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A Vegetation Classification and Map

Capulin Volcano National Monument

Natural Resource Technical Report NPS/SOPN/NRTR–2011/461

ON THE COVER
North face of Capulin Volcano (photo: Yvonne Chauvin)

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Acronyms and Abbreviations

AA	Accuracy Assessment
CAVO	Capulin Volcano National Monument
DOQQ	Digital Orthophotograph Quarter Quadrangle
ERDAS	Earth Resource Data Analysis System
ESRI	Environmental Systems Research Institute
ETM	Enhanced Thematic Mapper
FGDC	Federal Geographic Data Committee
GIS	Geographic Information System
GPS	Global Positioning System
I&M	Inventory and Monitoring Program
ITIS	Integrated Taxonomic Information System
MU	Map Unit
NDVI	Normalized Difference Vegetation Index
NDSVI	Normalized Difference Senescent Vegetation Index
NGO	Non-governmental Organization
NHNM	Natural Heritage NM
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NVC	National Vegetation Classification
NVCS	National Vegetation Classification Standard
PA	Plant Association
RCVF	Raton-Clayton Volcanic Field
SOPN	Southern Plains Network
TNC	The Nature Conservancy
UNESCO	United Nations Education, Science, and Cultural Organization
UNM	University of New Mexico
USDA	United States Department of Agriculture
USGS	United States Geological Survey

Executive Summary

A vegetation classification and high-resolution vegetation maps were developed for Capulin Volcano National Monument, New Mexico as part of the U.S. Geological Survey (USGS)-National Park Service (NPS) National Vegetation Mapping Program. The monument is located in the northeastern plains of New Mexico (southeast of Raton) and is 315.7 ha (780 ac) in size. While known for its geologic features, the park supports a relatively high diversity of habitats for wildlife and plants not found elsewhere in the surrounding grassland. Accordingly, the vegetation ranges from ponderosa pine and piñon-juniper woodlands to the montane shrubland and grasslands of the volcano, surrounding a mixture of grassland communities at the base and extending out into the prairie. We identified 24 plant associations from among nine vegetation groups following the National Vegetation Classification Standard (NVCS). These in turn were used to define a suite of vegetation map units. The vegetation map was developed using a combination of automated digital processing (supervised classifications and image segmentation) and direct image interpretation of high-resolution color aerial ortho-photography in combination with satellite imagery (DigitalGlobe QuickBird). The map was designed to facilitate ecologically based natural resources management at a 1:6,000 scale with a 0.5-ha minimum map unit size. The map legend was hierarchically structured with an upper Level 1 of 11 map units, nine of which correspond to the Group Level NVCS and two are miscellaneous land-use classes. These include: Southern Rocky Mountain Ponderosa Pine Forest and Woodland, Southern Rocky Mountain Piñon-Juniper Woodland, Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland, Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland, Southern Rocky Mountain Montane-Subalpine Grassland, Southwest Plains-Mesa Mixedgrass Prairie, Southwest Plains-Mesa Grassland, Southwest Ruderal Shrubland and Grassland, and Southwest Cliff, Scree and Rock Vegetation. Level 2 is a further refinement composed of 18 nested map units defined by specific plant associations in the vegetation classification that reflect variations in plant community structure as well as species composition within the broader Level 1units. Overall accuracy at Level 1 was estimated at 83% and 67% at Level 2. For many natural resource management applications, Level 1 units will likely be sufficient and most appropriate, while Level 2 units provide added fine-scale information within major ecological groups. To support the map as a management tool, an annotated map legend is provided along with descriptions of each plant association, a corresponding diagnostic key, field forms, and a plant species list. The map was delivered in both hard copy and digital form as part of a geographic information system (GIS) compatible with that used in the park and the USGS-NPS mapping program. The GIS allows flexibility to update the map as new information becomes available or as major vegetation changes, such as fire, disease or other impacts, occur in the park.

Acknowledgements

This project was supported by the USGS-NPS National Vegetation Mapping Program, NPS Fire Program, and the Southern Plains Network as part of a cooperative agreement with Natural Heritage New Mexico. At NHNM, Yvonne Chauvin, Charlie Jackson, Eric Lindahl, and Amanda Kennedy, NHNM technicians, conducted the majority of the fieldwork and data entry. Lisa Arnold was instrumental in final map cartography development. Rebecca Keeshen provided management support and editorial review. Kim Struthers from Capulin National Monument, and Heidi Sosinski and Robert Bennetts from the NPS Southern Plains Network provided logistical support, consultation, and editorial review, Tom Forsyth and Lynelle Wright at the NPS Intermountain Region assisted with contract development. From the USGS-NPS Vegetation Mapping Program national office, important guidance and review was provided by Karl Brown, Tammy Hamer, and Chris Lea.

1. Introduction

1.1. Background, scope, and products

Capulin Volcano juts out as a picturesque cinder cone in the wide expanse of shortgrass prairie of northeastern New Mexico (Figure 1.1). This "island" mountain is cloaked by woodlands and shrublands on its steep slopes that harbor wildlife and plants not found elsewhere in the surrounding grassland. While the park is known for its geology, the National Park Service has sought to manage the biological resources with the same care and attention as given to physical values. Accordingly, along with comprehensive biological inventories and monitoring, a key to effective biological management is the development of high-resolution vegetation maps that can support such activities as flora and fauna habitat modeling, recreation planning, fire management, ecological research, and broad-scale facilities planning.

Figure 1.1 The "island" cinder cone of Capulin Volcano National Monument stands out in the matrix of the shortgrass prairie in northeastern New Mexico (Photo: Phil Tonne).

To meet this objective, the U.S. Geological Survey (USGS)-National Park Service (NPS) Vegetation Mapping Program and the NPS Southern Plains Network (SOPN) of parks in cooperation with Natural Heritage New Mexico (NHNM, A division of the Museum of Southwestern Biology at the University of New Mexico), and the staff at Capulin Volcano National Monument (CAVO), set out to develop vegetation maps that meet or exceed USGS-NPS standards of 1:24,000-scale and 0.5-ha minimum map unit size (USGS 2010). The maps were based on high-resolution aerial photography and satellite imagery along with extensive ground sampling. The project was initiated in 2004 with ensuing field surveys of the vegetation communities from 2005 through 2009. The vegetation survey data was databased and used to develop a park-wide vegetation classification following the National Vegetation Classification System (FGDC 1997 and 2008; Grossman et al. 1998) guidelines. Then, using the vegetation classification and associated ground control points, vegetation maps were generated at a 1:6,000 scale using a combination of automated image analysis (image segmentation and supervised classifications) and direct image interpretation. Map units were designed to support ecologically based natural resources management with an emphasis on uses in fire and wildlife management.

We provide here the details on how the maps were constructed, an overview of the classification and ecology of the vegetation communities of the monument, the vegetation maps with associated map unit descriptions, plant community descriptions and a diagnostic key, and a vouchered species list. The maps are presented in both paper and digital form as part of a geographic information system (GIS) compatible with that used in the park and national USGS-NPS national mapping program. In addition, all field data were compiled into a relational database compatible with USGS-NPS database guidelines, and all data and report elements made ready for web-based applications. Finally, an accuracy assessment is included that provides an indication of both user and producer confidence in the map.

1.2. The USGS-NPS Vegetation Characterization/Mapping Program

The USGS-NPS Vegetation Characterization Program is a cooperative effort by USGS and NPS to classify, describe, and map vegetation communities in more than 280 national park units across the United States. Consistent vegetation classification, mapping, and accuracy assessment protocols and standards are applied across projects supported by this program. The National Vegetation Mapping Program is administered by the USGS Center for Biological Informatics in cooperation with the NPS Inventory & Monitoring (I&M) Program and its Vegetation Mapping Inventory. Through implementation of the NPS Natural Resource Challenge (NPS 1999), significant funding became available for completing important natural resource baseline inventories in park units, including vegetation classification and mapping. This support provided NPS with the opportunity to move forward with dozens of new park unit vegetation classification and mapping projects, including CAVO. Vegetation classification and mapping products produced by this program are incorporated into the USGS National Biological Information Infrastructure Program, which serves as an information-sharing network (see: http://biology.usgs.gov/npsveg/).

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

Protocols

- National Vegetation Classification System (TNC and ESRI 1994a, NatureServe 2003);
- Field methods and mapping procedures (TNC and ESRI 1994b);
- Statistically rigorous and consistent accuracy-assessment procedures (ESRI et al. 1994);
- Guidelines for using existing vegetation data (TNC 1996).

Standards

- National Vegetation Classification Standard (FGDC 1997; 2008);
- Spatial Data Transfer Standard (FGDC 1998b);
- Content Standard for Digital Geospatial Metadata (FGDC 1998a);
- United States National Map Accuracy Standards (USGS 1999);
- Integrated Taxonomic Information System;
- Program-defined standards for map attribute accuracy and minimum mapping unit.

1.3. Park Environment

1.3.1. Location and cultural setting

CAVO is located in the northeastern plains of New Mexico, 55.5 km (34.5 miles) southeast of Raton, NM near the Colorado border, and 95 km (59.1 miles) west of Clayton. The park is 315.7 ha (780 ac) in size and located near the small town of Capulin just a few km to the southeast, and amongst several private cattle ranches (Figures 1.2 and 1.3). Capulin Volcano has long been known for its geological features and, as a result, in 1891 Congress protected the site from development. This was followed by a presidential proclamation in 1916 that created the national monument, and further amended by Congress in 1962 with the mission "to protect the cinder cone and volcanic features that resulted from the eruption of Capulin Volcano" as well as "preserve the scientific integrity, educational and scenic values." At that time, it was also recognized that CAVO, because of it combination of volcanic and plains features, provided a relatively high diversity of biological habitats in a small area and was a focal point of biodiversity in the region. In addition, while the park is surrounded by livestock ranches, the park itself has been excluded from grazing since 1976, providing a benchmark for comparison to the surrounding managed landscape.

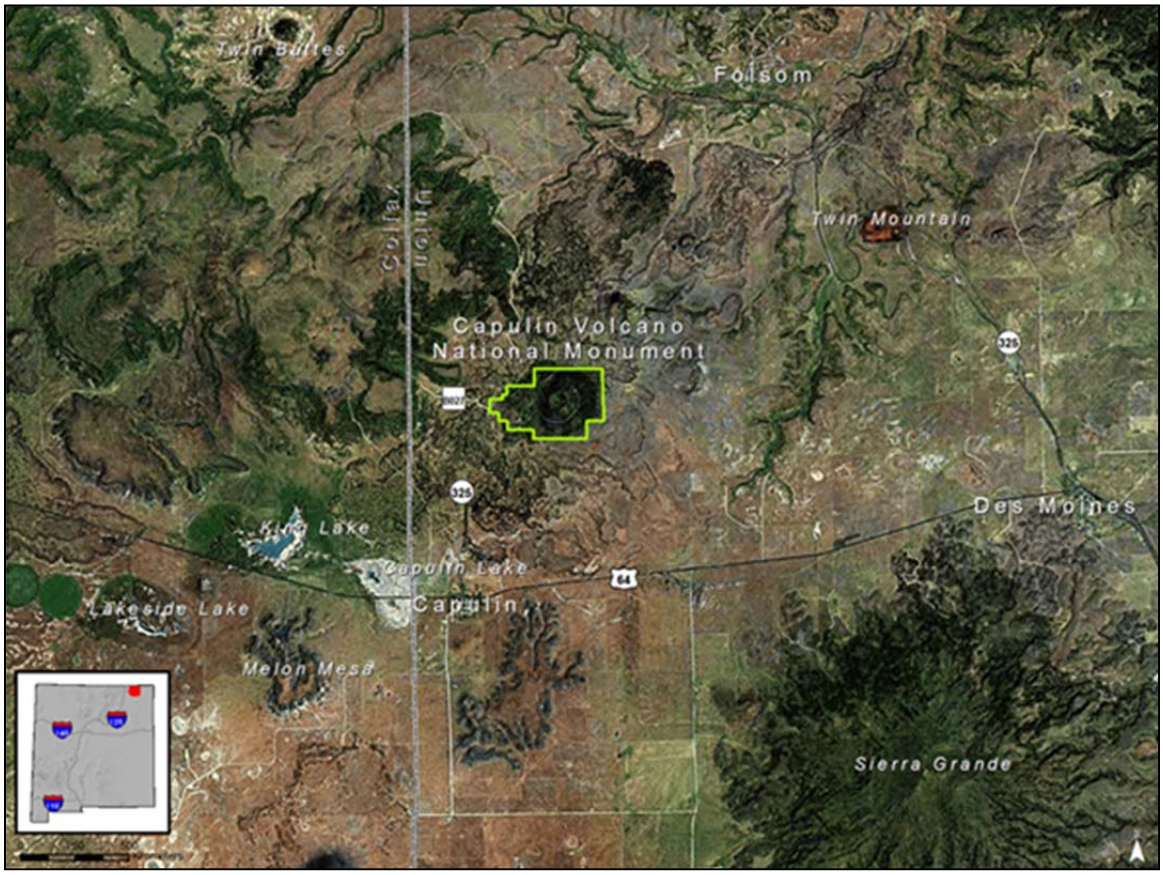

Figure 1.2 Capulin Volcano National Monument is located in northeast New Mexico near the town of Capulin and southeast of Raton New Mexico 60 miles (95 km). The large compound volcano, Sierra Grande, lies to the southeast. Both Capulin Volcano and Sierra Grande are part of the Raton-Clayton Volcanic Field.

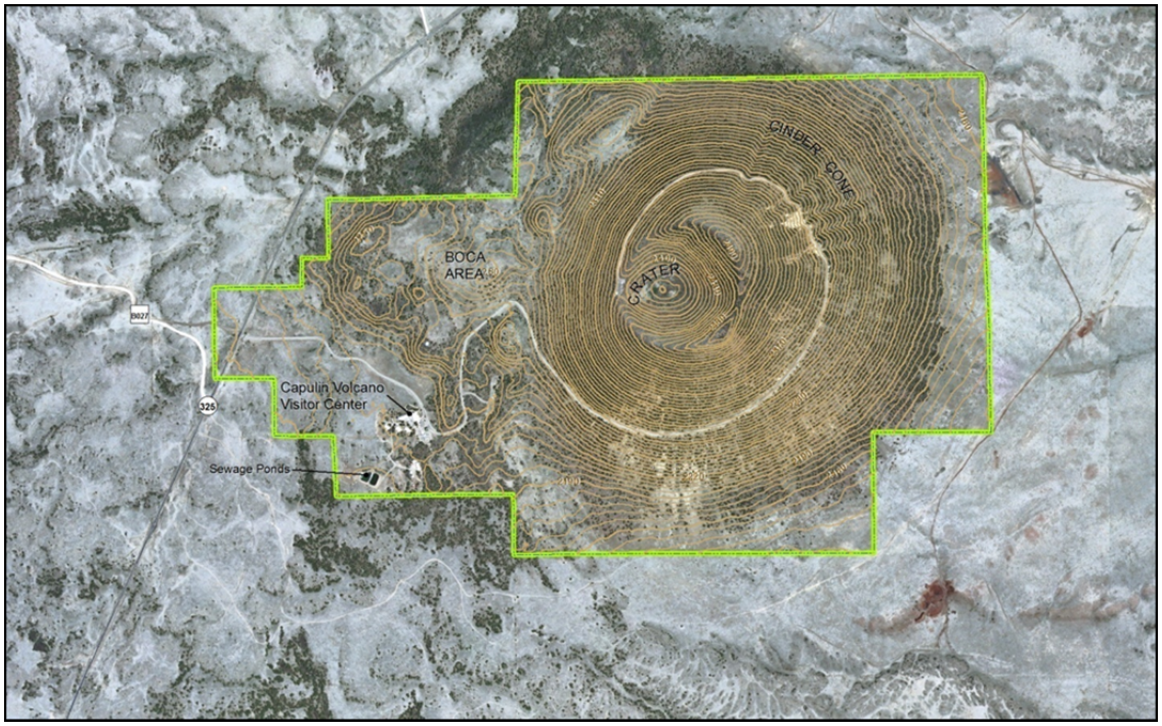

Figure 1.3 Capulin Volcano National Monument vegetation map study area follows the park boundary (green). A paved road circles the cinder cone and terminates at the lower crater's edge.

1.3.2. Climate

The climate of CAVO is fundamentally semi-arid and continental with cool-to-cold and predominantly dry winters followed by warm and usually moist summers. The mean annual precipitation is 420 mm (16.6 in) as recorded at Capulin National Monument itself (station 291454) between 1966 and 1979 (Figure 1.4), and 398 mm (15.68 in) in the town of Capulin between 1930 and 1969 (station 291452). About 80% of precipitation falls in the summer months as part of both the Arizona monsoon and storms out of the Gulf of Mexico (particularly in hurricane season). The winter precipitation comes mostly in the form of snow out of the Pacific following a southerly path across the continent between November and March.

With respect to temperature winters can be cold, with mean monthly minimums dipping below freezing from November through March with an extreme daily low of -34.3°C (-30°F) recorded in Capulin (Figure 1.5). Fall freezes are likely to occur by the first week in October or earlier, and the last freeze can extend into the middle of May or later. Summers are warm to hot with July the warmest month at 26.8°C (80°F) on average; daily extremes can reach 37.7°C (100°F).

1.3.3. Geology and soils

The focal feature of CAVO is the volcanic cinder cone that rises out of surrounding plains to a height of 2,493.9 m (8,182 ft.). The cone and associated lava fields are part of the Raton-Clayton Volcanic Field (RCVF), which anchors the eastern segment of the Jemez Lineament that stretches through northern New Mexico to northern Arizona (Figure 1.6). Based on cosmogenic helium dating of the exposed lavas, the age of the volcano is estimated at 59,100 ± 6,000 years (Sayre and Ort 1995; 1999) and is the most recent in the RCVF. The eruption at that time

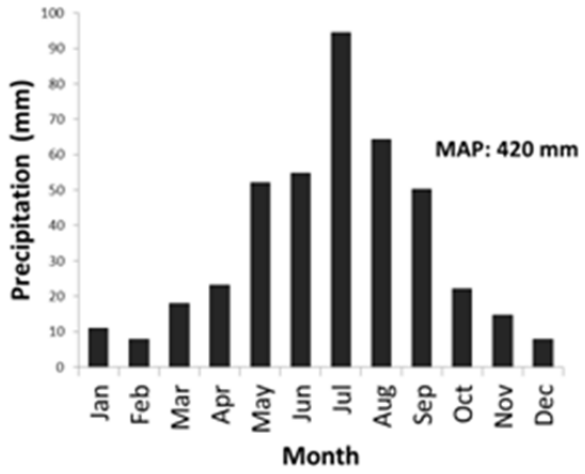

Figure 1.4 Average monthly precipitation pattern for Capulin Volcano National Monument (source: Coop Station 291454 Capulin Natl Monument 1966-79).

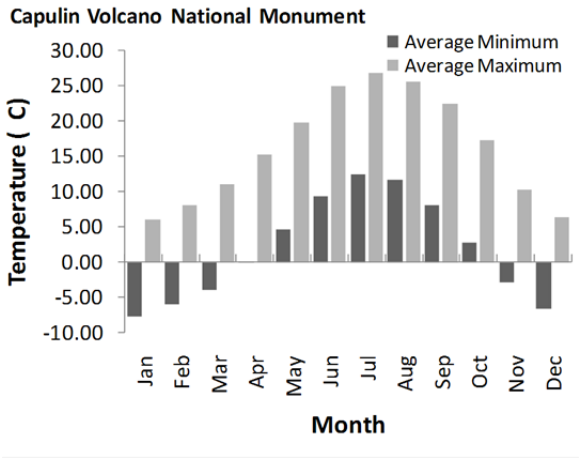

Figure 1.5 Average monthly maximum and minimum temperature patterns for Capulin Volcano National Monument (source: Coop Station 291454 Capulin Natl Monument 1966-79).

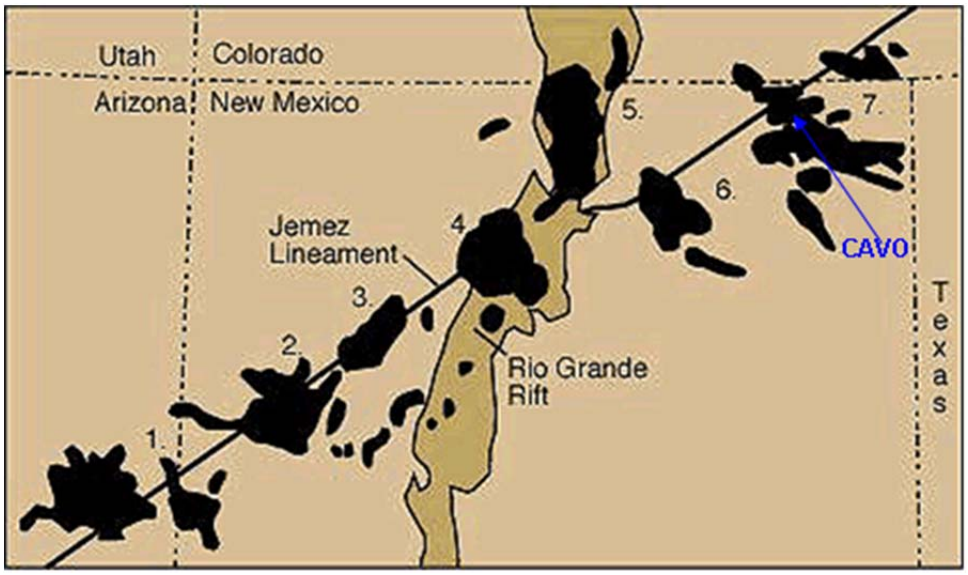

Figure 1.6 Geologically, Capulin Volcano National Monument is located in the Raton-Clayton Volcanic Field that is part of the Jemez Lineament: 1. Springerville; 2. Zuni-Bandera; 3. Mount Taylor; 4. Jemez Mountains; 5. Taos; 6. Ocate; and 7. Raton-Clayton (from Ander et al. (1981).

created a nearly circular, intact cinder cone with a central crater that is the hallmark of the monument (see Figure 1.3). It is a scoria-type cinder cone, meaning the cinders have large vesicles (compared to pumice) and are derived from dark basaltic, low silica lavas, which often weather to a reddish color. The cone has weathered some over the past 60,000 years as indicated by an apron of cinders around the base of the volcano and erosion of cinder beds into the crater and lack of cinder beds outward from the rim edge (Sayre and Ort 1995), and Jonsson (1992) suggests that the angle of repose of slopes have declined over this period from 30°-35° to 20°-30° due to erosion. The nearly intact structure of the cone is attributed to the lack of a lava flow from the central vent that would have cut an opening in the cone. Rather, basaltic lava flows

were initiated from vents at the base of cone after it had formed and emanate from the "Boca Area" on the western side of the monument (Figure 1.7). Besides the Boca, Sayre and Ort (1999) mapped four other lava flow series. On the monument, these flows are most evident around the southern perimeter of the park, and although they are relatively minor elements compared to the Boca and the cone itself, they extend for several miles outside the boundaries in all directions. The Boca has a mixture of lava tube collapse structures, tumuli (small conical lava cones), and rough "push-ups" (compression features amongst lava lake plains), creating a heterogeneous landscape and corresponding vegetation variability.

