	H
Tagetes micrantha Cav.	licorice marigold	N
Talinum parviflorum Nutt.	prairie flameflower	N
Taraxacum laevigatum (Willd.) DC.	red-seed dandelion	E
Tetradymia canescens DC. gray	horsebrush	N
Tetraneuris argentea (Gray) Parker	perkysue	N
Thalictrum fendleri var. *wrightii* (Gray) Trel.	Wright's meadowrue	N
Thelesperma megapotamicum (Spreng.) Kuntze	Hopi tea greenthread	N
Thlaspi montanum var. *montanum* L.	alpine pennycress	E
Tradescantia occidentalis var. *occidentalis* (Britt.) Smyth	prairie spiderwort	
Tradescantia pinetorum Greene	pinewoods spiderwort	N
Tragopogon dubius Scop.	common salsify	E
Tribulus terrestris L.	goathead	E
Tripterocalyx carnea var. *wootonii* (Standl.) L.A. Gal.	Wooton's sandpuffs	N
Typha latifolia L.	common cattail	N
Ulmus pumila L.	Siberian elm	H
Verbascum thapsus L.	common mullein	E
Verbena bracteata Lag. & Rodr.	prostrate verbena	N
Verbena macdougalii Heller	hillside verbena	N
Verbesina encelioides ssp. *encelioides* (Cav.) Benth. & Hook. f. ex Gray	golden crownbeard	N
Vicia americana ssp. *minor* (Hook.) C.R. Gunn	mat vetch	N
Vulpia myuros (L.) K.C. Gmel.	rattail fescue	E
Vulpia octoflora (Walt.) Rydb.	sixweeks fescue	N
Woodsia neomexicana Windham	New Mexico cliff fern	
Xanthium strumarium L.	cocklebur	N
Yucca angustissima Engelm. ex Trel	narrowleaf yucca	N
Yucca baccata Torr.	banana yucca	N

Appendix D: Look-up Tables

ID	Map_Unit	VEG_NAME	NVCS	FM_CLASS	FM_SUBCLASS
1	10	*Pinus edulis* / Sparse Understory Forest	CEGL000795	I–Forest	I.A–Evergreen forest
2	11	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	A.516	II–Woodland	II.A–Evergreen woodland
3	12	*Pinus ponderosa* Woodland Alliance	A.530	II–Woodland	II–Woodland
4	13	*Juniperus monosperma* / *Bouteloua gracilis* Woodland	CEGL000710	II–Woodland	II.A–Evergreen woodland
5	14	*Juniperus monosperma* Woodland Alliance	A.504	II–Woodland	II.A–Evergreen woodland
6	15	*Pinus edulis* - (*Juniperus monosperma*) / *Bouteloua gracilis* Woodland	CEGL002151	II–Woodland	II.A–Evergreen woodland
7	16	*Pinus ponderosa* / *Quercus gambelii* Woodland	CEGL000870	II–Woodland	II.A–Evergreen woodland
8	20	*Artemisia dracunculus* Shrubland Alliance	n/a	III–Shrubland	III.B–Deciduous shrubland
9	21	*Quercus gambelii* Shrubland Alliance	A.920	III–Shrubland	III.B–Deciduous shrubland
10	22	*Atriplex canescens* / *Bouteloua gracilis* Shrubland	CEGL001283	III–Shrubland	III.A–Evergreen shrubland
11	23	*Krascheninnikovia lanata* Dwarf-shrubland Alliance	A.1104	IV–Dwarf-shrubland	IV.A–Evergreen dwarf-shrubland
12	30	*Bouteloua gracilis* Dwarf-shrub Herbaceous Alliance	A.1571	V–Herbaceous Vegetation	V.A–Perennial graminoid vegetation
13	31	*Bromus tectorum* Semi-natural Herbaceous Alliance	A.1814	V–Herbaceous Vegetation	V.D–Annual graminoid or forb vegetation
14	32	*Hesperostipa comata* - *Bouteloua gracilis* Herbaceous Alliance	A.1234	V–Herbaceous Vegetation	V.A–Perennial graminoid vegetation
15	34	*Bouteloua gracilis* - *Sporobolus cryptandrus* Herbaceous Vegetation	CEGL001761	V–Herbaceous Vegetation	V.A–Perennial graminoid vegetation
16	35	*Bouteloua gracilis* Herbaceous Vegetation	CEGL001760	V–Herbaceous Vegetation	V.A–Perennial graminoid vegetation
17	36	*Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation	CEGL003495	V–Herbaceous Vegetation	V.A–Perennial graminoid vegetation
18	38	*Pinus edulis* – (*Juniperus monosperma*) / Sparse Woodland [Park Special]	n/a	II-Woodland	II.A – Evergreen woodland
19	50	Unvegetated Surface - Urban	n/a	n/a	n/a
20	37	Weedy Forbs - Prairie Dog Colony	n/a	n/a	n/a
21	51	Zuni Sandstone (Jz)	n/a	n/a	n/a