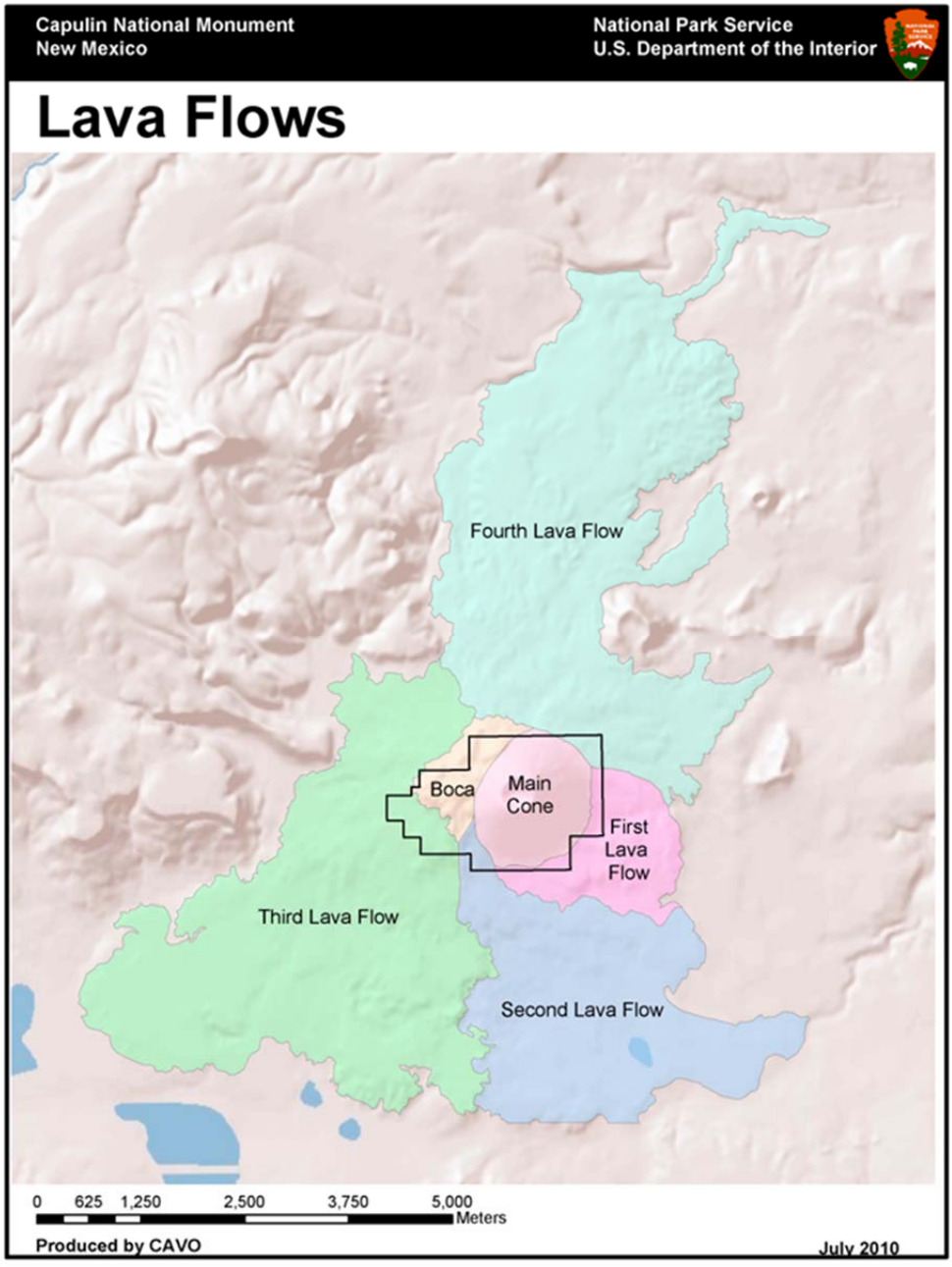

Figure 1.7 Besides the Boca, there were four lava flows identified by Sayre and Ort (1999) that emanate from the base of Capulin Volcano (source: Richman 2010).

Recently, a high-resolution soil survey was recently completed for CAVO by Weindorf et al. (2008) (Figure 1.8). They mapped four units made up of five soil series, all of which are classified as various mollisols, i.e., soils with relatively deep, organic-rich surface horizons (mollic epipedons) (Table 1.1) . The Bandera (Br) and Fallsam-Rock Outcrop Complex (Fr) soils dominate the eastern and western sides of the cinder cone, respectively (NRCS 2010). Weindorf et al. (2008) also identified in the Bandera unit, a weakly developed vitrandic ustorthent made up of cinders with little organic matter accumulation. The Raton-Rock Outcrop Complex dominates the Boca-associated lava flows. Lastly, the alluvial apron that rings the base of the volcano along its eastern front was mapped as the Capulin-Apache Complex of loamy soils.

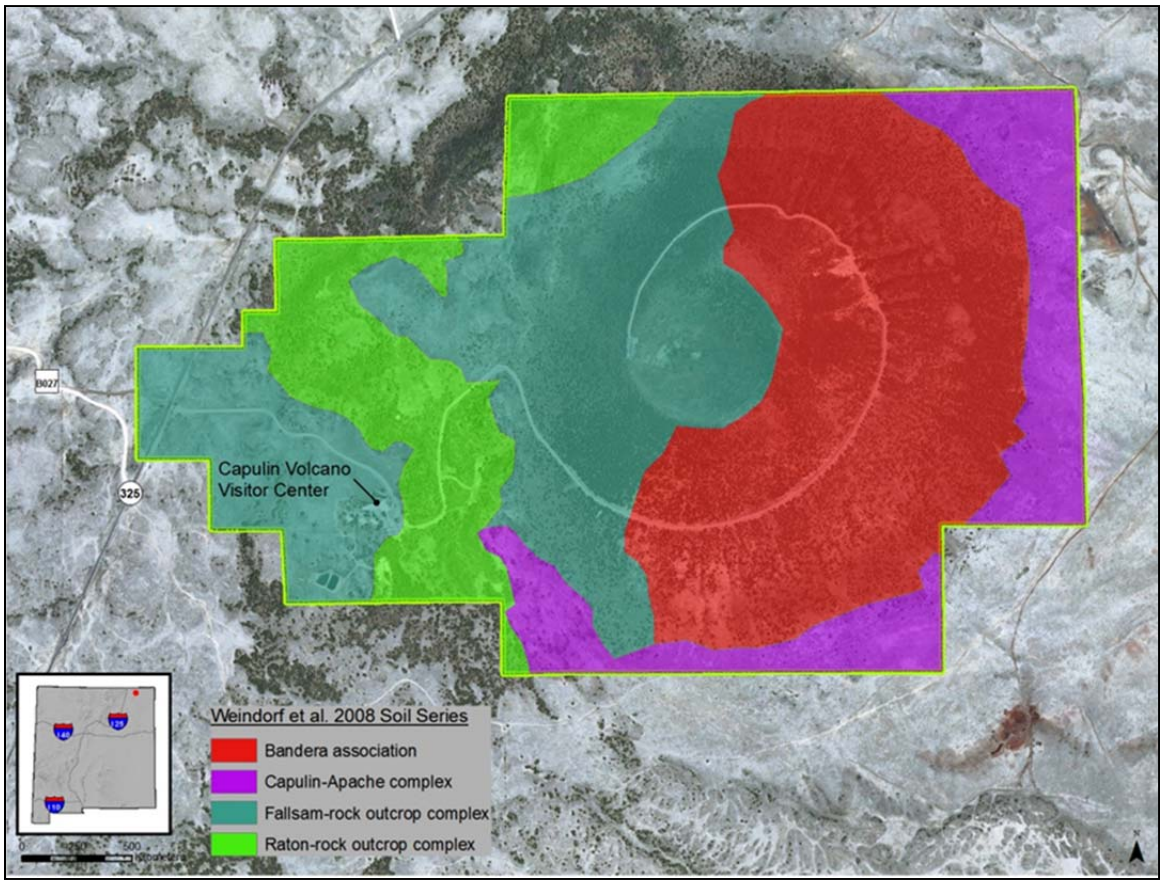

Figure 1.8 High-resolution soils map develop in 2008 for Capulin Volcano National Monument. See text for explanation of map units (source: Weindorf et al. (2008).

1.3.4. Ecoregions and vegetation studies

With respect to ecoregions as defined by Bailey et al. (1994), Bailey (1995) and McNab et al. (1994; 2005), the monument straddles the boundary between Arkansas Tablelands Section (331I) of the Great Plains-Palouse Dry Steppe Province (part of the Temperate Steppe Division that extends northward to Canada), and the Pecos Valley Section (315A) of the Southwest Plateau and Plains Dry Steppe and Shrub Province (part of the Tropical/Subtropical Steppe Division that

Table 1.1 CAVO soil units mapped by Weindorf et al. (2008) with component soils series; percent slope range; soil family, and parent material (rock type) as defined by Natural Resources Conservation Service

Map Unit Symbol	Map unit name	Soil series	Slope low (%)	Slope high (%)	Soil family	Parent material
Ch	Capulin-Apache Complex	Capulin	1	5	Fine-loamy, mixed, mesic Aridic Argiustolls	Eolian and residuum weathered from basalt
		Apache	1	15	Loamy, mixed, mesic Lithic Haplustolls	Eolian material and alluvium derived from basalt
Fr	Fallsam-Rock Outcrop Complex	Fallsam	1	9	Clayey-skeletal, montmorillonitic, mesic Pachic Argiustolls	Eolian and residuum weathered from basalt
Ra	Raton -Rock Outcrop Complex	Raton	3	15	Clayey-skeletal, mixed Lithic Argiborolls	Residuum weathered from basalt

extends southward to the Texas Gulf Coast). Griffith et al. (2006) place the monument within their Upper Canadian Plateau Subdivision of the Southwestern Tablelands Ecoregion. In all cases, they describe these landscapes as dominated by shortgrass prairie and some mixed-grass prairie along scattered piñon-juniper woodlands.

Previous botanical and ecological studies on CAVO are limited. Genaro et al. (1979) conducted a suite of biological studies including vegetation transects and a generalized vegetation map showing the distribution of piñon -juniper woodlands, shrublands, and grasslands. Harfert (undated) conducted a general soil-vegetation study for the park with a focus on the effect of caliche formation on plant distribution. Jőnsson (1992) conducted a repeat photography study of vegetation change on eight sites at the park between 1900 and 1992. He found evidence of tree cover increase on most sites but not all, plus suggestions of tree die-off, particularly among ponderosa pine. He attributed an increase in tree density to the impacts of domestic livestock grazing and wildlife browsing reducing the competition of grasses with tree seedlings. A fire-history study was conducted at the park by Guyette and Stambaugh (undated). They identified a high-frequency, low-intensity fire regime in place among ponderosa pine prior to most settlement that ended in around 1890. They also aged piñon woodlands at over 485 years that had little evidence of fire. This suggests that the piñon woodlands would be categorized as "persistent woodlands" following Romme et al. (2009), i.e., woodlands that have occupied the site for a long duration and have long-fire return intervals, usually in the form of stand-replacement fires (see section 2. 2.2.for a detailed discussion). With respect to biological surveys, Parmenter et al. (2000) conducted a rare-species inventory and reported no rare plant species.

2. Vegetation Classification

A consistent, ecologically based vegetation classification forms the foundation for the development of an information-rich vegetation map. Vegetation classifications are ground-based descriptions of vegetation patterns that take into account floristic composition and abundance, site characteristics, and ecological dynamics. Accordingly, for CAVO we used extensive field sampling and analysis to develop a hierarchical classification following the National Vegetation Classification Standard (FGDC 1997 & 2008). The outcome was the identification and description of a suite of plant associations that are singularly or in combination components of map units, depending on cartographic standards and constraints, and the targeted uses of the map (see Chapter 3). Below we describe our methods for classification development and provide an overview of the CAVO classification with discussion.

2.1. Classification methods

2.1.1. The National Vegetation Classification Standard[1]

The National Vegetation Classification (NVC) is used in SOPN vegetation mapping projects (TNC and ESRI 1994a), and is based on the National Vegetation Classification Standard (NVCS) adopted by the Federal Geographic Data Committee in 1997 and updated in 2008 (FGDC 1997 & 2008) (see Clark et al 2009 and Thomas et al. 2008 for additional details). The NVCS evolved from work conducted primarily by The Nature Conservancy (TNC), NatureServe, and the Natural Heritage Program network over more than two decades (Grossman et al. 1998). The structure of the NVC 1997 standard is based, in part, on an earlier international vegetation classification developed by the United Nations Educational, Cultural, and Scientific Organization (UNESCO 1973, Driscoll et al. 1984) and is presented in Table 2.1. Use of a standardized classification system helps to ensure data compatibility throughout the National Park Service and other agencies. In 2008, a revised standard was adopted by the FGDC that contains substantial revisions to the upper levels of the NVCS hierarchy that are currently under review (Table 2.2). A crosswalk of hierarchical levels between the two standards from FGDC (1997 & 2008) is given in Table 2.3. Accordingly, because the NVCS is in transition, in this project we provide the classification following both frameworks.

The NVCS is a hierarchical system that allows vegetation classification to occur at multiple scales. The FGDC (1997) standard incorporates physiognomic characters and floristic data to define seven levels of terrestrial vegetation classification (Table 2.1). The five upper levels (class, subclass, group, subgroup, and formation) are based on physiognomic features that vary among major vegetation groups such as vegetation structure, life form, botanical characteristics, etc. The two lower levels (alliance and association) are distinguished by differences in floristic composition. Alliances are physiognomically distinct groups of plant associations sharing one or more differential or diagnostic species (Mueller-Dombois and Ellenberg 1974). These are

[1] Information in this section is derived, in part, from either Clark et al. (2009) or Thomas et al. (2008).

Table 2.1 1997 U.S. National Vegetation Classification physiognomic-floristic hierarchy for terrestrial vegetation (FGDC 1997; Grossman et al. 1998) with a supplemental Alliance Group level.

Level	Primary Basis for Classification	Example
Class	Growth form and structure of vegetation	Shrubland
Subclass	Growth form characteristics, e.g., leaf phenology	Deciduous Shrubland
Group	Leaf types, corresponding to climate	Cold-deciduous Shrubland
Formation	Additional physiognomic and environmental factors	Temperate Cold-deciduous Shrubland
Alliance Group	Regional floristically and environmentally related Alliances	Rocky Mountain Montane Deciduous Scrub
Alliance	Dominant/diagnostic species of the uppermost or dominant stratum	Mountain Mahogany (Cercocarpus montanus)
Plant Association	Additional dominant/diagnostic species from any stratum	Mountain Mahogany/New Mexico Muhly Shrubland (Cercocarpus montanus/Muhlenbergia pauciflora Shrubland)

commonly the dominant(s) found in the uppermost strata of the vegetation. The plant association is the fundamental unit of the classification, and following the International Botanical Congress of 1910, is defined as a community of definite floristic composition (i.e., a repeating assemblage of species), uniform physiognomy, and habitat conditions (Mueller-Dombois and Ellenberg 1974).

The 2008 NVCS revision (Version 2; FGDC 2008) has eight levels (Table 2.2). The upper three levels, which are a reorganization of the five upper physiognomic levels from Version 1, indicate physiognomic characteristics that reflect geographically widespread (global) topographic and edaphic factors. The middle three levels are new to the NVCS hierarchy and focus on largely biogeographic and habitat factors along very broad, regional-to-continental topographic, edaphic, and disturbance gradients. The lower two levels, the alliance and association, are used in park mapping and are currently the same in the first and second versions (substantial revisions of the alliances are expected in the future to improve concordance through the hierarchy, but for the purposes of this report they have not been revised).

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

2.1.2. Field methods

Vegetation sampling was designed to capture as wide a variety of vegetation types as possible within the seasonal time frame available for field work (typically during the rainy season of July

Table 2.2 National Vegetation Classification hierarchy for terrestrial vegetation following the FGDC (2008) standard.

Level	Level name	Criteria	Example
Upper levels			
L1	Formation Class	Broad combinations of general dominant growth forms that are adapted to basic temperature (energy budget), moisture, and/or substrate or aquatic conditions.	Mesomorphic Shrub and Herb Vegetation (Shrubland and Grassland)
L2	Formation Subclass	Combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate or aquatic conditions.	Temperate and Boreal Shrub and Herb Vegetation (Temperate and Boreal Shrubland & Grassland)
L3	Formation	Combinations of dominant and diagnostic growth forms that reflect global macroclimatic factors as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.	Temperate Shrub and Herb Vegetation (Temperate Shrubland & Grassland)
Mid levels			
L4	Division	Combinations of dominant and diagnostic growth forms and a broad set of diagnostic plant taxa that reflect biogeographic differences in composition and continental differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon – Stipa – Bouteloua* Grassland & Shrubland Division (North American Great Plains Grassland & Shrubland)
L5	Macrogroup	Combinations of moderate sets of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences in composition and subcontinental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii – Schizachyrium scoparium – Sorghastrum nutans* Grassland & Shrubland Macrogroup (Great Plains Tall Grassland & Shrubland)
L6	Group	Combinations of relatively narrow sets of diagnostic plant species (including dominants and co-dominants), broadly similar composition, and diagnostic growth forms that reflect biogeographic differences in composition and sub-continental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii – Sporobolus heterolepis* Grassland Group (Great Plains Mesic Tallgrass Prairie)
Lower levels			
L7	Alliance	Diagnostic species, including some from the dominant growth form or layer, and moderately similar composition that reflect regional to subregional climate substrates, hydrology, moisture/nutrient factors, and disturbance regimes.	*Andropogon gerardii – (Calamagrostis canadensis – Panicum virgatum)* Herbaceous Alliance (Wet-mesic Tallgrass Prairie)
L8	Association	Diagnostic species, usually from multiple growth forms or layers, and more narrowly similar composition that reflect topo-edaphic climate, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii – Panicum virgatum – Helianthus grosseserratus* Herbaceous Vegetation (Central Wet-mesic Tallgrass Prairie)

15 to October 15 when botanical expression is at its best). Sampling campaigns were planned to optimize field crew efficiency while still capturing as wide a range of vegetation types as possible on any given day. Accordingly, we used a cluster sampling approach where a series of daily routes for the sampling crews were designed in a GIS using the digital ortho-photography and preliminary vegetation maps. The locations of eight to ten sampling points per route were driven by differences in vegetation, soils, and geologic pattern, plus logistics, i.e., what could be accomplished in one day's travel time by vehicle and foot by a field crew (sampling days were ten hours to further increase daily efficiency). Routes were distributed as widely as possible throughout the study area, but the emphasis was on capturing the range of variation within the park. While using the GIS was an excellent planning tool, final plot locations were decided in the field based on positioning the sampling point in homogenous stands of vegetation and habitat.

Table 2.3 Comparison of revised 2008 hierarchy for natural vegetation with the 1997 hierarchy. In the 1997 version, natural and cultural vegetation were not separated until Level 4 – formation subgroup (derived from FGDC 2008).

Revised Hierarchy for Natural Vegetation	1997 FGDC Hierarchy
Upper levels	
	Division - Vegetation vs. Non-vegetation
	Order – Tree, Shrub, Herb, Nonvascular
Level 1– Formation Class	Level 1 – Formation Class
	Level 2 - Formation Subclass
Level 2 – Formation Subclass	Level 3 – Formation Group
	Level 4 – Formation Subgroup – Natural/Cultural
Level 3 - Formation	Level 5 – Formation
Mid levels	
Level 4 – Division	
Level 5 – Macrogroup	
Level 6 – Group	
Lower levels	
Level 7 – Alliance	Level 6 – Alliance
Level 8 – Association	Level 7 – Association

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

For standard plots, a list of all vascular plant species, stratified by lifeform (tree, shrub, subshrub, grass and forb layers) was compiled and cover estimated for each species using a modified Domin-Krajina Scale (Table 2.4) (Mueller-Dombois and Ellenberg 1974). Site attributes included slope percent, aspect, slope shape, surface rock type, and ground cover (percent rock, gravel, bare soil and litter), along with detailed narratives on species composition and site conditions. Plot locations were recorded with a Garmin GPS Model 12 with +/- 10-m accuracy. For each plot, at least four photos were taken in the four directions from plot center with each photo containing a placard noting the project, sampling date, and plot number. The compass direction and focal length of each shot were logged for future reference. See Appendix A for NHNM field-survey handbook and examples of sampling forms.

Standard plots were used primarily to support vegetation classification development, and three to five can be established in a day. For maximizing ground control for the mapping process, stripped-down mapping plots (quick plots) were employed where only the cover of dominant species in each strata was recorded along with a reduced set of site parameters. Anywhere from 6 to 12 of these quick plots could be established in a day, depending on logistics (all accuracy-assessment plots were of this style). In addition, reconnaissance observation points were used in which only the diagnostic species were recorded for determining the plant association using diagnostic keys (see Vegetation Analysis section below) along with a GPS point and a

Table 2.4 Modified Domin-Krajina Vegetation Cover Scale from Mueller-Dombois and Ellenberg (1974). Cover Class is the scalar value assigned in the field; Percent Canopy Cover is the range of cover the class represents; m2/ 400 m2 is the actual area represented by the cover class within the 400m2 plot; and Midpoint % Cover is the midpoint canopy cover value used in data analysis.

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

photograph. Between 2002 and 2008, 45 standard plots, 35 mapping plots, and 10 observation points were taken across the park (Figure 2.1).

Plant voucher specimens were collected to confirm field identifications as necessary and are housed at the University of New Mexico Herbarium. Specimens were identified by NHNM botanist Yvonne Chauvin to lowest level possible given the material at hand and names assigned according to the PLANTS database (USDA-NRCS 2009) and the Integrated Taxonomic Information System (ITIS). Qualifying specimens were accessioned with both UNM accession numbers and NPS record numbers tied to the Herbarium and NPS databases. A species list derived from the plot data is provided in Appendix B.

2.1.3. Vegetation analysis

To develop the vegetation classification, the plot data were analyzed using standard tabular comparison techniques (Becking 1957, Mueller-Dombois and Ellenberg 1974, Ludwig and Reynolds 1988, McCune and Grace 2002). These analyses were based primarily on species-level canopy-cover values with some grouping at the genus level where taxonomic units were ambiguous (abundance scalar values were converted to percent-cover mid-point values). Data on site characteristics such as elevation, slope, aspect, and landform were also used to supplement the analysis. In general, each plot was classified into an alliance based on dominant or indicator species, and then to a particular plant association (PA) based on codominance and/or other groups of differential species. Phases of associations were assigned as necessary to further define the character of the plant community. Within the old NVCS (FGDC 1997), alliances were assigned to formations following Grossman et al. (1998) and subsequent database revisions. For the new NVCS (FGDC 2008), associations were assigned to the Group level based on a working classification developed by NatureServe in collaboration with government agency and Natural Heritage network ecologists (pers. comm., M. Reid, NatureServe Senior Regional Ecologist 2008). This assignment to the new NVC remains provisional pending review by either NatureServe (currently responsible for maintenance and consistency of the NVCS) or the Ecological Society of America Vegetation Classification Panel which is currently developing a comprehensive classification review process in collaboration with the FGDC Vegetation Subcommittee. The NVCS continues to be revised to meet the new standard and not all groups

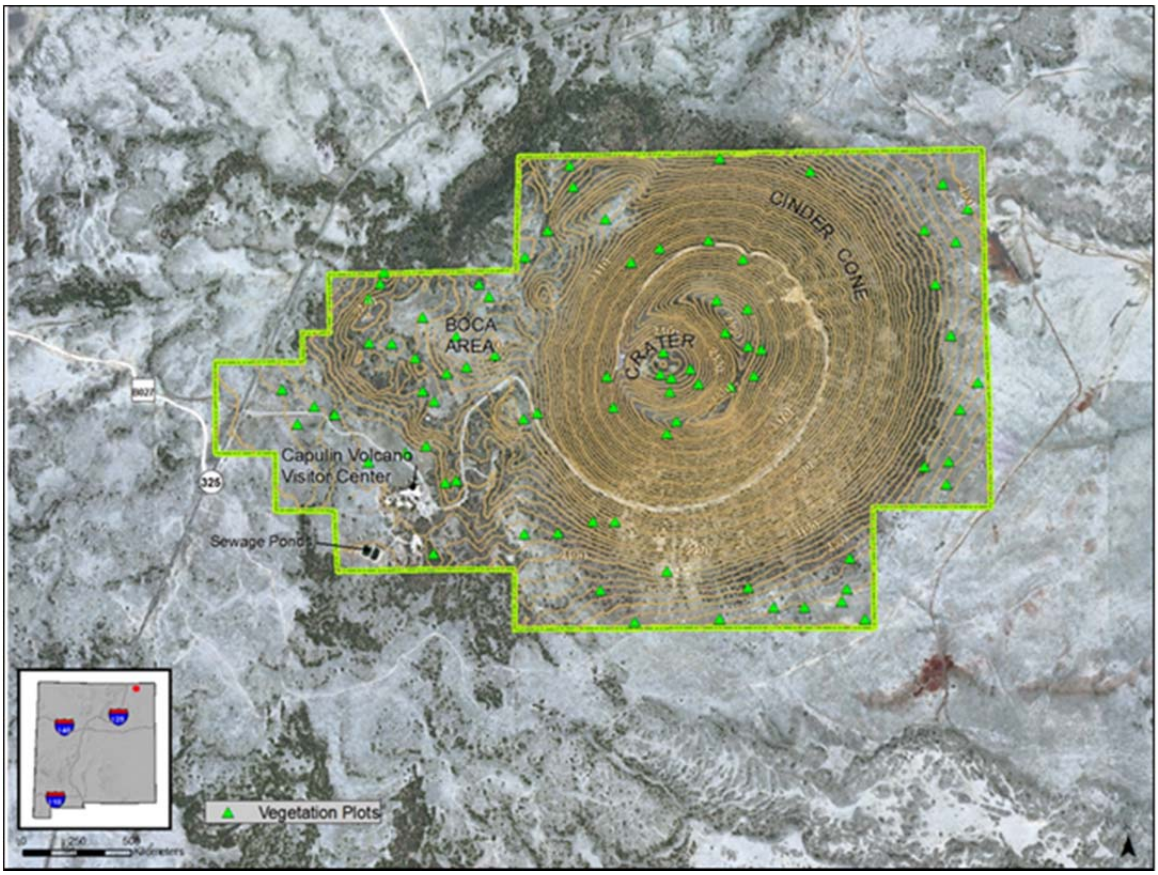

Figure 2.1 Distribution of classification and mapping sampling plots across the Capulin Volcano National Monument (including standard plots, mapping plots, and observation points).

have been defined. Hence, we had the opportunity here to propose new groups for review as part of the analysis (described below). Final summary floristic and site tables by plant association were computed and were the basis for plant association descriptions, and the development of diagnostic dichotomous keys that set the rule base for differentiating locally among plant associations.

2.2. Classification Results

A provisional vegetation classification for Capulin Volcano National Monument ordered by the new NVCS hierarchy is presented in Table 2.5. At the lowest level, we identified 24 plant associations (PAs) and have indicated in the table their relative status (major or incidental) at CAVO, the number of CAVO plots, and NatureServe or NHNM database code. Those PAs with NatureServe codes beginning with "CEGL" have been cross-walked provisionally to nationally recognized types held in the national database (see: (http://www.natureserve.org/explorer/). Codes beginning with "NPS_NM" are potentially new plant associations that at this time we could not link to a particular NVC PA concept; these are commonly referred to as "Park Specials" in NPS mapping projects. Overall, 15 PAs were considered major associations that were well documented in the park or in the region. The remaining nine were categorized as incidental associations that had minor distributions within the park and limited documentation. A diagnostic dichotomous key to the PAs is provided in Appendix C. In addition, for each association we provide local descriptions of floristic composition and site characteristics along with summary data in Appendix D. For some PAs, we have recognized phases that reflect

variants in floristic composition from the typical or central concept of an association ("Typic Phase"). While phases are not recognized or tracked in the NVCS at the national level, they can be important for mapping purposes within a park, or they may later be elevated to PA status. Lastly, we have cross-walked each PA to the map units in which they are either a primary or secondary component or related inclusion, or a contrasting inclusion (see Chapter 3 for a description of map-unit structure and Table 3.3).

Table 2.5 A provisional hierarchical plant association classification for the Capulin Volcano National Monument. "Form" and "Div" refer to Formation and Division levels, respectively, of the National Vegetation Classification System (see Table 2.2 for hierarchical level definitions). These are followed by Macrogroup, Group, and Plant Association levels (codes before level names refer to the NatureServe national database code for that element. "S" refers the significance of the plant association at CAVO where "M" refers to major associations and "I" associations are incidental association of limited distribution or supporting data. The "n" refers to the number of plots and observation points. "Code" is the plant association database (CEGL codes are NatureServe database codes for nationally/globally recognized associations; NPS_NMxxx codes are provisional associations from Natural Heritage New Mexico's database). "Map Units" refers to the vegetation map units in which the plant association is considered to be either a primary component (1), secondary component (2), related inclusion (Ri), or contrasting inclusion (Ci). Phases relevant to the vegetation map are listed under their plant association with references to their respective map units (the main plant association level without a phase designation is by default inclusive of the "typic" phase and other phases that were mapped implicitly).

Capulin Volcano National Monument Provisional Vegetation Classification

Form	Div	Macro-group	Group	Plant association	S	*n*	Code	Map Units 1,2,Ri	Ci
1 Forest & Woodland (Mesomorphic Tree Vegetation)									
1.C Temperate Forest									
1.C.2 Cool Temperate Forest									
	D009	1.C.2.b Western North American Cool Temperate Forest							
		MG022	Southern Rocky Mountain Lower Montane Forest						
			G228	Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group					
				Pinus ponderosa / Quercus gambelii Woodland	M	2	CEGL000870	1A	
	D010	1.C.2.c Western North American Scrub Woodland & Shrubland							
		MG027	Rocky Mountain Two-needle Pinyon - Juniper Woodland						
			G253	Southern Rocky Mountain Pinyon - Juniper Woodland Group					
				Juniperus scopulorum - Quercus gambelii Woodland [Provisional]	M	10	CEGL002967	2E	
				Pinus edulis / Achnatherum scribneri Woodland	M	3	CEGL000798	2C	
				Pinus edulis – (Juniperus monosperma) / Bouteloua gracilis Woodland	M	2	CEGL002151	2F	
				Pinus edulis - Juniperus spp. / Cercocarpus montanus - Mixed Shrubs Woodland	M	4	CEGL000780	2D	
				Pinus edulis - Juniperus spp. / Quercus gambelii Woodland	M	4	CEGL000791	2A	
				Pinus edulis / Muhlenbergia montana Woodland	I	2	NPS_NM070	2B	
				Pinus edulis / Quercus × pauciloba Woodland	M	7	CEGL000793	2D	

Capulin Volcano National Monument Provisional Vegetation Classification

Form	Div	Macro-group	Group	Plant association	S	*n*	Code	Map Units 1,2,Ri	Map Units Ci
2 Shrubland & Grassland (Mesomorphic Shrub & Herb Vegetation)									
2.C Temperate & Boreal Shrubland & Grassland									
	D022	2.C.1.a Vancouverian & Rocky Mountain Grassland & Shrubland							
		MG049	Southern Rocky Mountain Montane Grassland & Shrubland						
			G276	Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group					
				Cercocarpus montanus / Bouteloua gracilis Shrubland	I	1	NPS_NM069	4A	
				Quercus x pauciloba / Cercocarpus montanus Shrubland	I	1	CEGL001118	4A	
			G277	Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland Group					
				Jamesia americana - (Physocarpus monogynus, Holodiscus dumosus) Rock Outcrop Shrubland	I	1	CEGL002783	3B	
				Quercus gambelii - Cercocarpus montanus / (Carex geyeri) Shrubland	M	2	CEGL001113	3A	
				Quercus gambelii / Prunus virginiana Shrubland	M	4	CEGL005994	3A	3B
				Quercus gambelii / Rhus trilobata Shrubland	I	1	CEGL002338	3A	
			G268	Southern Rocky Mountain Montane-Subalpine Grassland Group					
				Festuca arizonica - Muhlenbergia montana Herbaceous Vegetation	M	4	CEGL001606	6A	
	D023	2.C.1.b Great Plains Grassland & Shrubland							
		MG051	Great Plains Mixedgrass Prairie & Shrubland						
			G-TBD	Southwest Plains-Mesa Mixedgrass Prairie Group					
				Andropogon gerardii - Schizachyrium scoparium Herbaceous Vegetation	M	6	CEGL001463	7A	
				Schizachyrium scoparium - Bouteloua gracilis Herbaceous Vegetation	M	3	NPS_NM071	7A	8A
		MG053	Great Plains Shortgrass Prairie & Shrubland						
			G-TBD	Southwest Plains-Mesa Grassland					
				Bouteloua gracilis - Bouteloua curtipendula Herbaceous Vegetation	I	1	CEGL001754	8A	7A
				Bouteloua gracilis / Ruderal Herbaceous Vegetation	I	2	NPS_NM043	8B	
				Pascopyrum smithii - Bouteloua gracilis Herbaceous Vegetation	M	9	CEGL001578	8B	

Capulin Volcano National Monument Provisional Vegetation Classification

Form	Div	Macro-group	Group	Plant association	S	*n*	Code	Map Units 1,2,Ri	Ci
				Pascopyrum smithii / Ruderal Herbaceous Vegetation	I	1	NPS_NM045	8B	
				Yucca glauca / Bouteloua gracilis Shrub Herbaceous Vegetation	I	2	NPS_NM055	8A	
		MGtbd	Great Plains Ruderal Shrubland & Grassland						
			G-TBD	Southwest Ruderal Shrubland & Grassland [Placeholder]					
				Atriplex canescens / Ruderal Herbs Shrubland	I	1	NPS_NM072	5A	
				Ruderal Disturbance Vegetation	M	4	NPS_NM027	9C	
6 Nonvascular & Sparse Vascular Rock Vegetation (Lithomorphic Vegetation)									
6.B Mediterranean, Temperate & Boreal Nonvascular & Sparse Vegetation									
6.B.2 Temperate & Boreal Cliff, Scree & Rock Vegetation									
	D053	6.B.2.c Great Plains Cliff, Scree & Rock Vegetation							
		MG116	Great Plains Cliff, Scree & Rock Vegetation						
			G-TBD	Southwest Cliff, Scree & Rock Vegetation					
				Sparse Vegetation / Bare Ground	I	1	NPS_NM073	9C	
				Sparse Vegetation / Cinder Cone	I	1	NPS_NM066	9B	
				Sparse Vegetation / Lava Flow	I	1	NPS_NM067	9A	

2.2.1. Classification overview

CAVO supports a relatively broad spectrum of vegetation communities in a small area, i.e., conifer woodlands, montane shrublands of the volcano and Boca to prairie grasslands and shrublands that extend out along the mountain toe slopes into the surrounding plains. Below we summarize the information on composition, structure, and environments of vegetation communities with the monument in the context of the new NVCS hierarchy. We focus on the middle tiers of the hierarchy (Division, Macrogroup, and Group) with brief summaries of plant association composition and distribution . See Appendix C for details on plant association composition and environments.

2.2.1.1. Western North America Cool Temperate Forest Division

Southern Rocky Mountain Lower Montane Forest Macrogroup

This macrogroup of cool-temperate forest communities regionally lie at mid elevations between 2,130 and 2,750 m (7,000 and 9,000 ft.) but may extend downslope along drainages to 1,800 m (6,000 ft.), or upslope on warmer exposures to over 3,000 m (9,850 ft.). The macrogroup on CAVO is represented by the Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group and one association, the *Pinus ponderosa - Quercus gambelii /* Woodland (Ponderosa Pine - Gambel Oak Woodland). This association occurs in insolated pockets associated with rough lava in the Boca area of the park (Figure 2.2). The shrubby understory is dominated by *Quercus gambelii* and the hybrid scrub oak *Q. pauciloba* along with a suite of relatively mesic deciduous shrubs such as *Ribes leptanthum* (trumpet gooseberry), *Rhus trilobata* (skunkbush

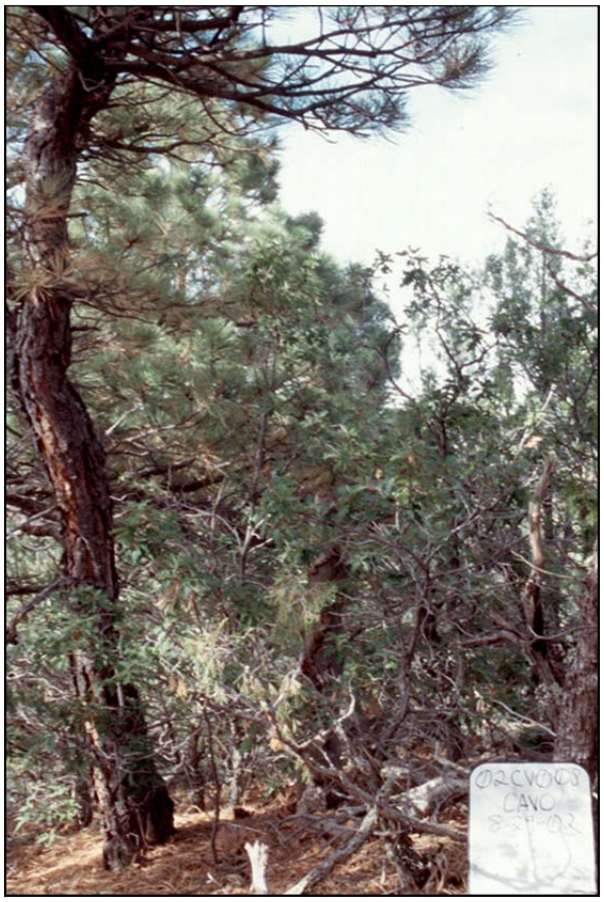

Figure 2.2 Ponderosa pine woodland with Gambel oak shrubs in the understory is located in the Boca area and is representative of the Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group.

sumac), *Cercocarpus montanus* (mountain mahogany), and *Rubus neomexicanus* (New Mexico raspberry). The herbaceous layer tends to be low to moderate in cover and characterized by a mixture of montane cool-season graminoids (e.g., *Poa fendleriana* (mutton bluegrass), *Koeleria macrantha* (June grass), *Elymus elymoides* (bottlebrush squirreltail), *Festuca arizonica* (Arizona fescue), and *Carex inops* ssp. *Heliophila* (deer sedge)) and warm-season grasses that have migrated up from the prairie below (e.g., *Andropogon gerardii* (big bluestem), *Bouteloua gracilis* (blue grama), and *Schizachyrium scoparium* (little bluestem)).

2.2.1.2. Western North America Scrub Woodland and Shrubland Division

Rocky Mountain Two-needle Piñon - Juniper Woodland Macrogroup

Piñon and juniper woodlands of this macrogroup dominate the cinder cone and the lava flows of CAVO and are represented by the Southern Rocky Mountain Piñon-Juniper Woodland Group (Figure 2.3). This group is typically dominated by *Pinus edulis* (two-needle piñon) and often codominant with junipers, in this case *Juniperus scopulorum* (Rocky Mountain juniper). We have identified six associations where *P. edulis* clearly dominates accounts for at least 25% of the total canopy relative to *Juniperus*, and one association where *Juniperus scopulorum* dominates and *P. edulis* is absent or accidental (*Juniperus scopulorum - Quercus gambelii* Woodland (Rocky Mountain Juniper - Gambel Oak Woodland)). The most common associations are those with shrubby understories: *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland (Two-needle Pinyon - Juniper species / Gambel Oak Woodland), *Pinus edulis / Quercus × pauciloba* Woodland (Two-needle Pinyon / Wavyleaf Oak Woodland), and the *Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrubs Woodland (Two-needle Pinyon - Juniper species / Alderleaf Mountain-mahogany - Mixed Shrubs Woodland).

Figure 2.3 This piñon-juniper/wavyleaf oak woodland is common on the volcano and in the Boca area and is a representative of the Southern Rocky Mountain Piñon-Juniper Woodland Group

Stands occur both on the rocky and rough lava fields of the Boca as well as on the scoria slopes of the cinder cone. Intermixed among them are stands of *Juniperus scopulorum - Quercus gambelii* Woodland. Other stands are grass dominated in the understory. The *Pinus edulis /Achnatherum scribneri* Woodland (Two-needle Pinyon / Scribner's Needlegrass Woodland) and *Pinus edulis / Muhlenbergia montana* Woodland (Pinyon Pine / Mountain Muhly Woodland) are most common on the upper slopes of the cinder cone while the *Pinus edulis - (Juniperus monosperma) / Bouteloua gracilis* Woodland (Two-needle Pinyon - (One-seed Juniper) / Blue Grama Woodland) is more prevalent downslope adjoining the prairie grasslands (*J. monosperma* is absent in this case and replaced by *J. scopulorum*). The grass-dominated woodlands tend to occur on scoria cinder sites that are less rocky or on lava fields where the basalt rocks have been at least a partially covered with wind-blown sediments to create a fine-textured soil mantle.

Fire is an important disturbance factor in pinyon-juniper woodlands and, most recently, Romme et al. (2009) provided an overview of fire's role in the dynamics and structuring of western U.S. piñon -juniper woodlands. They recognized the "savanna woodlands" as a separate element with a specific fire regime of high-frequency, low-intensity surface fires and (Dick-Peddie (1993) referred to it as an ecotonal type of vegetation between dense woodlands and true grasslands. The closest analogue to this type of woodland on CAVO would be the *Pinus edulis - (Juniperus monosperma) / Bouteloua gracilis* Woodland with its open canopy and grassy inter-tree spaces (a piñon-dominated savanna macrogroup has yet to be proposed in the NVC). This PA commonly lies along the ecotone with *B. gracilis* grasslands along the toe slopes and basalt plains of the park (see 2.2.1.4 below). Guyette and Stambuaugh (undated), working in *P. ponderosa* stands in the Boca and on the edge of the grasslands on nearby ranch, reported historic mean fire intervals (MFI) of between five and 20 years, which is in keeping with the concept of a high-frequency, low-intensity regime for a woodland savanna association such as this.