ID	Map_Unit	FM_GROUP	FM_SUBGROUP
1	10	I.A.8–Temperate or subpolar needle-leaved evergreen forest	I.A.8.N–Natural/Semi-natural temperate or subpolar needle-leaved evergreen forest
2	11	II.A.4–Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N–Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
3	12	II.A.4–Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N–Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
4	13	II.A.4–Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N–Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
5	14	II.A.4–Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N–Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
6	15	II.A.4–Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N–Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
7	16	II.A.4–Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N–Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
8	20	III.B.2–Cold-deciduous shrubland	III.B.2.N–Natural/Semi-natural cold-deciduous shrubland
9	21	III.B.2–Cold-deciduous shrubland	III.B.2.N–Natural/Semi-natural cold-deciduous shrubland
10	22	III.A.5–Extremely xeromorphic evergreen shrubland	III.A.5.N–Natural/Semi-natural extremely xeromorphic evergreen shrubland
11	23	IV.A.2–Extremely xeromorphic evergreen dwarf-shrubland	IV.A.2.N–Natural/Semi-natural extremely xeromorphic evergreen dwarf-shrubland
12	30	V.A.8–Temperate or subpolar grassland with a sparse dwarf-shrub layer	V.A.8.N–Natural/Semi-natural temperate or subpolar grassland with a sparse dwarf-shrub layer
13	31	V.D.2–Temperate or subpolar annual grasslands or forb vegetation	V.D.2.N–Natural/Semi-natural temperate or subpolar annual grasslands or forb vegetation
14	32	V.A.5–Temperate or subpolar grassland	V.A.5.N–Natural/Semi-natural temperate or subpolar grassland
15	34	V.A.5–Temperate or subpolar grassland	V.A.5.N–Natural/Semi-natural temperate or subpolar grassland
16	35	V.A.5–Temperate or subpolar grassland	V.A.5.N–Natural/Semi-natural temperate or subpolar grassland
17	36	V.A.7–Temperate or subpolar grassland with a sparse shrub layer	V.A.7.N–Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer
18	38	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
19	50	n/a	n/a
20	37	n/a	n/a
21	51	n/a	n/a

ID	Map_Unit	FORMATION	ALLIANCE
1	10	I.A.8.N.b–Rounded-crowned temperate or subpolar needle-leaved evergreen forest	*Pinus edulis* Forest Alliance
2	11	II.A.4.N.a–Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	*Pinus edulis*–(Juniperus spp.) Woodland Alliance
3	12	II.A.4.N.a–Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	*Pinus ponderosa* Woodland Alliance
4	13	II.A.4.N.a–Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	*Juniperus monosperma* Woodland Alliance
5	14	II.A.4.N.a–Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	*Juniperus monosperma* Woodland Alliance
6	15	II.A.4.N.a–Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	*Pinus edulis*–(Juniperus spp.) Woodland Alliance
7	16	II.A.4.N.a–Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	*Pinus ponderosa* Woodland Alliance
8	20	III.B.2.N.a–Temperate cold-deciduous shrubland	*Artemisia dracunculus* Shrubland Alliance
9	21	III.B.2.N.a–Temperate cold-deciduous shrubland	*Quercus gambelii* Shrubland Alliance
10	22	III.A.5.N.b–Facultatively deciduous extremely xeromorphic subdesert shrubland	*Atriplex canescens* Shrubland Alliance
11	23	IV.A.2.N.a–Extremely xeromorphic evergreen subdesert dwarf-shrubland	*Krascheninnikovia lanata* Dwarf-shrubland Alliance
12	30	V.A.8.N.a–Short temperate or subpolar lowland grassland with a sparse needle-leaved or microphyllous dwarf-shrub layer	*Bouteloua gracilis* Dwarf-shrub Herbaceous Alliance
13	31	V.D.2.N.d–Short temperate annual grassland	*Bromus tectorum* Semi-natural Herbaceous Alliance
14	32	V.A.5.N.c–Medium-tall sod temperate or subpolar grassland	*Hesperostipa comata–Bouteloua gracilis* Herbaceous Alliance
15	34	V.A.5.N.e–Short sod temperate or subpolar grassland	*Bouteloua gracilis* Herbaceous Alliance
16	35	V.A.5.N.e–Short sod temperate or subpolar grassland	*Bouteloua gracilis* Herbaceous Alliance
17	36	V.A.7.N.j–Short temperate or subpolar grassland with a sparse microphyllous evergreen shrub layer	*Ericameria nauseosa* Shrub Short Herbaceous Alliance
18	38	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance
19	50	n/a	n/a
20	37	n/a	n/a
21	51	n/a	n/a

ID	Map_Unit	ASSOCIATION	ECOSYS1_ID	ECOSYS1	ECOSYS2_ID
1	10	*Pinus edulis* / Sparse Understory Forest	CES304.767	Colorado Plateau Pinyon-Juniper Woodland	CES306.835
2	11				
3	12				
4	13	*Juniperus monosperma* / *Bouteloua gracilis* Woodland	CES303.664	Southwestern Great Plains Canyon	CES304.767
5	14		CES304.767	Colorado Plateau Pinyon-Juniper Woodland	CES306.835
6	15	*Pinus edulis* - (*Juniperus monosperma*) / *Bouteloua gracilis* Woodland	CES304.767	Colorado Plateau Pinyon-Juniper Woodland	CES306.835
7	16	*Pinus ponderosa* / *Quercus gambelii* Woodland	CES306.032	Southern Rocky Mountain Ponderosa Pine Woodland	
8	20				
9	21				
10	22	*Atriplex canescens* / *Bouteloua gracilis* Shrubland	CES302.749	Sonora-Mojave Mixed Salt Desert Scrub	CES304.784
11	23				
12	30				
13	31		CES303.672	Western Great Plains Shortgrass Prairie	CES303.817
14	32				
15	34	*Bouteloua gracilis* - *Sporobolus cryptandrus* Herbaceous Vegetation	CES302.735	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe	
16	35	*Bouteloua gracilis* Herbaceous Vegetation			
17	36	*Ericameria nauseosa* / *Bouteloua gracilis* Shrub Herbaceous Vegetation	CES304.787	Inter-Mountain Basins Semi-Desert Grassland	CES304.788
18	38				
19	50	n/a	n/a	n/a	n/a
20	37	n/a	n/a	n/a	n/a
21	51	n/a	n/a	n/a	n/a