Following, Romme et al. (2009), the *Quercus* and *Cercocarpus* shrub-dominated woodland understories associations described here would be considered part of their "wooded shrubland" with a mixed fire regime of crown and surface fires of moderate to high intensity and frequency. While lighting can be quite prevalent on the monument, providing potential for ignitions, fire spread may be limited by the rough terrain and the lack of continuous fuels, particularly in the Boca area. The upper end MFI of 20 years reported by Guyette and Stambuaugh (undated) for *P. ponderosa* could apply here, but as they and others have stated, we are hindered here because it is difficult to render a deep piñon fire-scar record because *P. edulis* trees that record fire scars are rare (we found no direct evidence of fire in the piñon woodlands). While this makes fire regime evaluation difficult, the intrinsic lower productivity of piñon-juniper woodlands suggests that MFIs are longer in these shrub-dominated systems than the lower savannas. In fact, Guyette and Stambuaugh (undated) report that on the upper slopes of the volcano they were unable to detect any fire scars on the *P. edulis* while trees as old as 485+ years were found. These older stands with little fire evidence would fall into Romme et al. (2009)'s "persistent woodland" with limited surface fuels that would have either low-frequency, high-intensity crown fires or none, depending on canopy density. On CAVO, these persistent woodlands are represented by the *Pinus edulis / Achnatherum scribneri* Woodland and *Pinus edulis / Muhlenbergia montana* Woodland associations. While these woodlands have grassy understories, they have somewhat closed canopies that create a patchy distribution of the understory grasses and discontinuous fuels. Hence, while fire still plays a role here (surface fires might still occur but much more rarely), the MFI might range in the 100 to 500 year range and by and large be patchy. The most likely way for major fires to occur on the slopes of the volcano is for fires to be initiated in the

lowland grasslands and then sweep upslope into the woodlands. Then, depending on weather conditions, surface fuel moisture and continuity, and canopy density, a large crown fire may be generated. The evidence for this lies primarily where we see large shrubland patches which may reflect sites for past woodlands (see as 2.2.1.3 below).

With respect to other regional classifications, these piñon-dominated woodland associations would be considered part of the *P. edulis* Series *sensu* Daubenmire (1966, 1976) and Layser and Schubert (1979), the Colorado Pinyon-Oneseed Juniper Series of Dick Peddie (1993), and the *Pinus edulis-Juniperus monosperma* Association of Brown et al. (1979). Overall, these woodland associations on CAVO are eastern extensions into the Short Grass Steppe of common lower montane woodland communities of the southern Rocky Mountains. Regionally, the *Pinus edulis / Achnatherum scribneri* Woodland is the rarest and is usually limited to high-elevation sites on limestone rather than basalt. The *Pinus edulis / Muhlenbergia montana* Woodland is a new association that has not been reported elsewhere (although *P. edulis* and *M. montana* are common components of the *Pinus ponderosa/Muhlenbergia montana* association that is common through the Southwest).

2.2.1.3. Vancouverian and Rocky Mountain Grassland and Shrubland Division

This western U.S. division is represented by three macrogroups on CAVO.

Southern Rocky Mountain Montane Shrubland and Grassland Macrogroup

On CAVO, there are four montane shrubland associations belonging to the Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland Group. They occur mostly interspersed among the piñon and juniper woodlands (Figure 2.4). Three of the four are dominated by *Q. gambelii*: *Quercus gambelii - Cercocarpus montanus* / (*Carex geyeri*) (Gambel Oak - Alderleaf Mountain-mahogany / (Geyer's Sedge)) Shrubland, *Quercus gambelii* / *Prunus virginiana* (Gambel Oak / Chokecherry) Shrubland, and *Quercus gambelii* / *Rhus trilobata* (Gambel Oak / Skunkbush Sumac) Shrubland. The fourth, *Jamesia americana - (Physocarpus monogynus, Holodiscus dumosus*) (Five-petal Cliffbush - (Mountain Ninebark, Glandular Oceanspray) Rock Outcrop Shrubland, lacks oaks but is characterized by a suite of relatively mesic shrubs (*J. americana, P. monogynus, Rhus trilobata, Ribes cereum*, and *Rosa woodsii*; *H. dumosus* is absent).

On drier sites, associations of the Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group become more prevalent (Figure 2.5). The two CAVO plant associations in this group are *Quercus X pauciloba* / *Cercocarpus montanus* (Wavyleaf Oak / Alderleaf Mountain-mahogany) Shrubland and *Cercocarpus montanus / Bouteloua gracilis* (Mountain Mahogany / Blue Grama) Shrubland. The former is dominated by the semi-deciduous scrub oak *Q.* x *pauciloba* as well as the deciduous *C. montanus*; the latter PA lacks the scrub oak component.

These montane shrubland associations tend to occur on either rocky and boulder lava substrates that do not favor trees or as successional shrublands following fire or other disturbances in ponderosa or piñon woodlands. That is, for those woodlands that originally had oak understories (e.g., *Pinus ponderosa - Quercus gambelii* or the *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland, etc.) the shrubland associations can be post-fire pioneer community correlates, particularly *Quercus gambelii - Cercocarpus montanus* / (*Carex geyeri*), *Quercus X pauciloba* / *Cercocarpus montanus* Shrubland and *Cercocarpus montanus / Bouteloua gracilis* PAs. In addition, *Q. gambelii* and *Q. pauciloba* are also strongly clonal species that after

Figure 2.4 This stand of Gambel oak on a north-facing slopes inside the crater of Capulin Volcano is representative of the Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland Group

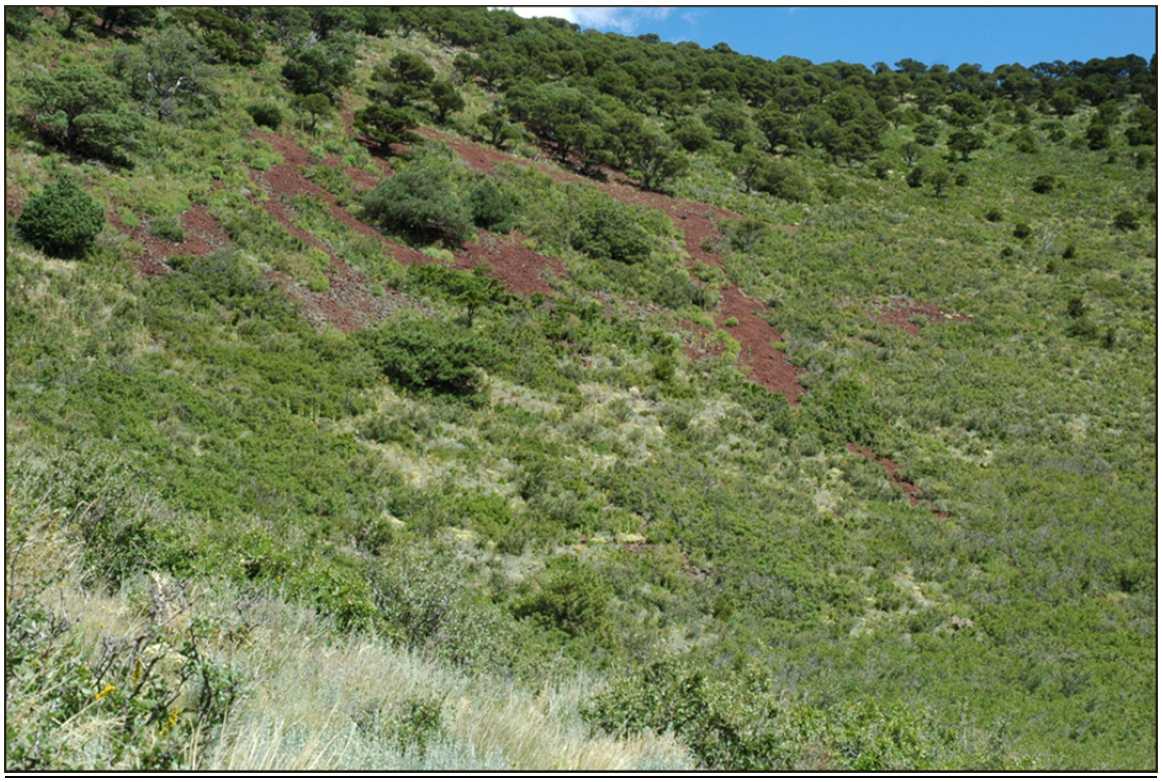

Figure 2.5 On the south-facing slopes inside the crater wavyleaf oak and alderleaf mountain-mahogany dominate and are representative of the Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group.

disturbance may dominate and persist for long periods with or without fire, and preclude the establishment of trees. Thus, they can naturally become the long-term vegetation community on a site rather than woodlands.

In other regional classifications, montane shrublands would fall within Brown et al. (1979)'s Great Basin Montane Scrub Biome within the Cold Temperate Scrublands climate zone where they specified *C. montanus, Q. gambelliii*, and Mixed Deciduous (shrub) series. Dick-Peddie (1993) has a similar classification of a Mountain Mahogany-Mixed Shrub Series under Montane Scrub, but he specifically put *Q. gambelii* and *Q. x pauciloba*-dominated shrublands in an Oak Successional Series under Successional-Disturbance Scrub (rather than Montane Scrub). As with the woodlands, these shrubland associations on CAVO are eastern extensions into the Short Grass Steppe of common lower montane shrubland communities of the southern Rocky Mountains and the Southwest.

With respect to grasslands in this macrogroup, they are represented by the Southern Rocky Mountain Montane-Subalpine Grassland Group and the *Festuca arizonica - Muhlenbergia montana* (Arizona Fescue - Mountain Muhly) Herbaceous Vegetation PA (Figure 2.6). Both *F. arizonica* and *M. montana* are common dominants in montane grasslands of the southern Rocky Mountains and the Southwest. On CAVO, this association is found both in the Boca and on the cinder cone, and *M. montana* is usually the dominant. Other species that are more prevalent in the lower-elevation grasslands can also make their way into stands (e.g., *B. gracilis* and *Schizachyrium scoparium*). Elsewhere in the Southwest, these grasslands are often associated

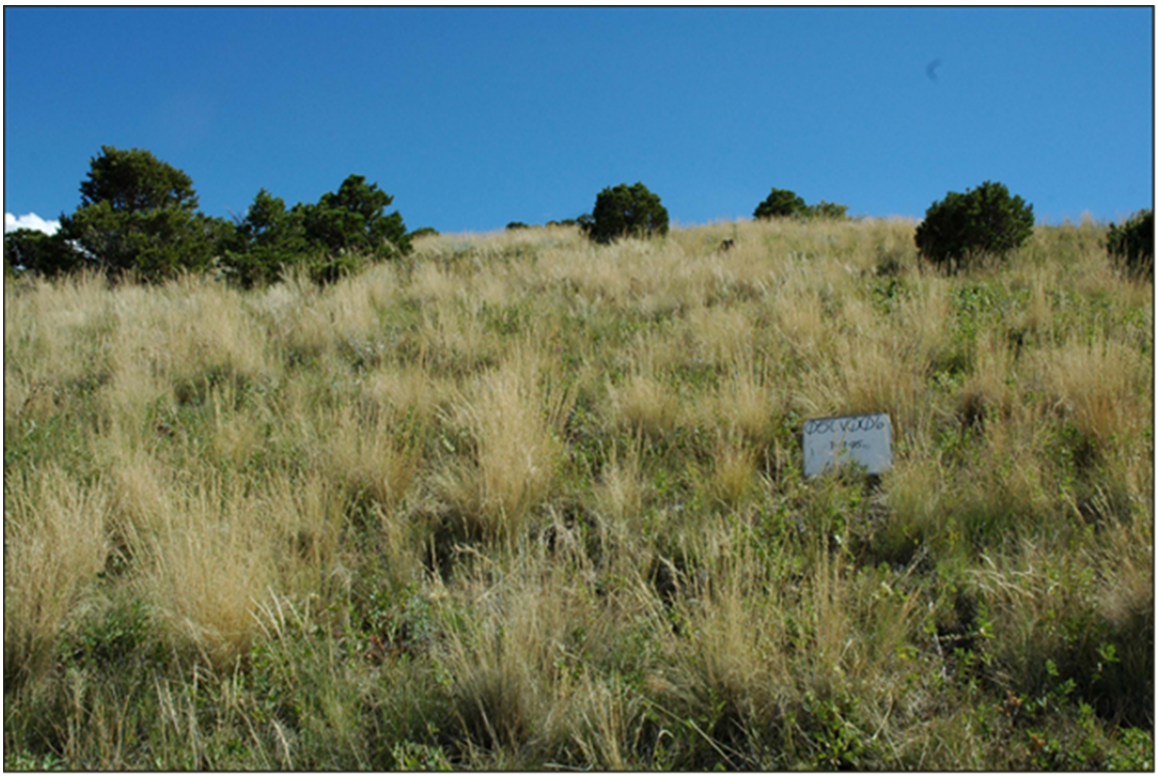

Figure 2.6 On CAVO, the Southern Rocky Mountain Montane-Subalpine Grassland Group is represented by stands of the Fescue - Mountain Muhly association such as this one on the north slope of the volcano.

with post-fire landscapes that were once dominated by mixed-conifer and ponderosa pine forests (e.g., the *Pinus ponderosa / Muhlenbergia montana* PA). Accordingly, on CAVO these grasslands may also be post-fire successional correlates to the *Pinus edulis / Muhlenbergia montana* Woodland. Regionally, this association falls within Brown et al. (1979)'s Bunchgrass Series within the Rocky Mountain Alpine and Subalpine Grassland Biome, and in Dick-Peddie (1993)'s Fescue Series under Subalpine-Montane Grassland.

2.2.1.4. Great Plains Grassland and Shrubland Division

CAVO lies along the western edge of the Great Plains and supports grassland and shrubland communities that are common to that biome, which we have segregated into three macrogroups as follows:

Great Plains Mixedgrass Prairie & Shrubland Macrogroup

This macrogroup is widespread throughout the central portion of the Great Plains. It becomes patchy in distribution to the west within the matrix of shortgrass prairie. Currently, in the NVC there are no "groups" that reflect the PA composition found on CAVO. Hence, we have defined a provisional Southwest Plains-Mesa Mixedgrass Prairie Group that contains the *Andropogon gerardii - Schizachyrium scoparium* Western (Big Bluestem - Little Bluestem) Great Plains Herbaceous Vegetation and *Schizachyrium scoparium - Bouteloua gracilis* (Little Bluestem - Blue Grama) Herbaceous Vegetation PAs. These associations are dominated by their respective tall and medium bunch grasses, *A. gerardii* and *S. scoparium*, but the dominant from the surrounding short grass prairie, *B. gracilis*, can be abundant and co-dominant as well. Stands are common, but patchy in distribution along the base of the cinder cone and in the Boca area (Figure 2.7).

Great Plains Shortgrass Prairie & Shrubland Macrogroup

As with the other macrogroups in this division, we have identified a provisional Southwest Plains-Mesa Grassland Group containing a mix of five plant associations that are not adequately represented in other NVC groups within the macrogroup at this time (Table 2.5). These grasslands are mainly dominated by short to medium-tall bunch grasses (e.g., *Bouteloua gracilis, B. curtipendula, Pascopyrum smithii* (western wheatgrass), *Aristida purpurea* (purple three-awn), and *Sporobolus cryptandrus* (sand dropseed)). These are primarily *B. gracilis*-dominated or co-dominated grasslands that form the matrix grassland of the lowland lava flows, becoming patchier along the toes slopes of the cinder cone and in the Boca area. (Figure 2.8). Some have a significant subshrub component where such species as *Yucca glauca* (soaptree yucca) and *Artemisia frigida* (prairie sagewort) are well represented to abundant (i.e., in the *Yucca glauca / Bouteloua gracilis* Shrub Herbaceous Vegetation and *Bouteloua gracilis* / Ruderal Herbaceous Vegetation PAs). Stands where *P. smithii* is dominant or co-dominant are often located in swales and other lowland areas where water tends to accumulate.

Great Plains Ruderal Shrubland & Grassland Macrogroup

We have proposed this provisional macrogroup to encompass communities where prehistoric and/or historic human disturbances including residential/commercial development, agriculture, or high-intensity grazing have imparted a legacy of abundant ruderal (weedy) species, often in a heterogeneous mix of annual and short-lived perennials (Figure 2.9). Accordingly, for CAVO, we have identified four associations within a provisional Southwest Ruderal Shrubland & Grassland Group to reflect these conditions: *Bouteloua gracilis* / Ruderal Herbaceous

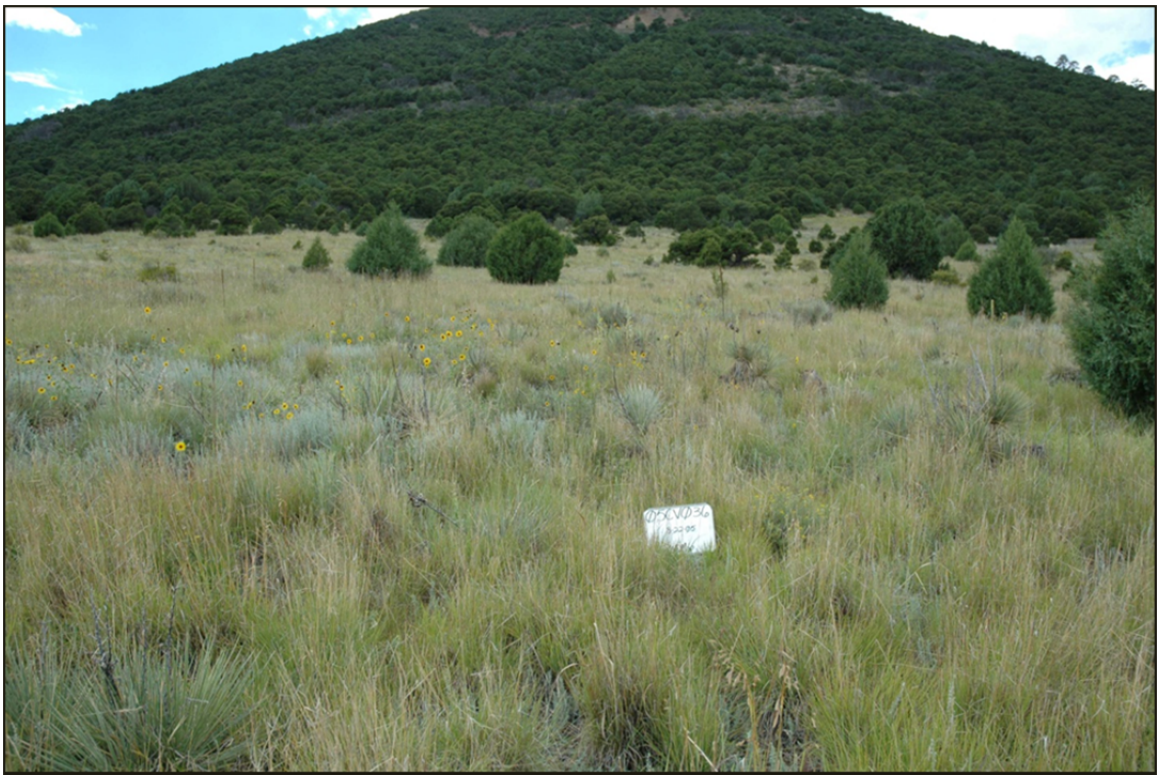

Figure 2.7 The Southwest Plains-Mesa Mixedgrass Prairie Group on CAVO is characterized by stands dominated by big bluestem and little bluestem, such as this one found on the north-facing toes slopes of the volcano.

Figure 2.8 Blue grama-dominated grasslands such as this one on a southeast-facing lower slope on CAVO typify the Southwest Plains-Mesa Grassland Group. In the Southwest, soaptree yucca and fringed sage are common associates.

Figure 2.9 Weedy (ruderal) vegetation primarily composed of annual forbs and scattered grasses represent the most disturbed elements of the Southwest Ruderal Shrubland & Grassland Group. Evidence of ground-burrowing animals such as gophers is often evident.

Vegetation, *Pascopyrum smithii* / Ruderal Herbaceous Vegetation, and *Atriplex canescens* (Fourwing Saltbush)/ Ruderal Herbs Shrubland associations as well as generalized Ruderal Disturbance Vegetation PA characterized primarily by annual forbs and grasses.

Regionally, these grasslands would be considered part of Brown et al. (1979)'s Plains Grassland Biome that includes a Bluestem "tall-grass" Series, Grama "short-grass" Series and a Mixed "short-grass" Series. Dick-Peddie (1993) was the first to coin the term "Plains-Mesa Grassland" for those communities that were potentially unique to the Southwest and New Mexico in particular. Under this heading he identified a Bluestem-Sideoasts Series, Grama Grass Series, and Grama-Western Wheatgrass Series that we suggest would include the various grassland PAs we identified for CAVO (only the *Pascopyrum smithii /Bouteloua gracilis* PA from CAVO explicitly matches his list of associations).

The *Schizachyrium scoparium - Bouteloua gracilis* Herbaceous Vegetation and *Yucca glauca / Bouteloua gracilis* Shrub Herbaceous Vegetation PAs are provisional types not found in the NVC (along with the various ruderal associations). At this time, the *Schizachyrium scoparium - Bouteloua gracilis* Herbaceous Vegetation PA has only been reported from CAVO and should remain provisional, but we suspect that it occurs elsewhere in the high plains of New Mexico. In contrast, *Yucca glauca / Bouteloua gracilis* Shrub Herbaceous Vegetation has been documented in the NHNM plot database as occurring throughout the high plains and we would recommend its incorporation into the NVC as an accepted association.