ID	Map_Unit	ECOSYS2	ECOSYS3_ID	ECOSYS3	ECOSYS4_ID	ECOSYS4	ECOSYS5_ID
1	10	Southern Rocky Mountain Pinyon-Juniper Woodland					
2	11						
3	12						
4	13	Colorado Plateau Pinyon-Juniper Woodland	CES304.782	Inter-Mountain Basins Juniper Savanna	CES306.834	Southern Rocky Mountain Juniper Woodland and Savanna	CES306.835
5	14	Southern Rocky Mountain Pinyon-Juniper Woodland					
6	15	Southern Rocky Mountain Pinyon-Juniper Woodland					
7	16						
8	20						
9	21						
10	22	Inter-Mountain Basins Mixed Salt Desert Scrub					
11	23						
12	30						
13	31	Western Great Plains Foothill and Piedmont Grassland	CES304.787	Inter-Mountain Basins Semi-Desert Grassland			
14	32						
15	34						
16	35						
17	36	Inter-Mountain Basins Semi-Desert Shrub-Steppe					
18	38						
19	50	n/a	n/a	n/a	n/a	n/a	n/a
20	37	n/a	n/a	n/a	n/a	n/a	n/a
21	51	n/a	n/a	n/a	n/a	n/a	n/a

ID	Map_Unit	ECOSYS5	Anderson_ Level1_ID	Anderson_ Level1	Anderson_ Level2_ID	Anderson_ Level2	Global_ Status	Rounded_Global _Status
1	10		4	Forest Land	42	Evergreen Forest Land	G5	G5–Secure
2	11		4	Forest Land	42	Evergreen Forest Land		
3	12		4	Forest Land	42	Evergreen Forest Land		
4	13	Southern Rocky Mountain Pinyon-Juniper Woodland	4	Forest Land	42	Evergreen Forest Land	G5	G5–Secure
5	14		4	Forest Land	42	Evergreen Forest Land	G4	G4-Apparently Secure
6	15		4	Forest Land	42	Evergreen Forest Land	G5?	G5–Secure
7	16		4	Forest Land	42	Evergreen Forest Land	G5	G5–Secure
8	20		3	Rangeland	32	Shrub and Brush Rangeland.		
9	21		3	Rangeland	32	Shrub and Brush Rangeland.		
10	22		3	Rangeland	32	Shrub and Brush Rangeland.	G3	G3–Vulnerable
11	23		3	Rangeland	32	Shrub and Brush Rangeland.		
12	30		3	Rangeland	31	Shrub and Brush Rangeland.		
13	31		3	Rangeland	31	Shrub and Brush Rangeland.		
14	32		3	Rangeland	31	Shrub and Brush Rangeland.		G4 -Apparently Secure
15	34		3	Rangeland	31	Shrub and Brush Rangeland.	GNRQ	GNR–Not Yet Ranked
16	35		3	Rangeland	31	Shrub and Brush Rangeland.	G4Q	G4–Apparently Secure
17	36		3	Rangeland	31	Shrub and Brush Rangeland.	GNR	GNR–Not Yet Ranked
18	38		4	Forest Land	42	Evergreen Forest Land		
19	50	n/a	1	Urban or Built-up Land	17	Other Urban or Built-up Land.		
20	37	n/a	3	Rangeland	31	Shrub and Brush Rangeland.	n/a	n/a
21	51	n/a	7	Barren Land	74	Bare Exposed Rock	n/a	n/a