2.2.1.5. Great Plains Cliff, Scree & Rock Vegetation

Great Plains Cliff, Scree & Rock Vegetation Macrogroup
This macrogroup includes the provisional Southwest Cliff, Scree & Rock Vegetation Group that represents sparely vegetated ground and includes Sparse Vegetation / Bare Ground, Sparse Vegetation / Cinder Cone, and Vegetation / Lava Flow (Figure 2.10).

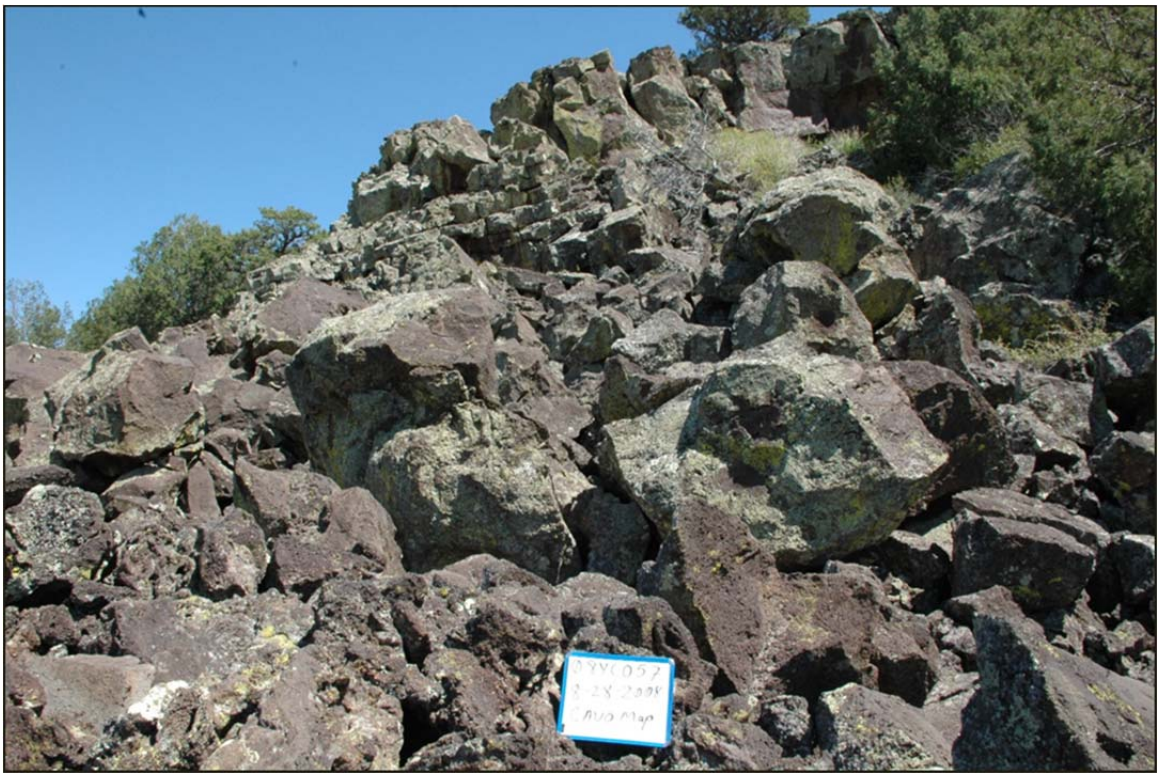

Figure 2.10 Exposed, sparsely vegetated rocklands such as this jumble of boulders that make up a lava flow remnant in the Boca area is representative of a provisional Southwest Cliff, Scree & Rock Vegetation Group identified for CAVO.

2.3. Classification Discussion

Several of the groups and associations described here are new under the current FGDC (2008) NVCS hierarchy. They have not had a formal review by either NatureServe (currently managing the NVC database) or the Ecological Society of America Vegetation Panel (responsible for final decisions regarding the classification) to confirm or reject the assignment of plots to the various classification categories. Accordingly, the classification remains provisional, and we would recommend that it be submitted for review to either NatureServe and/or the ESA panel before it and the accompanying plots are incorporated into the NPS national database (PLOTS). In addition, the descriptions provided in Appendix D are localized for the park and lack global content to provide a context for management and applied research. We would recommend that these locals also be incorporated into NatureServe's global framework and database and the global descriptions provided back to the park as a separate report.

Daubenmire (1974) suggested that plant communities integrate all impinging environmental conditions and, hence, the classification and description of plant associations provides a framework for understanding the ecological composition and structure of a given landscape. Accordingly, plant associations are used in the mapping process to define map-unit components,

providing the information linkage between a vegetation community's spatial distribution and its ecology. The outcome is that by grouping land areas based on their ability to support similar associations, general management observations and recommendations can be made for each grouping. In addition, resource managers have found that the classification of vegetation into plant associations has provided insight and the ability to predict vegetation changes in response to various disturbance processes. Yet, the development of a vegetation classification is an incremental process of successive approximation (Shimwell 1971). In particular, on CAVO we suggest that further work is needed in evaluating the provisional associations identified in Table 2.5 to come to a better understanding of the ecosystem structure, composition, and processes in the park.

3. Capulin Volcano National Monument Vegetation Map

3.1. Mapping process overview

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

Per the guidance of the National Vegetation Mapping Program (http://biology.usgs.gov/npsveg/), the key mapping standards call for spatial data to be provided with a horizontal positional accuracy meeting National Map Accuracy Standards of at least the 1:24,000 scale (i.e., that each well-defined object in the spatial database be within 1/50-of-an-inch display scale or 12.2 m (40 ft.) of its actual location).

3.2. Mapping methods

3.2.1. Data sources and processing

Initially, DigitalGlobe QuickBird satellite imagery was used as the foundation for the map and the initial classification from which polygon primitives were developed. As that imagery was found to have significant geometric errors, mostly along the northeastern slopes of the volcano, our mapping effort switched to using aerial digital ortho-photography (Digital Orthophoto Quarter Quads, or DOQQ) as the foundation for the final development of the map. The DOQQs used were the statewide one-meter resolution true-color imagery from 2005. In addition, multi-temporal Landsat data was also incorporated into the classification. All imagery was processed using ERDAS Imagine 9.2. The final image products and other spatial data layers were compiled into a geodatabase and GIS using ArcGIS 9.3.1 (ESRI 201, http://www.esri.com). To support the mapping process, we acquired as a standard set of relevant spatial data layers (e.g., roads, building, topographic maps, etc.)

QuickBird imagery was acquired over the park on September 25, 2006. The QuickBird data consisted of the four band multi-spectral imagery at 2.4-meter spatial resolution (Table 3.1) and the 0.6-meter spatial panchromatic band (0.4-0.9 μms). Despite having the best spatial resolution, the panchromatic integrates the spectral reflectance over the visible and near infrared wavelengths into just one output response per pixel. Multi-spectral satellite imagery, on the other hand, records different reflectance values of the variable natural radiation of surface materials such as rocks, plants, soils, and water over the Instantaneous Field of View (IFOV), which denotes the image's spatial resolution. Variations in plant reflection and absorption due to biochemical composition produce distinct spectral "signatures" (Jensen 2007). These signatures

Table 3.1 Quickbird[Q] and Landsat[L] satellite imagery multi-spectral band descriptions.

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

Table 3.2 Landsat ETM+ spectral band descriptions (Jensen, 2004).

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

provide a quantitative measure of reflectance at specific wavelengths, which can be analyzed statistically to develop a vegetation map of spectrally similar plant communities.

Three multi-spectral satellite Landsat Enhanced Thematic Mapper$^+$ (ETM$^+$) images were also used. Despite its coarser spatial resolution of 30 m, the Landsat imagery provides data in the mid-infrared wavelengths unavailable in QuickBird imagery (Table 3.2). In addition, its relatively affordable cost at the time of mapping allowed the acquisition of seasonal images to better detect differences in phenology between the plant communities. These images were from April 16, 2000, June 22, 2001, and September 7, 2000. These multi-temporal scenes capture the seasonal vegetation changes of deciduous shrub leaf-out, forb emergence, and transition from cool-to warm-season grasses. Although the ETM$^+$ images were already geo-corrected, they were re-rectified to the QuickBird imagery. This was to ensure the images overlaid each other directly. The ETM$^+$ images were sampled to a 20-m spatial resolution and projected into the QuickBird imagery's projection.

Four vegetation indices were computed to enhance various vegetation or ecosystem characteristics using primarily ETM$^+$ spectral bands, although in regard to the Normalized Difference Vegetation Index (NDVI) QuickBird imagery was substituted. These were the Normalized Difference Senescent Vegetation Index (NDSVI) [Eq. 1], the NDVI [Eq. 2], a moisture index [Eq. 3], and a vegetative moisture index [Eq. 4] computed as follows:

$$NDSVI = ((Band\ 7 - Band\ 3) / (Band\ 7 + Band\ 3) + 1) * 100 \quad \text{(Eq. 1)}$$

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

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

Structure index = ((Band 4 – Band 5) / (Band 4 + Band 5) + 1) * 100 (Eq. 4)

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

The NDSVI enhances the spectral characteristics of senescent vegetation (specifically grasses), which have a relatively low reflectance response in the red wavelengths (Band 3) and a high reflectance in the mid-infrared wavelengths (Band 5). The NDVI emphasizes vigorous green plant growth by comparing a strong chlorophyll reflectance in the near-infrared wavelengths (Band 4) against chlorophyll absorption in the visible red wavelengths (Band 3). The moisture index compares relatively high reflectance values in the shorter wavelengths of the mid-infrared (Band 5) against strong absorption at the longer wavelengths of the mid-infrared (Band 7) caused by water molecules found in soil and vegetation. Similarly, the vegetative moisture index enhances shadowing and leaf-water content in plants.

All imagery, the QuickBird multi-spectral imagery, the multi-temporal ETM^+ multi-spectral imagery and their derived vegetation indices were merged with the QuickBird panchromatic imagery using a multiplicative data fusion technique. The resulting file provided much of the spectral capabilities inherent in the above images but at the spatial resolution of the panchromatic imagery. The imagery was resampled up to a one-meter spatial resolution, to reduce its file size and provide a more logical unit of a pixel being 1 m^2.

3.2.2. Vegetation map units and legend development

The development of map units (map classes) and construction of a map legend is an iterative process that integrates the ecological vegetation classification units (plant associations, groups, etc.) described above with their spatial distribution as determined by the quality of the remote sensing imagery and on-the-ground reconnaissance work. Following NPS guidelines, the desired target is the development of map units that correspond to the plant-association level of the national classification, but this is contingent on being able to discern differences in the available imagery at that level using various remote techniques.

The hierarchical working legend formed the foundation for subsequent image analysis and classification. Based on the results of the image analysis and subsequent heads-up screen editing, the legend was further refined both by lumping and splitting the draft units. Detailed map unit descriptions that include plant association composition and distribution were developed and presented in Appendix E.

3.2.3. Image analysis and map development

3.2.3.1. Base map development

To efficiently develop a base map with a polygon structure (versus raster/pixel) per NPS specifications we employed eCognition, Definiens Cognition Network Technology® object-oriented classification software (Definiens http://www.definiens.com). This software uses an image segmentation technique to delineate the imagery into objects (polygons) of similar color, contrast, and shape. The advantage of this approach is that these objects will preserve edge boundaries of detailed surface features such as roads, cliffs, and drainages – features that would be lost or misclassified in a more traditional pixel-based classification. In this automated polygon delineation framework, the level of detail is controlled by a unitless scale parameter[2] that considers each polygon object based on its homogeneity of color and shape, each of which is weighted from zero to one. The smaller the scale parameter, the more detail is represented and the more the image is segmented into polygon objects, with a scale factor of "1" theoretically representing individual pixels of the original photography base. In this project, the scale parameter varied from 75 to 125 from region to region of analysis. The scale parameter is dependent on the weighting of the shape and color factors. In this case, the color factor and the shape factor were given equal weight at 0.5. The shape sub-factors of smoothness and compactness were weighted equally (0.5). This process generated over 1,700 raw polygons ranging in size from 0.007 m^2 to 33,617 m^2 with the average size of 4,500 m^2.

3.2.3.2. Supervised Classification

At the same time, polygons were digitally drawn on the imagery based on information from vegetation plots gathered in the field and their accompanying notes. From these polygons, image statistics were collected to perform a supervised classification. Supervised classifications are based on a maximum likelihood decision rule containing a Bayesian classifier that uses probabilities to weight the classification toward particular classes. In this study, the probabilities were unknown, so the maximum likelihood equation (Eq. 7) for each of the classes is given as:

$$D = [0.5\ln(cov_c)]-[0.5(X-M_c)^T * (cov_c^{-1})*(X-M_c)] \text{ (Eq.7)},$$

where **D** is the weighted distance, $\mathbf{cov_c}$ is the covariance matrix for a particular class, **X** is the measurement vector of the pixel, $\mathbf{M_c}$ is the mean vector of the class and $^{\mathbf{T}}$ is the matrix transpose function (ERDAS 2010, http://www.erdas.com). Each pixel is then assigned to the class with the lowest weighted distance. This technique assumes the statistical signatures have a normal distribution.

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

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

3.2.4. Final map classification and ancillary layers

Once a final supervised classification was completed, the resulting 45 classes were recoded into one of the 23 map units that best represented them. The image polygons developed from the object-oriented classification were imported as a feature dataset polygon layer in ESRI ArcGIS (v. 9.3), the file quality controlled, and topology built. The image polygons were then overlaid onto the recoded classification and the majority map unit was assigned as that polygon's map unit.

During this process, we discovered a significant geometric error in the QuickBird imagery along the northeastern slopes of the volcano. To compensate, we used the recently available 2005 natural color DOQQ to improve the geometric accuracy of the line work, and as the basis for final photo-interpretive editing of the polygons. Adjacent polygons of the same class were merged for the final map, and a 1:6,000-scale poster map was produced using the NPS-provided standard template.

3.3. Mapping Results

3.3.1. Vegetation Map and Map Legend

The vegetation map for CAVO is presented in Figure 3.1 along with an abbreviated legend in Table 3.3. We also produced a 1:6,000-scale poster map that is available as both a PDF and shape file for GIS use at http://biology.usgs.gov/npsveg/products/parkname.html. There are nine Level 1 units that correspond to the group level of the NVCS plus a set of land-cover units that reflect human land uses such as urban and built-up land including residential vegetation, structures and buildings, roads, trails and water (MUs 10 and 11). At Level 2, there are 18 vegetation units and these are further defined by one or more plant associations per the CAVO vegetation classification in Table 2.5, and each is identified as either a primary or secondary component, or a related or contrasting inclusion. The Level 2 map units are also cross-referenced by a map symbol in the vegetation classification table (see Table 2.5). While some units are more heterogeneous than others, the attempt was made to keep the map units as monophyletic as possible, that is, to minimize the overlap of associations from one unit to the next. The map-unit name reflects the primary component associations of the unit. A complete annotated legend with summary descriptions of the units, distribution maps, aerial photo examples of map unit polygons, and representative photos is provided in Appendix E.

3.3.2. Discussion

Mapping the grasslands and woodlands that dominate CAVO presented challenges because of the relatively low spatial and spectral resolution by modern standards of the satellite and aerial photo imagery (one meter). Hence, spectral signatures overlap significantly among grass species and even shrubs. Therefore, much of our interpretation was based on modeling landscape characteristics and soil signatures in relation to grassland composition as sampled in the field. This was further compounded by the long land-use history, both historic and prehistoric, that shapes much of the vegetation pattern, particularly in the grasslands. For example, there were indications in the vegetation expression of long-term use of grasslands reflected on the ground by the presence of ruderal, weedy, grasses, forb species and shrubs grasses such as *Aristida purpurea* (purple threeawn), *Muhlenbergia torreyana* (ring muhly), and dwarf shrubs such as *Gutierrezia sarothrae* (broom snakeweed), and *Yucca glauca* (soapweed yucca) (i.e., map units 8A and 8B). While the target scale of the map was 1:24,000 per NPS national standards, much of the interpretation required work at 1:3,000 and below to be effective. Lastly, detecting these

species remotely is subtle at best and we relied heavily on ground surveys to confirm polygon assignments (see Accuracy Assessment below).

Landscapes are of course in constant flux with respect to vegetation, particularly where there is active resource management. This map represents a snapshot in time based on the 2006 imagery. Since that time, there have been active treatments for shrubs and trees at CAVO, particularly along the base of the volcano and in the Boca area. However, because the map is high resolution and has a well-defined and detailed legend that can be used in the GIS platform that the park uses, we expect, and in fact encourage, updates to polygons to reflect the ongoing change. Overall, the combination of the annotated legend (Appendix E) and the detailed floristic and site descriptions of individual plant associations (Appendix D) provide for a vegetation map that is ecologically rich in information and one that can serve multiple purposes in the management of the park and the broader network of parks.

Table 3.3. Hierarchical map unit legend for the Capulin Volcano National Monument Vegetation Map. See text for definition of map unit levels one and two (L1 and L2). Level 1 numbers in brackets refer to the NVCS Group number in Table 2.5. The lowest level (3) shows component plant associations of the unit per those listed in Table 2.5. Under "Type", each association is designated either as a primary (1), secondary component (2), Related Inclusion (Ri), or Contrasting Inclusion (Ci). "P" refers to the number of polygons represented on the map along with the total area in hectares and acres.

Capulin Volcano National Monument Vegetation Map Legend						
Map Unit		**Map unit name and component plant associations**	**Type**	**P**	**Area (ha)**	**Area (ac)**
L1	**L2**					
1		**Southern Rocky Mountain Ponderosa Pine Forest and Woodland**		**4**	**1.4**	**3.6**
	A	• Ponderosa Pine/Oak Lava Forest		4	1.5	3.6
		• *Pinus ponderosa* / *Quercus gambelii* Woodland	1			
2		**Southern Rocky Mountain Piñon-Juniper Woodland**		**90**	**179.3**	**443.0**
	A	• Piñon/Gambel Oak Cinder Woodland		7	25.3	62.6
		• *Pinus edulis* - *Juniperus* spp. / *Quercus gambelii* Woodland	1			
	B	Piñon/Mountain Muhly Cinder Woodland		5	7.2	17.98
		• *Pinus edulis* / *Muhlenbergia montana* Woodland	1			
	C	• Piñon/Scribner Needlegrass-Mountain Muhly Cinder Woodland		8	14.8	36.6
		• *Pinus edulis* / *Achnatherum scribneri* Woodland	1			
	D	Piñon/Wavyleaf Oak-Mountain Mahogany Woodland		14	78.2	193.2
		• *Pinus edulis* - *Juniperus spp.* / *Cercocarpus montanus* - Mixed Shrubs Woodland	1			
		• *Pinus edulis* / *Quercus* ×*pauciloba* Woodland	2			
	E	Rocky Mountain Juniper/Gambel Oak Lava Woodland		36	48.7	120.2
		• *Juniperus scopulorum* - *Quercus gambelii* Woodland	1			
	F	Piñon/Blue Grama Lava Savanna		20	4.9	12.3
		• *Pinus edulis – (Juniperus monosperma)* / *Bouteloua gracilis* Woodland	1			
3		**Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland**		**20**	**13.3**	**32.8**
	A	Gambel Oak Shrubland		18	12.9	32.0
		• *Quercus gambelii* - *Cercocarpus montanus* / *(Carex geyeri)* Shrubland	1			
		• *Quercus gambelii* - *Prunus virginiana* Shrubland	1			
		• *Quercus gambelii* / *Rhus trilobata* Shrubland	Ri			
	B	Fivepetal Cliffbush Cinder Shrubland		2	0.3	0.8
		• Jamesia americana - *(Physocarpus monogynus, Holodiscus dumosus*) Rock Outcrop Shrubland	2			
		• *Quercus gambelii* - *Prunus virginiana* Shrubland	Ci			
4		**Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland**		**41**	**18.1**	**44.8**
	A	Mountain Mahogany-Wavyleaf Oak Shrubland		41	18.2	44.8
		• *Cercocarpus montanus* / *Bouteloua gracilis* Shrubland	1			
		• *Quercus x pauciloba* / *Cercocarpus montanus* Shrubland	1			
5		**Southwest Ruderal Shrubland and Grassland**		**3**	**1.7**	**4.1**
	A	Fourwing Saltbush Shrubland		3	1.7	4.1
		• *Atriplex canescens* / Ruderal Herbs Shrubland	1			
		• Ruderal Disturbance Vegetation	2			

Capulin Volcano National Monument Vegetation Map Legend						
Map Unit		**Map unit name and component plant associations**	**Type**	**P**	**Area (ha)**	**Area (ac)**
L1	**L2**					
6		**Southern Rocky Mountain Montane-Subalpine Grassland**		**7**	**9.9**	**24.6**
	A	Arizona Fescue-Mountain Muhly Grassland		7	9.9	24.6
		• *Festuca arizonica - Muhlenbergia montana* Herbaceous Vegetation	1			
7		**Southwest Plains-Mesa Mixedgrass Prairie**		**22**	**23.6**	**58.4**
	A	Big Bluestem-Little Bluestem Lava Grassland		22	23.6	58.4
		• *Andropogon gerardii - Schizachyrium scoparium* Herbaceous Vegetation	1			
		• *Schizachyrium scoparium – Bouteloua gracilis* Herbaceous Vegetation	1			
		• *Bouteloua gracilis - Bouteloua curtipendula* Herbaceous Vegetation	Ci			
8		**Southwest Plains-Mesa Grassland**		**55**	**48.1**	**118.9**
	A	Blue Grama Shortgrass Steppe		33	24.1	59.7
		• *Bouteloua gracilis - Bouteloua curtipendula* Herbaceous Vegetation	1			
		• *Yucca glauca* / *Bouteloua gracilis* Shrub Herbaceous Vegetation	2			
		• *Schizachyrium scoparium – Bouteloua gracilis* Herbaceous Vegetation	Ci			
	B	Blue Grama-Western Wheatgrass Swale Shortgrass Steppe		22	24.0	59.2
		• *Pascopyrum smithii - Bouteloua gracilis* Herbaceous Vegetation	1			
		• *Pascopyrum smithii* / Ruderal Herbaceous Vegetation	2			
		• *Bouteloua gracilis* / Ruderal Herbaceous Vegetation	Ri			
9		**Southwest Cliff, Scree and Rock Vegetation**		**33**	**8.4**	**20.8**
	A	Lava Rockland		9	1.1	2.8
		• Sparse Vegetation / Lava Flow	1			
	B	Cinder/Scoria Rockland		3	0.4	1.1
		• Sparse Vegetation / Cinder Cone	1			
	C	Barren Ground/Ruderal Vegetation		21	6.8	16.9
		• Sparse Vegetation / Bare Ground	1			
		• Ruderal Disturbance Vegetation	2			
10		**Urban or Built-up Land**		**29**	**11.6**	**28.6**
	A	Residential Vegetation		10	1.7	4.2
	B	Structure/Building		10	0.5	1.2
	C	Road		1	5.8	14.4
	D	Trail		8	3.5	8.7
11		**Water**		**2**	**0.2**	**0.4**
	A	Open water - Pond/Tank		2	0.2	0.4

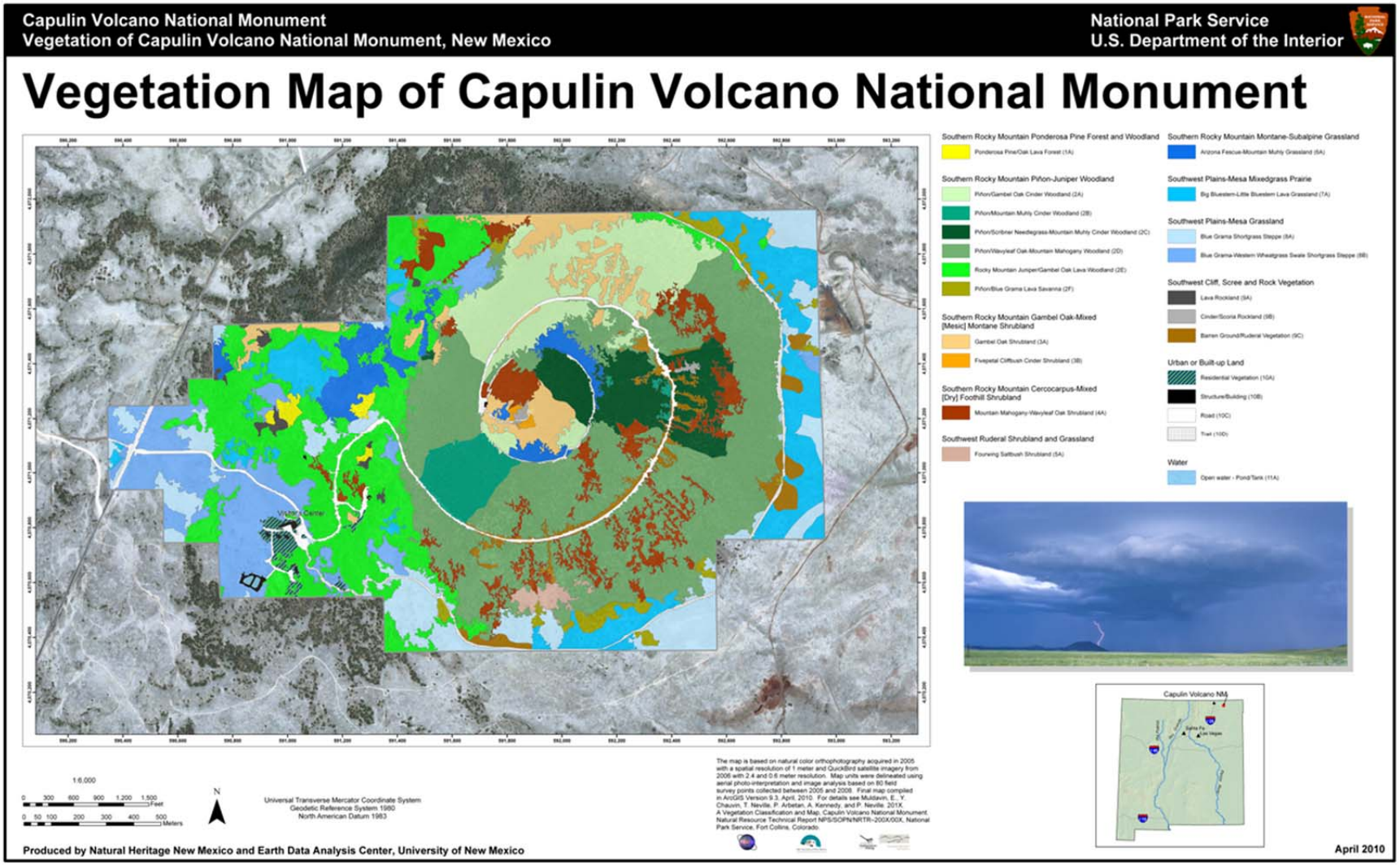

Figure 3.1 A vegetation map of Capulin Volcano National Monument based on 2002 and 2005 1:12.000 color aerial photography. This map portrays Level 1 units only at a scale reduced from 1:24,000 to approximately 1:150,000. See Table 3.1 and Appendix E for legend details. For the full-scale 1:24,000 map with Level 2 units see: http://biology.usgs.gov/npsveg/products/parkname.html

4. Accuracy Assessment

The thematic accuracy of the CAVO vegetation map was assessed following the USGS-NPS guidelines (ESRI et al. 1994; pers. com. Chris Lee 2009). Under these guidelines, the goal is to determine if overall and individual map unit accuracies exceed 80% from both producers' and users' perspectives. We tested both Level 1 (NVCS Group) and Level 2 of the legend hierarchy, and also scaled up to broad physiognomic classes of forest, woodland, shrubland, grassland, and riparian. We report the results here and make recommendations on the use of the map in the context of users' and producers' errors detected among the map units at various levels of the hierarchy.

With respect to positional accuracy, this is usually omitted from USGS-NPS National Vegetation Mapping Program products since vegetation seldom splits along discrete edges that can be positively located in the field. The subjectivity involved in this effort plus the high resolution and accuracy of the ortho-photo imagery usually allows for the assumption that all products derived from them are well within National Map Accuracy Standards for 1:12,000-scale maps (±30 feet). Further, since no additional funding was budgeted or available, the positional accuracy was not assessed (Cogan 2007).

4.1. Accuracy Assessment Methods

The USGS-NPS accuracy assessment (AA) methodology follows a point-based, minimum-mapping-unit design versus a polygon-based design. That is, to test the map, a set of points are distributed in random systematic design such that each point represents a non-overlapping area of, in this case, 0.50 ha (the required minimum mapping unit polygon area for the project). Each point is attributed according to the map unit of the polygon that it falls in. The points are then randomly selected for field sampling, but stratified by map unit and as constrained by logistical considerations (primarily access and safety). For statistical robustness, the guidelines suggest at least 30 sample points per map unit by which to construct a set of contingency tables and compute as a suite of error statistics for evaluating the accuracy of the map from both a producer and user perspective. In this case, at Level 2 this would have required 540 sample plots, well beyond the resources available for the accuracy assessment portion of the project. Instead, we targeted the nine map units (MU) at Level 1. Even so, some units are underrepresented because of their limited extent and, accordingly, the lack of available points to sample. Lastly, we did not sample the miscellaneous land cover types that were conspicuous in the imagery such as water, buildings, and roads. (MUs 10 & 11).

4.1.1. Field data collection

To allocate sampling, we gridded the park into a set of 0.05-ha grid cells with a central sampling point in each. We excluded points that were beyond 1,000 m from a known trail or a road that had open access. We then designed sampling tracks that a field person could reasonably cover in a single ten-hour day (including vehicle travel). The AA sampling was conducted during the summer of 2008. To support field sampling, paper maps were created at a 1:6,000-scale with target sample points and the underlying imagery and topography. These were used by the field crew as guidance in developing optimal sampling strategies with respect to map-unit targets and logistics, and for reconnoitering in the field. In the field, crews would navigate to the point location and determine if the point was representative of the surrounding vegetation as a whole. If not, crews were allowed to move the point to a representative area and provide a justification

for the move. The key was to avoid sampling small patches or fragments of plant associations not typical of the target stand.

At the sample location, a validation plot was taken that included cover of the dominant species in each strata (trees, shrubs, subshrubs, grasses, and forbs), aspect (azimuth), slope (%), a brief description of the polygon landscape and composition relative to the sampling point, the GPS location (+/- 10 m precision), and four representative digital photos. A total of 109 validation plots were collected (Figure 4.1).

The plot data were entered from the paper field sheets into the NHNM Plot Database (MS Access-based) and quality controlled with automated error routines and manual read-backs of the data. The digital photos were also databased and archived. Plant voucher specimens of unknowns were identified and those of high quality accessioned into the University of New Mexico Herbarium.

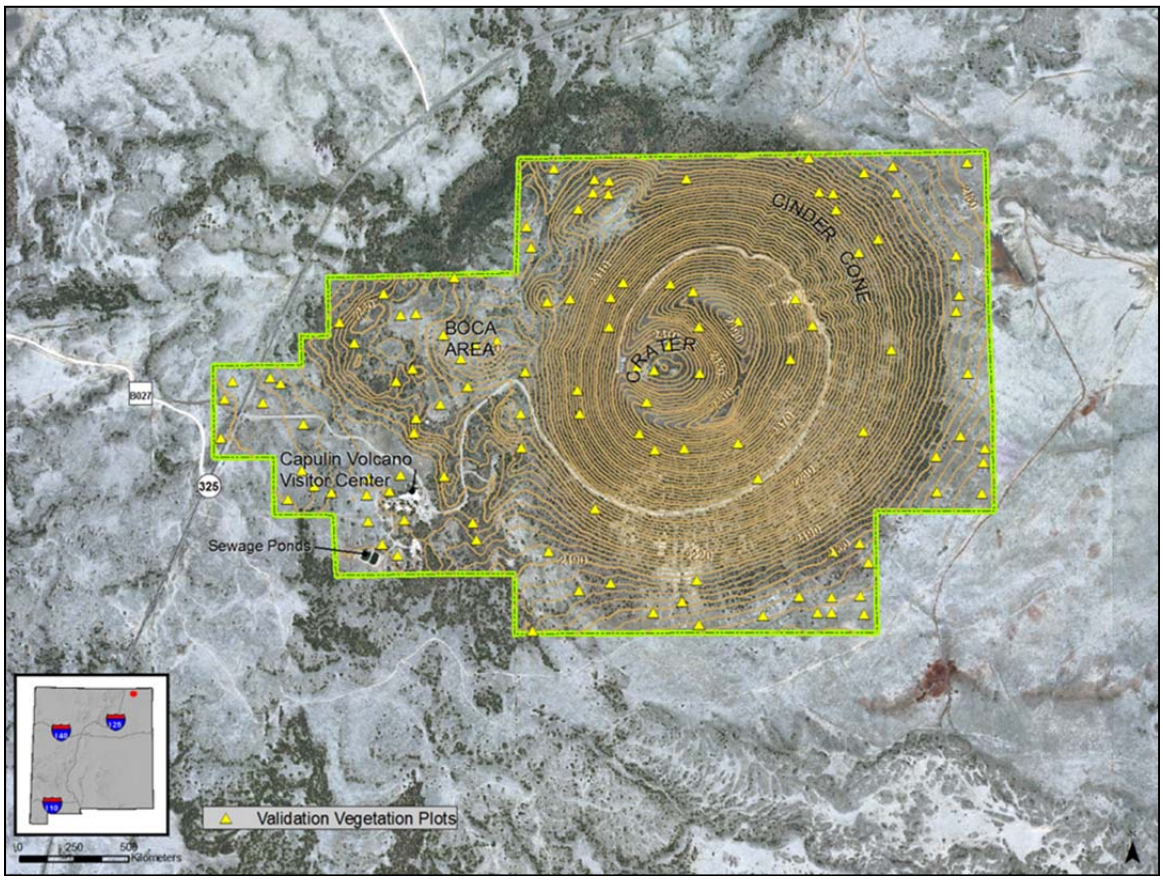

Figure 4.1. Distribution of Capulin Volcano National Monument vegetation map 2008 accuracy assessment sampling points.

4.1.2. Analysis methods

Initially, each validation point was classified based on dominance and indicator species into a plant association following the CAVO vegetation classification and dichotomous key (Table 2.5 and Appendix C). A validation point was then assigned to a map unit according to the plant association composition of the unit as reflected in the map unit descriptions (Table 3.3, Appendix E). In most cases, assignments were from either the primary or secondary components of the map units, and occasionally related inclusions (<5%). Contrasting inclusions were considered

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

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

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

4.2. Accuracy Assessment Results

At the broadest scale of the NVC division (essentially physiognomic classes of forest & woodland, shrubland & grassland, and non-vegetated), overall accuracy was 94% (Table 4.1). The highest error rate was the result of the Vancouverian & Rocky Mountain Grassland & Shrubland Division cross-classifying with the Great Plains Grassland & Shrubland, but all error rates were less than 18 %. The error rate among woodlands suggests that accurately detecting trees among shrubs and grasses continues to be a challenge, particularly with respect to boundary conditions (> 10% trees to be classified as a woodland or forest).

At Level 1, the NVCS Group level of the legend hierarchy and the primary target of the accuracy assessment, overall accuracy was 83% (Table 4.2). Most of the errors occurred among grassland units, and in particular Southern Rocky Mountain Montane-Subalpine Grassland (MU 6) with more than half of the producers' points being mapped as plains-mesa grassland, or in one case Gambel oak scrub. Detecting and mapping Southwest Plains-Mesa Mixedgrass Prairie (MU 7) was also problematic with four out of 13 producers' points mapped as either short-grass grasslands (Southwest Plains-Mesa Grassland (MU 8)) or as non-vegetated (Southwest Cliff, Scree and Rock Vegetation (MU 9). In addition, 31% of users' points that were classified as MU 7 on the ground were mapped as MU 8. Much of this MU 7 error may be attributed to the fact that *B. gracilis* is major element in both MU 7 and MU 8. In contrast, the most prevalent grassland of park, the short-grass Southwest Plains-Mesa Grassland (MU 8) where *B. gracilis* is

Table 4.1 Accuracy assessment contingency table for the Capulin Volcano National Monument vegetation map at broadest scale of the Division following the FGDC (2008) NVCS hierarchy with the exception that the single sample of Western North American Cool Temperate Forest (D009 -- ponderosa pine woodlands) has been lumped with the piñon-juniper woodlands under Western North American Scrub Woodland & Shrubland (D010). We provide the Producers' and User's accuracies with 90% confidence intervals where *n* = number of sampling points per class used to calculate percent correct by class. Also presented is the overall accuracy based on the total *n,* and the associated Kappa (KHAT) index. Below the table is a key to the divisions.

Division		Polygon Mapped As				Users' Accuracy			
		D010	**D022**	**D023**	**D053**	**n**	**Correct (%)**	**90% CI-**	**90% CI+**
Polygon Validated As	D010	39				39	100	99	101
	D022	1	14			15	93	79	107
	D023	2	3	44		49	90	82	98
	D053				6	6	100	92	108
Producers' Accuracy	n	42	17	44	6	109			
	Correct (%)	93	82	100	100		**94**	**Overall Accuracy (%)**	
	90% CI-	85	64	99	92		90	Overall 90% CI-	
	90% CI+	101	101	101	108		186	Overall 90% CI+	
							0.92	Kappa Index	
D010	Western North American Scrub Woodland & Shrubland				D022	Vancouverian & Rocky Mountain Grassland & Shrubland			
D023	Great Plains Grassland & Shrubland				D053	Great Plains Cliff, Scree & Rock Vegetation			

the clear dominant, had sufficient user's and producer's error rates of 81% and 79%, respectively. Once again, errors were mostly due to cross-classification with other nearby or adjacent grassland units.

At Level 2 of the legend, the attempt to map six different classes of piñon-juniper woodlands had mixed results ranging from about 50% to 100% accuracy from both a users' and producers' perspective (Table 4.3). For the two most abundant classes, Rocky Mountain Juniper/Gambel Oak Lava Woodland (2E) and Piñon/Wavyleaf Oak-Mountain Mahogany Woodland (2D), the producers' accuracy was sufficient, although 2D, suffered a reduced users' accuracy because of cross-classification with the Gambel oak dominated Piñon/Gambel Oak Cinder Woodland (2A). This is likely due to the difficulty determining whether a site is dominated by the deciduous *Q. gambelii* (Gambel oak) or the semi-deciduous *Q. pauciloba* (wavyleaf oak), a hybrid species closely related to *Q. gambelii* (i.e., the error rate may be attributable to field errors rather than mapping errors). If 2D and 2A are combined, the users' rate for the combined class rises to 81% accuracy (Table 4.4). For the grassland classes, the accuracy issues for units 6A (Arizona Fescue-Mountain Muhly Grassland) and 7A (Big Bluestem-Little Bluestem Lava Grassland) are by definition identical to that of Level 1 units 6 and 7. The differentiation of the Southwest Plains-Mesa Grassland (MU 8) into two Level 2 classes was only partially successful. In particular, in 8A, the monotypic Blue Grama Shortgrass Steppe, most producers' error occurred with polygons that were actually either 7A or 7B (Blue Grama-Western Wheatgrass Swale Shortgrass Steppe), units that reflect a more mixed-grass composition. Conversely, users' points classified on the ground as 8B were occasionally mapped as either 7A or 8A. If we lump the 7 and 8 classes, the producers' accuracy for the prairie grasslands rises to 93% and the user's accuracy to 88% (Table 4.4). Overall accuracy for Level 2 employing these two combined map units is 83%.

Table 4.2 Accuracy assessment contingency table for the Capulin Volcano National Monument vegetation map at Level 1. We provide the Producers' and User's accuracies with 90% confidence intervals where *n* = number of sampling points per class used to calculate percent correct by class. Also presented is the overall accuracy based on the total *n,* and the associated Kappa (KHAT) index. Below the table is a key to the Level 1 map unit classes.

	Level 1 MU	Polygon Mapped As									Users' Accuracy			
		1	**2**	**4**	**3**	**6**	**7**	**8**	**5**	**9**	**n**	**Correct (%)**	**90% CI-**	**90% CI+**
Polygon Validated As	1	1									1	100	50	150
	2		38								38	100	99	101
	4			4	1						5	80	41	119
	3		1		6	1					8	75	44	106
	6					2					2	100	75	125
	7					2	9	5			16	56	33	80
	8		2			1	2	22			27	81	67	96
	5							1	1		1	100	50	150
	9						2			8	10	80	54	106
Producers' Accuracy	n	1	41	4	7	6	13	28	1	8	109			
	Correct (%)	100	93	100	86	33	69	79	100	100		**83**	**Overall Accuracy (%)**	
	90% CI-	50	85	88	57	-7	44	64	50	94		77	Overlall 90 CI-	
	90% CI+	150	101	113	115	73	94	93	150	106		162	Overall 90 CI+	
												0.79	Kappa Index	

1	Southern Rocky Mountain Ponderosa Pine Forest and Woodland	7	Southwest Plains-Mesa Mixedgrass Prairie
2	Southern Rocky Mountain Piñon-Juniper Woodland	8	Southwest Plains-Mesa Grassland
4	Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland	5	Southwest Ruderal Shrubland and Grassland
3	Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland	9	Southwest Cliff, Scree and Rock Vegetation
6	Southern Rocky Mountain Montane-Subalpine Grassland		

Table 4.3 Accuracy assessment contingency table for the Capulin Volcano National Monument vegetation map at Level 2. We provide the Producers' and User's accuracies with 10% confidence intervals where *n* = number of sampling points per class used to calculate percent correct by class. Also presented is the overall accuracy based on the total *n,* and the associated Kappa (KHAT) index. Below the table is a key to various Level 2 classes.

		Polygon Mapped As																	Users' Accuracy			
	Level 2 MU	1A	2E	2C	2F	2D	2A	2B	4A	3B	3A	6A	7A	8A	8B	5A	9C	9A	n	Correct (%)	90 Cl-	90 Cl+
Polygon Validated As	1A	1																	1	100	50	150
	2E		12		2	1													15	80	60	100
	2C			1															1	100	50	150
	2F				3														3	100	83	117
	2D		1	1		7	6												15	47	22	71
	2A		1				0												1	0	-50	50
	2B					1		2											3	67	5	128
	4A								4		1								5	80	41	119
	3B									0									1	0	-50	50
	3A						1			1	5	1							8	63	28	97
	6A											2							2	100	75	125
	7A											2	9	4	1				16	56	33	80
	8A													6	1				7	86	57	115
	8B		1		1							1	2	3	12				20	60	39	81
	5A															1			1	100	50	150
	9C												2	1			6		9	67	35	98
	9A																	2	2	100	75	125
Producers' Accuracy	n	1	15	2	6	9	7	2	4	1	6	6	13	14	14	1	6	2	109			
	Cor. (%)	100	80	50	50	78	0	100	100	0	83	33	69	43	86	100	100	100		67	Overall Accuracy	
	90% Cl-	50	60	-33	8	49	-7	75	88	-50	50	-7	44	18	67	50	92	75		59	Overlall 90% Cl-	
	90% Cl+	150	100	133	92	106	7	125	113	50	117	73	94	68	105	150	108	125		75	Overall 90% Cl+	
																				0.64	Kappa Index	

1A	Ponderosa Pine/Oak Lava Forest	2B	Piñon/Mountain Muhly Cinder Woodland	8A	Blue Grama Shortgrass Steppe
2E	Rocky Mountain Juniper/Gambel Oak Lava Woodland	4A	Mountain Mahogany-Wavyleaf Oak Shrubland	8B	Blue Grama-Western Wheatgrass Swale Shortgrass Steppe
2C	Piñon/Scribner Needlegrass-Mountain Muhly Cinder Woodland	3B	Fivepetal Cliffbush Cinder Shrubland	5A	Fourwing Saltbush Shrubland
2F	Piñon/Blue Grama Lava Savanna	3A	Gambel Oak Shrubland	9C	Barren Ground/Ruderal Vegetation
2D	Piñon/Wavyleaf Oak-Mountain Mahogany Woodland	6A	Arizona Fescue-Mountain Muhly Grassland	9A	Lava Rockland
2A	Piñon/Gambel Oak Cinder Woodland	7A	Big Bluestem-Little Bluestem Lava Grassland		

Table 4.4 Accuracy assessment contingency table for the Capulin Volcano National Monument vegetation map at Level 2 with selected combined units. We provide the Producers' and User's accuracies with 90% confidence intervals where *n* = number of sampling points per class used to calculate percent correct by class. Also presented is the overall accuracy based on the total *n,* and the associated Kappa (KHAT) index. Below the table is a key to the Level 2 classes.