Appendix E. List of Plant Names Appearing in This Report

Scientific name	Common name
Abies sp.	fir
Abies concolor	white fir
Abies grandis	giant fir
Achillea millefolium	common yarrow
Achnatherum sp.	needlegrass
Achnatherum hymenoides (= Oryzopsis hymenoides)	Indian ricegrass
Achnatherum lobatum (= Stipa lobata)	littleawn needlegrass
Achnatherum occidentale (= Stipa occidentalis)	western needlegrass
Aesculus californica	California buckeye
Agave sp.	agave
Agave lechuguilla	lechuguilla
Ageratina herbacea	fragrant snakeroot
Ambrosia dumosa	burrobush
Amelanchier sp.	serviceberry
Amelanchier alnifolia	Saskatoon serviceberry
Amelanchier utahensis	Utah serviceberry
Andropogon gerardii	big bluestem
Andropogon hallii	sand bluestem
Antennaria	pussytoes
Arctostaphylos sp.	manzanita
Arctostaphylos nevadensis	pinemat manzanita
Arctostaphylos patula	greenleaf manzanita
Arctostaphylos pungens	pointleaf manzanita
Arctostaphylos uva-ursi	kinnikinnick
Arctostaphylos viscida	sticky whiteleaf manzanita
Arenaria sp.	sandwort
Aristida sp.	threeawn
Aristida purpurea	purple threeawn
Aristida purpurea var. longiseta (= Aristida longiseta)	Fendler's threeawn
Artemisia sp.	sagebrush
Artemisia arbuscula	little sagebrush
Artemisia bigelovii	Bigelow's sage
Artemisia cana	silver sagebrush
Artemisia dracunculus	false tarragon
Artemisia filifolia	sand sagebrush
Artemisia frigida	fringed sagewort
Artemisia ludoviciana	white sagebrush
Artemisia nova	black sagebrush
Artemisia tridentata	big sagebrush
Aspidotis densa	Indian's dream
Aster sp.	aster
Asteraceae sp.	sunflower
Astragalus purshii	woollypod milkvetch
Atriplex sp.	saltbush
Atriplex canescens	fourwing saltbush
Atriplex confertifolia	shadscale
Atriplex polycarpa	cattle saltbush
Balsamorhiza sagittata	arrowleaf balsamroot
Betula papyrifera	paper birch
Bothriochloa barbinodis (= var. barbinodis)	cane bluestem
Bouteloua curtipendula	sideoats grama
Bouteloua eriopoda	black grama
Bouteloua gracilis	blue grama
Bouteloua hirsuta	hairy grama
Bromus hordeaceus	soft brome
Bromus japonicus	Japanese brome
Bromus madritensis	compact brome
Bromus rigidus	ripgut brome
Bromus rubens	red brome
Bromus tectorum	cheatgrass
Calamovilfa longifolia	prairie sandreed
Calocedrus decurrens	incense cedar
Calochortus macrocarpus	sagebrush mariposa lily
Carex sp.	sedge
Carex duriuscula (= Carex eleocharis)	spikerush sedge
Carex filifolia	threadleaf sedge
Carex geophila	White Mountain sedge
Carex geyeri	Geyer's sedge
Carex inops	long-stolon sedge
Carex pensylvanica	Pennsylvania sedge
Carex rossii	Ross' sedge
Ceanothus sp.	ceanothus

Note: Whereas Appendix C is a species list for El Morro National Monument, this appendix provides a list of species specifically named in this report and appendices. Its purpose is solely to serve as a reference for readers of this report.

Scientific name	Common name
Ceanothus cuneatus	buckbrush
Ceanothus fendleri	Fendler's ceanothus
Ceanothus greggii	desert ceanothus
Ceanothus velutinus	snowbrush ceanothus
Cercocarpus sp.	mountain mahogany
Cercocarpus ledifolius	curl-leaf mountain mahogany
Cercocarpus montanus	alderleaf mountain mahogany
Cheilanthes sp.	lipfern
Chrysothamnus viscidiflorus	yellow rabbitbrush
Coleogyne ramosissima	blackbrush
Corydalis aurea	scrambled eggs
Cryptantha cinerea var. *jamesii*	James' catseye
Dalea sp.	prairieclover
Dalea formosa	featherplume
Danthonia sp.	oatgrass
Dasylirion wheeleri	common stool
Descurainia sp.	tansymustard
Draba verna	spring draba
Elymus sp.	wildrye
Elymus arizonicus	Arizona wheatgrass
Elymus elymoides	squirreltail
Ephedra torreyana	Torrey's jointfir
Ephedra viridis	Mormon tea
Eragrostis sp.	lovegrass
Ericameria nauseosa	rubber rabbitbrush
Erigeron sp.	daisy
Eriogonum sp.	buckwheat
Eriogonum effusum	spreading buckwheat
Eriogonum jamesii	James' buckwheat
Erioneuron pilosum	hairy woollygrass
Erodium cicutarium	filaree
Fallugia paradoxa	Apache plume
Festuca arizonica	Arizona fescue
Festuca idahoensis	Idaho fescue
Festuca sp.	fescue
Fragaria sp.	strawberry
Frangula californica (= Rhamnus californica)	California buckthorn
Garrya sp.	silktassel
Gaura coccinea	scarlet gaura
Geranium sp.	geranium
Geranium caespitosum	pineywoods geranium
Grayia spinosa	spiny hopsage
Gutierrezia sarothrae	snakeweed
Helianthus sp.	sunflower
Helianthus annuus	common sunflower
Hesperostipa sp.	needle and thread
Hesperostipa comata	needle and thread
Hesperostipa neomexicana	New Mexico needlegrass
Heterotheca sp.	false goldenaster
Holodiscus dumosus	oceanspray
Hymenopappus filifolius	fineleaf hymenopappus
Hymenopappus flavescens	collegeflower
Hymenoxys	rubberweed
Juniperus coahuilensis (= Juniperus erythrocarpa)	redberry juniper
Juniperus communis	common juniper
Juniperus deppeana	alligator juniper
Juniperus monosperma	one-seed juniper
Juniperus occidentalis	western juniper
Juniperus osteosperma	Utah juniper
Juniperus scopulorum	Rocky Mountain juniper
Juniperus sp.	juniper
Koeleria macrantha	Junegrass
Krascheninnikovia lanata	winterfat
Lactuca serriola	prickly lettuce
Lappula occidentalis (= Lappula redowskii)	flatspine stickseed
Larix occidentalis	mountain larch
Larrea tridentate	creosote bush
Lathyrus sp.	pea
Lepidium sp.	pepperweed
Leucopoa kingii (= Festuca kingii)	spike fescue
Liatris punctata	dotted blazing star
Lithophragma glabrum	bulbous woodland-star
Lithospermum multiflorum	manyflowered stoneseed
Lupinus sp.	lupine
Lupinus pusillus	rusty lupine
Lycium andersonii	water jacket
Lycium pallidum	pale wolfberry
Mahonia repens	creeping barberry
Maianthemum racemosum (= Smilacina racemosa	feathery false lily of the valley