Level 2 MU		Polygon Mapped As														Users' Accuracy			
		1A	2E	2C	2F	2D/2A	2B	4A	3B	3A	6A	7/8	5A	9C	9A	n	Correct (%)	90% CI-	90% CI+
Polygon Validated As	1A	1														1	100	50	150
	2E		12		2	1										15	80	60	100
	2C			1												1	100	50	150
	2F				3											3	100	83	117
	2D/2A		2	1		13										16	81	62	100
	2B					1	2									3	67	5	128
	4A							4		1						5	80	41	119
	3B								0							1	0	-50	50
	3A					1			1	5	1					8	63	28	97
	6A										2					2	100	75	125
	7/8		1		1						3	38				43	88	79	98
	5A												1			1	100	50	150
	9C											3		6		9	67	35	98
	9A														2	2	100	75	125
Producers' Accuracy	n	1	15	2	6	16	2	4	1	6	6	41	1	6	2	109			
	Correct	100	80	50	50	81	100	100	0	83	33	93	100	100	100		83	Overall Accuracy	
	90% CI-	50	60	-33	8	62	75	88	-50	50	-7	85	50	92	75		76	Overlall 90% CI-	
	90% CI+	150	100	133	92	100	125	113	50	117	73	101	150	108	125		89	Overall 90% CI+	
																	0.78	Kappa Index	

1A	Ponderosa Pine/Oak Lava Forest	2B	Piñon/Mountain Muhly Cinder Woodland	7/8	Big Bluestem-Little Bluestem Lava Grassland; Blue Grama Shortgrass Steppe; Blue Grama-Western Wheatgrass Swale Shortgrass Steppe
2E	Rocky Mountain Juniper/Gambel Oak Lava Woodland	4A	Mountain Mahogany-Wavyleaf Oak Shrubland		
2C	Piñon/Scribner Needlegrass-Mountain Muhly Cinder Woodland	3B	Fivepetal Cliffbush Cinder Shrubland	5A	Fourwing Saltbush Shrubland
2F	Piñon/Blue Grama Lava Savanna	3A	Gambel Oak Shrubland	9C	Barren Ground/Ruderal Vegetation
2D/2A	Piñon/Wavyleaf Oak-Mountain Mahogany Woodland; Piñon/Gambel Oak Cinder Woodland	6A	Arizona Fescue-Mountain Muhly Grassland	9A	Lava Rockland

4.3. Accuracy Assessment Discussion

While the sampling depth of this accuracy assessment is limited in several respects, it does suggest confidence in the broad physiognomic level of woodlands, shrublands etc., and at

Level 1, representing the Group level of NVCS. Overall, for many natural resource planning and evaluations, Level 1 units will likely be sufficient and most appropriate.

The attempt to refine vegetation units at Level 2 did incur additional errors that may or may not be acceptable depending on the unit, and could be potentially lumped as shown in Table 4.4. However, at Level 2 many of the units are differentiated based on shrub versus grass cover as well as species differences that are not necessarily reflected at Level 1, and these may be important from a management perspective. Accordingly, while there are errors, most are explainable to the degree that the units can be used at least provisionally with caution and with an understanding that higher resolution mapping may be required at a later date. In addition, a this time, given that many of the map units were under-sampled, we would recommend that all Level 2 units be maintained as pending either additional sampling or testing in field applications. In particular, distribution of *Q. gambelii* versus *Q. pauciloba* among in the piñon-juniper units 2D and 2A should be further evaluated. With respect to the error rates among the grasslands, we recommend keeping the Level 2 units as a general guideline to the pattern of these grasslands on the monument. Many of these polygons are the result of direct charting on the ground and some of the errors we suspect may be due to small boundary differences that can be rectified with further ground survey work in a small park such as this.

Lastly, the accuracy assessment was affected by significant vegetation manipulations that occurred at the park in 2008 that lead to full type conversions from woodlands and shrublands to grasslands and, hence, make AA plot calls problematic on the ground. This suggests that new high-resolution imagery will be needed to update the map, and if that imagery is at scales approaching six-inch, structural differences among shrub and grass species can be detected and used in combination with spectral differences to improve and update the map across all classes.

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Appendix A. Field Handbook and Field Datasheets

This appendix contains the Natural Heritage New Mexico Vegetation Survey Handbook that was the guiding document for all vegetation plot data taken during the course of the Capulin Volcano Missions National Monument mapping project. The handbook and associated datasheets follow. While this is the 2008 version, there were no significant changes made to the protocol during the life of the project.

VEGETATION SURVEY HANDBOOK

NATURAL HERITAGE NEW MEXICO

DEPARTMENT OF BIOLOGY

UNIVERSITY OF NEW MEXICO

NATURAL HERITAGE NEW MEXICO

2008

The University of New Mexico

Natural Heritage New Mexico Vegetation Survey Protocols

Plot Establishment Guidelines and Techniques (May 2002)

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

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

Plot Types:

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

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

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

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

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

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

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

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

Instructions and Forms

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

PLOT ID: Seven-character alphanumeric code. **[Required]**
This is the master NMNHP record identification number for all sampling at the site. All subsequent sampling or other independent data at the site will be tied to this number. It must be unique and is formatted as follows:

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

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

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

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

PLOT TYPE: [**Required]**

RP = Releve or Reconnaissance plot. Full species list of both plot and stand and their abundance estimated. May also include Element Quality Ranking using the ranking form.

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

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

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

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

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

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

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

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

SUBPROJECT: Subproject code, if applicable

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

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

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

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

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

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

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

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

COUNTY and STATE: Abbreviations. NMNHP code for the county assigned when entered into Natural Heritage Database.

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

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

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

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

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

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

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

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

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

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

PHOTOGRAPHER: Record the initials of the photographer.

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

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

ELEV: Elevation *in feet,* unless otherwise noted.

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

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

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

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

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

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

SITE /VEG SUMMARY: A description (a "word picture") of the site and community sampled. Indicate stand dominants, the structure and physiognomy of the community along with a landscape position and site features narrative (including geomorphology, soils and geology). Indicate successional status, if known (e.g., climax (old growth); young, second growth). Reserve other condition comments for Condition section below. Use clear, complete sentences and avoid extraneous personal comments that do not belong in a scientific database (no jokes, please, or comments in bad taste; these plots are long-term records that will be read again and again in the future).
Adjacent Communities: Indicate surrounding plant associations and the spatial relationships (e.g., the occurrence is a matrix community with other smaller patch communities within it, or vice versa). Indicate the width and nature of ecotones to other communities.
Disease/exotics: Examples are dwarf mistletoe damage (give a rating of average percent and extent of spread within and among trees); insect damage (e.g., spruce budworm); fungal rot and rusts.
Animal use evidence: Wildlife browse damage, sightings and sign (bird calls, tracks, scat and animal disturbances such as beaver dens, gopher holes, etc., and remember the insects).
Condition (Disturbance, Fragmentation, Erosion): Describe disturbances both natural and otherwise, their extent, intensity, and time frame: livestock grazing and impacts; roads, number and distance from; logging and fuelwood cutting; buildings and obstructions; and fires, floods, landslides, significant recent erosion features, etc. Estimate frequency and degree of disturbance (light, moderate, heavy, etc.). Indicate degree of element fragmentation, e.g., reduced patch size and corridors, and other watershed -level impacts (dams, parking lots, settlements).
Distance: If relevant, note the distance in kilometers to the nearest human disturbance such as roads, dams, clearcut, housing, mine, dump, etc.).

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

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

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

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

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

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

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

L/R: Enter plot **radius** (for circular plots) or **length** (for rectangular plots). Indicate units of measurement. Note: a 400-m-square plot has a radius of 11.3 m (37.1 ft); a 100-m-square plot has a radius of 5.6 m (18.5 ft).

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

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

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

MANAGEMENT/CONSERVATION/ OTHER COMMENTS: Comment on any stewardship (new or additional) needed to ensure continued existence of the community occurrence, and chances (and means) of bringing it about. Any other pertinent comments go here as well, e.g., "clearing of competing vegetation has been tried in the past but without success." Comment on the conservation attributes of the occurrence, long-term viability, and threats. Also, add miscellaneous comments from all sections. Again, no jokes, please, or comments in bad taste.

FORMS CHECKOFF: please indicate if other forms were used besides those given.
Forms: ☐ Floristics ☐ Trees ☐ Soils ☐ Quadrats ☐ Point/Line Intercept ☐ EO Assessment ☐ Site Evaluation

<u>Floristic Inventory (Form 3)</u>

PLOT ID: Seven-character alphanumeric code**.** NMNHP standard record tracking number (see general description, Form 2).

BOTANIST: Name of person responsible for assessing the botany.

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

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

S - exposed soil: particles < 1/16-in. (2-mm) dia..
G – gravel: particles 1/16 to 3-in. (2-mm to 7.5-cm) dia..
R - rock as composed of cobbles, stones and bed rock: particles > 3-in. (>7.5-cm) dia.
L - litter and duff. Litter includes dead and detached vegetation, freshly fallen leaves, needles, twigs < 2 in. (5cm), bark, fruits, seeds; duff is decomposed litter (fermentation layer and humus layer).
HCC – herbaceous canopy cover is the total combined canopy cover of forbs and graminoids, including attached litter and current year's standing dead annuals, and does not include overlapping cover where canopies interlock.
WO – woody, downed debris: > 2-in. (5-cm) dia.

M - microphytic (cryptogams) crust cover; mosses, lichens and algae on soil surface (excludes cover found on logs, rocks and tree bases).
WA – water, standing pools of water, or streams if within the plot.

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

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

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

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

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

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

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

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

Voucher Tag Format:

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

If an unknown species from a previous data form is referred to on the current data sheet, **be sure the plot and species ID numbers** that the plant refers to are recorded on the current data sheet and the species ID number is **circled**. For example if you're at plot 05YC001 and you collect UNIDG5 (G5 should be circled on this plot form), then at plot 05YC004 you have the same unknown grass that is the second grass on this

data form, **circle G2** and write **05YC001-G5** after the species ID number. If you **know the genus or family, enter those acronyms** or **spell out the name** before the plot ID number.

Data sheet from 05YC004:

```
|G1_MUHMON_____________________|_@|_20_|__.4||___ ____________________________|__|____|____||
|G2_BROMUS - 05YC001-G5________|__|___5|__.2||___ ____________________________|__|____|____||
|G3_____________________________|__|____|____||___ ____________________________|__|____|____||
```

Circle G2

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

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

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

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

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

TOTAL COV. (BY STRATA): Percent aerial cover for tree, shrub, dwarf shrub, graminoid and forb layers. This is the total canopy cover of a strata as projected over the surface, regardless of species, and does not include overlapping cover where canopies interlock within a strata. ***Note: cover cannot exceed 100%.** For graminoids an additional category is added for **% green** which includes the current year's growth (green or tawny), but disregards the standing dead litter (grey).

COV.: Percent cover for each species within the plot, estimated by either directly using the precision guidelines below, *or* the Modified Domin-Krajina scale in Table 1 (both are at the bottom of Floristics-Form 3 and Standard Data Form). **Be sure to check box on data sheet to indicate which cover type is used.**

Percent Cover Estimation Precision Guidelines:

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

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

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

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

STANDARD DATA FORM – Page 2 is a continuation of the floristic inventory portion of the data form when more space is needed for additional species.

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

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

. .
. . One dot is used as each of the four corners and represents one tree.
Lines are then used to connect the dots and cross from corner to corner.
☒ Each line also represents one tree. A complete box equals 10 trees.

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

Element Occurrence Condition Evaluation

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

Condition Factors

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

Landscape Context Factors

Beyond immediate impacts, an element occurrence is also subject to landscape-level processes that affect its condition and perhaps more importantly its long-term sustainability. Accordingly, there are seven landscape-level parameters considered in the ranking process that can be evaluated through a combination of field studies, historical inquiry and GIS-based map analysis. The first three center on the hydrologic regime and pertain primarily to wetland/riparian community assessment. Stream flow changes, lateral stream movement, and channel condition are best addressed through analysis of historical records, monitoring, and field assessment. Analogously, fire patch size and fire frequency can be addressed by a reconstruction

of the past record through tree-ring fire-scar evidence and historical photography, as well as current stand structures as they might reflect fire history.

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

Size Factor

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

NHNM VEGETATION SURVEY - Standard Data Form – 2008

PLOT ID_____**PLOT TYPE**_____**PROJECT**_____**Subproject** _____ **MO**___**DAY**___**YEAR**_____
EO/PA_____
EO/PA Comment_____
FIELD POINT ID_____**MONUMENT** ☐
_____**MU**_____
SURVEY SITE_____ **SURVEYORS**_____
COUNTY_____ **NM/**____ **MAP NAME**_____ **- __ MARGNUM___ 10,10 __,__**
DIRECTIONS_____
GPS Unit_____ **GPS File**_____ **PREC**____**m UTM:EASTING** __ __ __ __ __ __ **NORTHING** __ __ __ __ __ __ __
Zone_____ **Datum: NAD83** ☐ **/ NAD27** ☐**; Other**_____**; Log#**_____D☐ / F☐ **Photographer**_____
PP1:Exp____**AZM**____**FocL**___ **Notes**_____ **PP3:Exp**____**AZM**____**FocL**___ **Notes**_____
PP2:Exp____**AZM**____**FocL**___ **Notes**_____ **PP4:Exp**____**AZM**____**FocL**___ **Notes**_____
Other Site Photos:_____
ELEV _____**ft., SLOPE** ___**%, ASPECT**____**, SLOPE SHAPE**_____/___**, Surface Rock Type**_____/_____
LANDFORM:_____/ __ __ __ __ __ __
Lndfrm/Geol/Soil Notes:_____
SUMMARY DESCRIPTION: □ **Site** □ **Veg** □ **Adjacent Com** □ **Disturb/Frag** □ **Animals** □ **Disease** □ **Management** □ **Condition**

_____
_____
_____
_____
_____
_____
_____
_____

PLOTDIM(M)L/R ____**W** ____ **EO Size**_____**Ha**__**/Ac**__ **Est**□ **Map** □ **Condition**____ **Landscape Context**_____ ☐ **EOMapped**:_____
Comments:_____
Ground Surface Cover (%) Soil_____ Grav_____ Rock_____ Litter_____ HCC_____ Wood_____ Micro_____ Water_____=100%
Botanist:_____ ***CIRCLE YOUR VOUCHER NUMBERS***
Phenology: * = Flowering; @ = fruiting; X = dead annual ☐ Cover Scale or ☐ Percent Cover

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

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

Cover: +0=outside plot,in stand **2**=scattered, <1% (.5m^2 & <4m^2) **5**=10-<25%(40m^2 & <100m^2) **8**=50-<75%

Scale +=solitary/very few(<0.2m^2/400m^2) **3**=1-<5% (>4m^2 & <20m^2) **6**=25-<33%(100m^2 & <132m^2) **9**=75-<95%

1=very scattered (0.2m^2 -<.5m/400m^2) **4**=5-<10%(>20m^2 & <40m^2) **7**=33-<50% **10**=95-100%____

Percent: +0=outside plot,in stand **0.5%**= scattered, <1% (.5m^2 & <4m^2) **30-100%** to nearest 10%

Scale +=solitary/very few(<0.2m^2/400m^2) **1-10%** to the nearest 1% (each % equals 4m^2/400m^2)

0.1%=very scattered (0.2m^2 -<.5m/400m^2) **10-30%** to the nearest 5% _____

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

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

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

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

TREE INVENTORY FORM – NHNM 2006

Plot ID:_____ Project_____ Subproject:_____ Surveyors:_____

Date:_____ - _____ - 200__

PLOTDIM (m) L/R ____W ____

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

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

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

Appendix B. Plant Species List

A list of plant species recorded on vegetation plots Capulin Volcano National Monument as part of the vegetation mapping project between 2005 and 2009. Plant voucher specimens were collected to confirm field identifications as necessary and are housed at the University of New Mexico Herbarium. Specimens were identified by NHNM botanist Yvonne Chauvin to lowest level possible given the material at hand and names assigned according to the PLANTS database (USDA-NRCS 2002) and the Integrated Taxonomic Information System (ITIS). Suitable quality specimens were accessioned with both UNM accession numbers and NPS record numbers tied to the Herbarium and NPS databases. Table B.1 provides the list ordered by lifeform code (LFC) and scientific name and Table B.2 is ordered by lifeform and common name. NHNM Acronym refers to the Natural Heritage New Mexico database code for the species; PLANTS symbol is database code from the USDA PLANTS database. Whether a voucher collection was made for the species is indicated in the last column.

Table B.1 Capulin Volcano National Monument Vegetation Map plant species list by lifeform and scientific name

LFC	Life Form	Scientific Name	Common Name	Family	PLANTS Symbol	NHNM Acronym	C
1	Tree	Juniperus scopulorum	Rocky Mountain juniper	Cupressaceae	JUSC2	JUNSCO	Yes
1	Tree	Pinus edulis	pinyon pine	Pinaceae	PIED	PINEDU	No
1	Tree	Pinus ponderosa	ponderosa pine	Pinaceae	PIPO	PINPON	No
1	Tree	Pinus ponderosa var. scopulorum	ponderosa pine	Pinaceae	PIPOS	PINPONS	Yes
1	Tree	Populus tremuloides	quaking aspen	Salicaceae	POTR5	POPTRE	Yes
1	Tree	Prunus virginiana	common chokecherry	Rosaceae	PRVI	PRUVIR	Yes
1	Tree	Quercus gambelii	Gambel's oak	Fagaceae	QUGA	QUEGAM	Yes
2	Shrub	Amorpha canescens	leadplant	Fabaceae	AMCA6	AMOCAN	Yes
2	Shrub	Atriplex canescens	fourwing saltbush	Chenopodiaceae	ATCA2	ATRCAN	Yes
2	Shrub	Cercocarpus montanus	mountain mahogany	Rosaceae	CEMO2	CERMON	No
2	Shrub	Clematis columbiana var.columbiana	rock clematis	Ranunculaceae	CLCOC2	CLECOLC	Yes
2	Shrub	Jamesia americana	cliffbush	Hydrangeaceae	JAAM	JAMAME	Yes
2	Shrub	Parthenocissus vitacea	thicket creeper	Vitaceae	PAVI5	PARVIT	Yes
2	Shrub	Physocarpus monogynus	mountain ninebark	Rosaceae	PHMO4	PHYMON	Yes
2	Shrub	Quercus ×pauciloba	wavyleaf oak	Fagaceae	QUPA4	QUEPAU	Yes
2	Shrub	Rhus trilobata	skunkbush sumac	Anacardiaceae	RHTR	RHUTRI	Yes
2	Shrub	Ribes cereum	wax currant	Grossulariaceae	RICE	RIBCER	Yes
2	Shrub	Ribes leptanthum	trumpet gooseberry	Grossulariaceae	RILE	RIBLEP	Yes
2	Shrub	Robinia neomexicana	New Mexico locust	Fabaceae	RONE	ROBNEO	No
2	Shrub	Rosa woodsii	Woods' rose	Rosaceae	ROWO	ROSWOO	No
2	Shrub	Rubus neomexicana	New Mexico raspberry	Rosaceae	RUNE	RUBNEO	Yes
2	Shrub	Symphoricarpos occidentalis	western snowberry	Caprifoliaceae	SYOC	SYMOCC	Yes
2	Shrub	Toxicodendron rydbergii	western poison ivy	Anacardiaceae	TORY	TOXRYD	Yes
2	Shrub	Yucca glauca	soapweed yucca	Agavaceae	YUGL	YUCGLA	No
2.5	Sub-shrub	Artemisia frigida	fringed sagewort	Asteraceae	ARFR4	ARTFRI	Yes
2.5	Sub-shrub	Brickellia eupatorioides var. chlorolepis	false boneset	Asteraceae	BREUC2	BRIEUPC	Yes