Scientific name	Common name
Maianthemum stellatum	starry false lily of the valley
Medicago sativa	alfalfa
Melilotus officinalis	yellow sweetclover
Mentzelia sp.	blazingstar
Mirabilis sp.	four o'clock
Monarda sp.	beebalm
Muhlenbergia sp.	muhly
Muhlenbergia dubia	pine muhly
Muhlenbergia longiligula	longtongue muhly
Muhlenbergia montana	mountain muhly
Muhlenbergia rigida	purple muhly
Muhlenbergia torreyi	ring muhly
Muhlenbergia virescens	screwleaf muhly
Nassella viridula	green needlegrass
Nolina microcarpa	sacahuista
Oenothera elata	Hooker's evening-primrose
Opuntia sp.	pricklypear
Opuntia aurea (= Opuntia basilaris var. aurea)	golden pricklypear
Opuntia erinacea	grizzlybear pricklypear
Opuntia polyacantha	plains pricklypear
Packera multilobata	lobeleaf groundsel
Packera neomexicana	New Mexico groundsel
Panicum bulbosum	bulb panicgrass
Pascopyrum smithii	western wheatgrass
Paxistima myrsinites	Oregon boxleaf
Pediomelum (= Psoralea) sp.	breadroot
Pediomelum argophyllum (= Psoralea argophylla)	silverleaf Indian breadroot
Penstemon sp.	penstemon
Phlox sp.	phlox
Phlox gracilis	slender phlox
Phlox hoodii	spiny phlox
Physalis sp.	groundcherry
Physocarpus	ninebark
Physocarpus monogynus	mountain ninebark
Picea sp.	spruce
Picea glauca	Black Hills spruce
Picea pungens	blue spruce
Pinus sp.	pine
Pinus attenuate	knobcone pine
Pinus cembroides	Mexican pinyon
Pinus contorta	lodgepole pine
Pinus discolor	border pinyon
Pinus edulis	two-needle pinyon
Pinus flexilis	limber pine
Pinus lambertiana	sugar pine
Pinus monophylla	singleleaf pinyon
Pinus ponderosa	ponderosa pine
Pinus sabiniana	California foothill pine
Pinus strobiformis	southwestern white pine
Piptatherum micranthum (= Oryzopsis micrantha	little-seed mountain ricegrass
Piptochaetium sp.	needlegrass
Piptochaetium fimbriatum	pinyon ricegrass
Piptochaetium pringlei	Pringle's speargrass
Plantago patagonica	woolly plantain
Pleuraphis jamesii (= Hilaria jamesii)	James' galleta
Poa sp.	bluegrass
Poa fendleriana	muttongrass
Poa secunda	Sandberg bluegrass
Populus sp.	cottonwood
Populus tremuloides	quaking aspen
Prunus virginiana	chokecherry
Pseudoroegneria spicata	bluebunch wheatgrass
Pseudotsuga sp.	Douglas-fir
Pseudotsuga menziesii	Douglas-fir
Psoralea lanceolata	lemon scurfpea
Ptelea trifoliate	common hoptree
Purshia sp.	cliffrose
Purshia mexicana	Mexican cliffrose
Purshia tridentata	antelope bitterbrush
Quercus sp.	oak
Quercus arizonica	Arizona white oak
Quercus gambelii	Gambel oak
Quercus garryana	Oregon white oak
Quercus grisea	gray oak
Quercus hypoleucoides	silverleaf oak
Quercus macrocarpa	bur oak
Quercus mohriana	Mohr oak
Quercus X pauciloba	wavyleaf oak
Quercus pungens	pungent oak
Quercus turbinella	scrub oak
Rhus aromatica	fragrant sumac
Rhus trilobata	three-leaf sumac
Ribes sp.	currant

Scientific name	Common name
Robinia neomexicana	New Mexico locust
Rosa sp.	rose
Rosa woodsii	Woods' rose
Salsola kali	Russian thistle
Sarcobatus vermiculatus	greasewood
Schizachyrium scoparium	little bluestem
Sedum stenopetalum	wormleaf stonecrop
Selaginella densa	dense clubmoss
Senecio sp.	groundsel
Senecio multilobatus	lobeleaf groundsel
Shepherdia canadensis	russet buffaloberry
Shepherdia rotundifolia	roundleaf buffaloberry
Sisymbrium altissimum	tumblemustard
Sphaeralcea sp.	globemallow
Sphaeralcea coccinea (= Malvastrum coccineum)	scarlet globemallow
Sphaeralcea munroana	Munro's globemallow
Sporobolus sp.	dropseed
Sporobolus airoides	alkali sacaton
Sporobolus contractus	spike dropseed
Sporobolus cryptandrus	sand dropseed
Stipa sp.	needle and thread
Symphoricarpos sp.	snowberry
Symphoricarpos albus	common snowberry
Symphoricarpos occidentalis	western snowberry
Symphoricarpos oreophilus	mountain snowberry
Symphoricarpos rotundifolius	roundleaf snowberry
Taraxacum officinale	dandelion
Tetradymia canescens	gray horsebrush
Thalictrum fendleri	Fendler's meadowrue
Toxicodendron diversilobum	Pacific poison oak
Toxicodendron rydbergii	western poison ivy
Tradescantia occidentalis	prairie spiderwort
Tragopogon sp.	goatsbeard
Tragopogon dubius	common salsify
Tridens sp.	tridens
Verbascum thapsus	common mullein
Vicia americana	American vetch
Woodsia sp.	cliff fern
Wyethia amplexicaulis	mule-ears
Wyethia mollis	woolly mule-ears
Yucca sp.	yucca
Yucca baccata	banana yucca
Yucca glauca	soapweed yucca
Zinnia sp.	zinnia

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