LFC	Life Form	Scientific Name	Common Name	Family	PLANTS Symbol	NHNM Acronym	C
2.5	Sub-shrub	Brickellia grandiflora	tasselflower brickellbush	Asteraceae	BRGR	BRIGRA	Yes
2.5	Sub-shrub	Brickelliastrum fendleri	Fendler's brickellbush	Asteraceae	BRFE2	BRIFEN2	Yes
2.5	Sub-shrub	Echinocereus viridiflorus	nylon hedgehog cactus	Cactaceae	ECVI2	ECHVIR	No
2.5	Sub-shrub	Gutierrezia sarothrae	broom snakeweed	Asteraceae	GUSA2	GUTSAR	Yes
2.5	Sub-shrub	Opuntia phaeacantha	tulip pricklypear	Cactaceae	OPPH	OPUPHA	No
2.5	Sub-shrub	Opuntia polyacantha	plains pricklypear	Cactaceae	OPPO	OPUPOL	No
3	Grass	Achnatherum robustum	sleepygrass	Poaceae	ACRO7	ACHROB	Yes
3	Grass	Achnatherum scribneri	Scribner's needlegrass	Poaceae	ACSC11	ACHSCR	Yes
3	Grass	Agrostis scabra	rough bentgrass	Poaceae	AGSC5	AGRSCA	Yes
3	Grass	Andropogon gerardii	big bluestem	Poaceae	ANGE	ANDGER	Yes
3	Grass	Aristida divaricata	poverty threeawn	Poaceae	ARDI5	ARIDIV	Yes
3	Grass	Aristida purpurea	purple threeawn	Poaceae	ARPU9	ARIPUR	No
3	Grass	Aristida purpurea var. longiseta	red threeawn	Poaceae	ARPUL	ARIPURL	Yes
3	Grass	Aristida purpurea var. purpurea	purple threeawn	Poaceae	ARPUP6	ARIPURP	Yes
3	Grass	Blepharoneuron tricholepis	pine dropseed	Poaceae	BLTR	BLETRI	Yes
3	Grass	Bouteloua curtipendula	sideoats grama	Poaceae	BOCU	BOUCUR	Yes
3	Grass	Bouteloua gracilis	blue grama	Poaceae	BOGR2	BOUGRA	Yes
3	Grass	Bouteloua hirsuta	hairy grama	Poaceae	BOHI2	BOUHIR	Yes
3	Grass	Bromus anomalus	nodding brome	Poaceae	BRAN	BROANO	Yes
3	Grass	Bromus carinatus	California brome	Poaceae	BRCA5	BROCAR	Yes
3	Grass	Bromus inermis	smooth brome	Poaceae	BRIN2	BROINE	Yes
3	Grass	Bromus japonicus	Japanese brome	Poaceae	BRJA	BROJAP	Yes
3	Grass	Bromus lanatipes	woolly brome	Poaceae	BRLA6	BROLAN	Yes
3	Grass	Bromus porteri	Porter brome	Poaceae	BRPO2	BROPOR	Yes
3	Grass	Bromus tectorum	cheatgrass	Poaceae	BRTE	BROTEC	No
3	Grass	Buchloe dactyloides	buffalograss	Poaceae	BUDA	BUCDAC	Yes
3	Grass	Carex duriuscula	needleleaf sedge	Cyperaceae	CADU6	CARDUR	Yes
3	Grass	Carex geophila	White Mountain sedge	Cyperaceae	CAGE	CARGEO	Yes
3	Grass	Carex inops ssp. heliophila	sun sedge	Cyperaceae	CAINH2	CARINOH	Yes
3	Grass	Carex occidentalis	western sedge	Cyperaceae	CAOC2	CAROCC	Yes
3	Grass	Cyperus fendlerianus	Fendler's flatsedge	Cyperaceae	CYFE2	CYPFEN	No
3	Grass	Elymus canadensis	Canada wildrye	Poaceae	ELCA4	ELYCAN	Yes
3	Grass	Elymus elymoides	bottlebrush squirreltail	Poaceae	ELEL5	ELYELY	Yes
3	Grass	Elymus trachycaulus ssp. subsecundus	bearded wheatgrass	Poaceae	ELTRS	ELYTRAS	Yes
3	Grass	Elymus x pseudorepens	false quackgrass	Poaceae	ELPS	ELYPSE	Yes
3	Grass	Festuca arizonica	Arizona fescue	Poaceae	FEAR2	FESARI	No
3	Grass	Hesperostipa comata	needle-and-thread grass	Poaceae	HECO26	HESCOM	Yes
3	Grass	Koeleria macrantha	prairie junegrass	Poaceae	KOMA	KOEMAC	Yes
3	Grass	Lycurus setosus	bristly wolfstail	Poaceae	LYSE3	LYCSET	Yes
3	Grass	Melica porteri	Porter's melicgrass	Poaceae	MEPO	MELPOR	Yes
3	Grass	Muhlenbergia montana	mountain muhly	Poaceae	MUMO	MUHMON	No

LFC	Life Form	Scientific Name	Common Name	Family	PLANTS Symbol	NHNM Acronym	C
3	Grass	Muhlenbergia torreyi	ring muhly	Poaceae	MUTO2	MUHTOR	Yes
3	Grass	Muhlenbergia wrightii	spike muhly	Poaceae	MUWR	MUHWRI	Yes
3	Grass	Munroa squarrosa	false buffalograss	Poaceae	MUSQ3	MUNSQU	Yes
3	Grass	Panicum capillare	witchgrass	Poaceae	PACA6	PANCAP	Yes
3	Grass	Panicum virgatum	switchgrass	Poaceae	PAVI2	PANVIR	Yes
3	Grass	Pascopyrum smithii	western wheatgrass	Poaceae	PASM	PASSMI	Yes
3	Grass	Piptatherum micranthum	littleseed ricegrass	Poaceae	PIMI7	PIPMIC	Yes
3	Grass	Poa compressa	Canada bluegrass	Poaceae	POCO	POACOM	No
3	Grass	Poa fendleriana	muttongrass	Poaceae	POFE	POAFEN	Yes
3	Grass	Poa fendleriana ssp. fendleriana	skyline blugrass	Poaceae	POFEF	POAFENF	Yes
3	Grass	Poa pratensis	Kentucky bluegrass	Poaceae	POPR	POAPRA	Yes
3	Grass	Schedonnardus paniculatus	tumblegrass	Poaceae	SCPA	SCHPAN	Yes
3	Grass	Schizachyrium scoparium	little bluestem	Poaceae	SCSC	SCHSCO	Yes
3	Grass	Setaria viridis	green bristlegrass	Poaceae	SEVI4	SETVIR	Yes
3	Grass	Sporobolus cryptandrus	sand dropseed	Poaceae	SPCR	SPOCRY	Yes
4	Forb	Achillea millefolium	common yarrow	Asteraceae	ACMI2	ACHMIL	No
4	Forb	Achillea millefolium var. occidentalis	western yarrow	Asteraceae	ACMIO	ACHMILO	Yes
4	Forb	Allium cernuum	nodding onion	Liliaceae	ALCE2	ALLCER	Yes
4	Forb	Amaranthus hybridus	slim amaranth	Amaranthaceae	AMHY	AMAHYB	Yes
4	Forb	Ambrosia confertiflora	weakleaf bur ragweed	Asteraceae	AMCO3	AMBCON	Yes
4	Forb	Androsace septentrionalis	pygmyflower rockjasmine	Primulaceae	ANSE4	ANDSEP	Yes
4	Forb	Anemone cylindrica	candle anemone	Ranunculaceae	ANCY	ANECYL	Yes
4	Forb	Antennaria parvifolia	smallleaf pussytoes	Asteraceae	ANPA4	ANTPAR	No
4	Forb	Apocynum androsaemifolium	spreading dogbane	Apocynaceae	APAN2	APOAND	Yes
4	Forb	Arabis hirsuta	hairy rockcress	Brassicaceae	ARHI	ARAHIR	Yes
4	Forb	Arenaria lanuginosa ssp. saxosa	spreading sandwort	Caryophyllaceae	ARLAS	ARELANS	Yes
4	Forb	Argemone hispida	prickly poppy	Papaveraceae	ARHI4	ARGHIS	Yes
4	Forb	Artemisia carruthii	Carruth's sagewort	Asteraceae	ARCA14	ARTCAR	Yes
4	Forb	Artemisia dracunculus	tarragon	Asteraceae	ARDR4	ARTDRA	Yes
4	Forb	Artemisia ludoviciana	white sagebrush	Asteraceae	ARLU	ARTLUD	Yes
4	Forb	Asclepias pumila	plains milkweed	Asclepiadaceae	ASPU	ASCPUM	Yes
4	Forb	Astragalus flexuosus	stinking milkvetch	Fabaceae	ASFL2	ASTFLE	Yes
4	Forb	Bidens bigelovii	Bigelow's beggarticks	Asteraceae	BIBI	BIDBIG	Yes
4	Forb	Brickellia brachyphylla	plumed brickellbush	Asteraceae	BRBR2	BRIBRA	Yes
4	Forb	Castilleja integra	wholeleaf Indian paintbrush	Scrophulariaceae	CAIN14	CASINT	Yes
4	Forb	Chaetopappa ericoides	rose heath	Asteraceae	CHER2	CHAERI	Yes
4	Forb	Chamaesyce serpyllifolia	thymeleaf sandmat	Euphorbiaceae	CHSE6	CHASER2	Yes
4	Forb	Cheilanthes feei	slender lipfern	Pteridaceae	CHFE	CHEFEE	Yes
4	Forb	Chenopodium fremontii	Fremont's goosefoot	Chenopodiaceae	CHFR3	CHEFRE	Yes
4	Forb	Chenopodium graveolens	fetid goosefoot	Chenopodiaceae	CHGR2	CHEGRA	Yes
4	Forb	Chenopodium leptophyllum	narrowleaf goosefoot	Chenopodiaceae	CHLE4	CHELEP	Yes
4	Forb	Chenopodium pratericola	desert goosefoot	Chenopodiaceae	CHPR5	CHEPRA	Yes
4	Forb	Cirsium undulatum	wavyleaf thistle	Asteraceae	CIUN	CIRUND	No
4	Forb	Convolvulus arvensis	field bindweed	Convolvulaceae	COAR4	CONARV	Yes
4	Forb	Conyza canadensis	Canadian horseweed	Asteraceae	COCA5	CONCAN	Yes

LFC	Life Form	Scientific Name	Common Name	Family	PLANTS Symbol	NHNM Acronym	C
4	Forb	Cryptantha thyrsiflora	calcareous cryptantha	Boraginaceae	CRTH	CRYTHY	Yes
4	Forb	Cynoglossum officinale	hound's tongue	Boraginaceae	CYOF	CYNOFF	No
4	Forb	Dalea aurea	Golden prairieclover	Fabaceae	DAAU	DALAUR	Yes
4	Forb	Dalea candida var. oligophylla	white prairieclover	Fabaceae	DACAO	DALCANO	Yes
4	Forb	Dalea purpurea	purple prairieclover	Fabaceae	DAPU5	DALPUR	Yes
4	Forb	Dieteria canescens var. glabra	hoary tansyaster	Asteraceae	MACAG	DIECANG	Yes
4	Forb	Dyssodia papposa	fetid marigold	Asteraceae	DYPA	DYSPAP	Yes
4	Forb	Erigeron flagellaris	trailing fleabane	Asteraceae	ERFL	ERIFLA	Yes
4	Forb	Erigeron tracyi	running fleabane	Asteraceae	ERCO28	ERITRA	Yes
4	Forb	Eriogonum alatum	winged buckwheat	Polygonaceae	ERAL4	ERIALA	Yes
4	Forb	Eriogonum jamesii	James' buckwheat	Polygonaceae	ERJA	ERIJAM	No
4	Forb	Eriogonum jamesii var. jamesii	James' buckwheat	Polygonaceae	ERJAJ	ERIJAMJ	Yes
4	Forb	Erysimum asperum	plains wallflower	Brassicaceae	ERAS2	ERYASP	Yes
4	Forb	Euphorbia brachycera	horned spurge	Euphorbiaceae	EUBR	EUPBRA	Yes
4	Forb	Euphorbia davidii	David's spurge	Euphorbiaceae	EUDA5	EUPDAV	Yes
4	Forb	Galium trifidum ssp. subbiflorum	threepetal bedstraw	Rubiaceae	GATRS2	GALTRIS	Yes
4	Forb	Gaura coccinea	scarlet beeblossom	Onagraceae	GACO5	GAUCOC	Yes
4	Forb	Gentiana affinis	pleated gentian	Gentianaceae	GEAF	GENAFF	No
4	Forb	Geranium caespitosum var. fremontii	Fremont's geranium	Geraniaceae	GECAF	GERCAEF	Yes
4	Forb	Gilia pinnatifida	sticky gilia	Polemoniaceae	GIPI	GILPIN	Yes
4	Forb	Glandularia bipinnatifida	Dakota mock vervain	Verbenaceae	GLBI2	GLABIP	Yes
4	Forb	Glycyrrhiza lepidota	American licorice	Fabaceae	GLLE3	GLYLEP	Yes
4	Forb	Grindelia squarrosa	curlycup gumweed	Asteraceae	GRSQ	GRISQU	Yes
4	Forb	Hackelia hirsuta	New Mexico stickseed	Boraginaceae	HAHI2	HACHIR	Yes
4	Forb	Helianthus annuus	common sunflower	Asteraceae	HEAN3	HELANN	Yes
4	Forb	Helianthus pauciflorus ssp. subrhomboideus	stiff sunflower	Asteraceae	HEPAS	HELPAUS	Yes
4	Forb	Heliomeris multiflora	showy goldeneye	Asteraceae	HEMU3	HELMUL	Yes
4	Forb	Heterotheca villosa	hairy goldenaster	Asteraceae	HEVI4	HETVIL	Yes
4	Forb	Heuchera parvifolia	littleleaf alumroot	Saxifragaceae	HEPA11	HEUPAR	Yes
4	Forb	Ipomoea leptophylla	bush morningglory	Convolvulaceae	IPLE	IPOLEP	Yes
4	Forb	Ipomopsis aggregata	skyrocket gilia	Polemoniaceae	IPAG	IPOAGG	No
4	Forb	Ipomopsis aggregata ssp. candida	scarlet gilia	Polemoniaceae	IPAGC	IPOAGGC	Yes
4	Forb	Iva xanthifolia	Giant sumpweed	Asteraceae	IVXA	IVAXAN	Yes
4	Forb	Kochia scoparia	common kochia	Chenopodiaceae	KOSC	KOCSCO	Yes
4	Forb	Lactuca serriola	prickly lettuce	Asteraceae	LASE	LACSER	Yes
4	Forb	Lappula occidentalis	flatspine stickseed	Boraginaceae	LAOC3	LAPOCC	Yes
4	Forb	Liatris punctata	dotted gayfeather	Asteraceae	LIPU	LIAPUN	Yes
4	Forb	Linum australe var. australe	southern flax	Linaceae	LIAUA	LINAUSA	Yes
4	Forb	Linum lewisii	prairie flax	Linaceae	LILE3	LINLEW	Yes
4	Forb	Lithospermum multiflorum	manyflowered gromwell	Boraginaceae	LIMU3	LITMUL	Yes
4	Forb	Lupinus argenteus	silvery lupine	Fabaceae	LUAR3	LUPARG	Yes
4	Forb	Maianthemum stellatum	starry false Solomon's seal	Liliaceae	MAST4	MAISTE	Yes
4	Forb	Marrubium vulgare	horehound	Lamiaceae	MAVU	MARVUL	No

LFC	Life Form	Scientific Name	Common Name	Family	PLANTS Symbol	NHNM Acronym	C
4	Forb	Melilotus officinalis	yellow sweetclover	Fabaceae	MEOF	MELOFF	No
4	Forb	Mentzelia nuda var. stricta	bractless blazingstar	Loasaceae	MENUS	MENNUDS	Yes
4	Forb	Mertensia lanceolata var. lanceolata	prairie bluebells	Boraginaceae	MELAL2	MERLANL	Yes
4	Forb	Mirabilis linearis	narrowleaf four o'clock	Nyctaginaceae	MILI3	MIRLIN	Yes
4	Forb	Mirabilis oxybaphoides	smooth spreading four o'clock	Nyctaginaceae	MIOX	MIROXY	Yes
4	Forb	Monarda fistulosa	wildbergamot beebalm	Lamiaceae	MOFI	MONFIS	Yes
4	Forb	Nama dichotomum	wishbone fiddleleaf	Hydrophyllaceae	NADI	NAMDIC	Yes
4	Forb	Oenothera caespitosa	tufted eveningprimrose	Onagraceae	OECA10	OENCAE	Yes
4	Forb	Oenothera coronopifolia	crownleaf evening-primrose	Onagraceae	OECO2	OENCOR	Yes
4	Forb	Onosmodium molle ssp. occidentale	western marbleseed	Boraginaceae	ONMOO2	ONOMOLO	Yes
4	Forb	Orthocarpus luteus	yellow owlclover	Scrophulariaceae	ORLU2	ORTLUT	Yes
4	Forb	Oxytropis sericea	silvery lupine	Fabaceae	OXSE	OXYSER	Yes
4	Forb	Packera fendleri	Fendler's ragwort	Asteraceae	PAFE4	PACFEN	Yes
4	Forb	Packera tridenticulata	threetooth ragwort	Asteraceae	PATR7	PACTRI	Yes
4	Forb	Pectis angustifolia	narrowleaf pectis	Asteraceae	PEAN	PECANG	No
4	Forb	Pectis angustifolia var. angustifolia	narrowleaf pectis	Asteraceae	PEANA	PECANGA	Yes
4	Forb	Penstemon angustifolius	broadbeard beardtongue	Scrophulariaceae	PEAN4	PENANG	Yes
4	Forb	Penstemon barbatus	beardlip penstemon	Scrophulariaceae	PEBA2	PENBAR	Yes
4	Forb	Penstemon fendleri	Fendler's penstemon	Scrophulariaceae	PEFE	PENFEN	No
4	Forb	Pericome caudata	mountain leaftail	Asteraceae	PECA10	PERCAU	Yes
4	Forb	Phacelia denticulata	Rocky Mountain scorpionweed	Hydrophyllaceae	PHDE2	PHADEN	Yes
4	Forb	Phacelia heterophylla	varileaf phacelia	Hydrophyllaceae	PHHE2	PHAHET	Yes
4	Forb	Physalis longifolia var. longifolia	longleaf groundcherry	Solanaceae	PHLOL3	PHYLONL	Yes
4	Forb	Physalis subulata var. neomexicana	New Mexican groundcherry	Solanaceae	PHSUN	PHYSUBN	Yes
4	Forb	Picradeniopsis oppositifolia	oppositeleaf bahia	Asteraceae	PIOP	PICOPP	Yes
4	Forb	Polanisia dodecandra ssp. trachysperma	sandyseed clammyweed	Capparaceae	PODOT	POLDODT	Yes
4	Forb	Polygonum convolvulus	black bindweed	Polygonaceae	POCO10	POLCON	Yes
4	Forb	Polygonum douglasii ssp. johnstonii	Johnston's knotweed	Polygonaceae	PODOJ2	POLDOUJ	Yes
4	Forb	Portulaca oleracea	common purslane	Portulacaceae	POOL	POROLE	No
4	Forb	Potentilla arguta	tall cinquefoil	Rosaceae	POAR7	POTARG	No
4	Forb	Potentilla hippiana	woolly cinquefoil	Rosaceae	POHI6	POTHIP	Yes
4	Forb	Potentilla pensylvanica	Pennsylvania cinquefoil	Rosaceae	POPE8	POTPEN	Yes
4	Forb	Pseudognaphalium stramineum	cottonbatting cudweed	Asteraceae	PSST7	PSESTR	Yes
4	Forb	Psoralidium tenuiflorum	slimflower scurfpea	Fabaceae	PSTE5	PSOTEN	Yes
4	Forb	Ratibida columnifera	upright prairie coneflower	Asteraceae	RACO3	RATCOL	Yes
4	Forb	Ratibida tagetes	green prairie coneflower	Asteraceae	RATA	RATTAG	Yes
4	Forb	Salsola tragus	prickly Russian thistle	Chenopodiaceae	SATR12	SALTRA	Yes
4	Forb	Salvia reflexa	lanceleaf sage	Lamiaceae	SARE3	SALREF	Yes

LFC	Life Form	Scientific Name	Common Name	Family	PLANTS Symbol	NHNM Acronym	C
4	Forb	Schoenocrambe linearifolia	slimleaf plainsmustard	Brassicaceae	SCLI12	SCHLIN	Yes
4	Forb	Selaginella densa	lesser spikemoss	Selaginellaceae	SEDE2	SELDEN	Yes
4	Forb	Senecio flaccidus	threadleaf ragwort	Asteraceae	SEFL3	SENFLA	No
4	Forb	Senecio spartioides	broom groundsel	Asteraceae	SESP3	SENSPA	Yes
4	Forb	Silene drummondii	Drummond's campion	Caryophyllaceae	SIDR	SILDRU	Yes
4	Forb	Solanum heterodoxum var. novomexicanum	New Mexican nightshade	Solanaceae	SOHEN	SOLHETN	Yes
4	Forb	Solanum jamesii	wild potato	Solanaceae	SOJA	SOLJAM	No
4	Forb	Solanum rostratum	buffalobur nightshade	Solanaceae	SORO	SOLROS	No
4	Forb	Solanum triflorum	cutleaf nightshade	Solanaceae	SOTR	SOLTRI	Yes
4	Forb	Solidago mollis	velvety goldenrod	Asteraceae	SOMO	SOLMOL	Yes
4	Forb	Sphaeralcea coccinea	scarlet globemallow	Malvaceae	SPCO	SPHCOC	Yes
4	Forb	Stephanomeria minor	narrowleaf wirelettuce	Asteraceae	STMI13	STEMIN	Yes
4	Forb	Taraxacum officinale	common dandelion	Asteraceae	TAOF	TAROFF	No
4	Forb	Thelesperma megapotamicum	Hopi tea greenthread	Asteraceae	THME	THEMEG	Yes
4	Forb	Thermopsis rhombifolia	golden pea	Fabaceae	THRH	THERHO	No
4	Forb	Thermopsis rhombifolia var. montana	mountain thermopsis	Fabaceae	THRHM	THERHOM	No
4	Forb	Tragia ramosa	branched noseburn	Euphorbiaceae	TRRA5	TRARAM	Yes
4	Forb	Tragopogon dubius	yellow salsify	Asteraceae	TRDU	TRADUB	No
4	Forb	Tragopogon pratensis	meadow salsify	Asteraceae	TRPR	TRAPRA	Yes
4	Forb	Verbascum thapsus	common mullein	Scrophulariaceae	VETH	VERTHA	No
4	Forb	Verbena macdougalii	MacDougal verbena	Verbenaceae	VEMA	VERMAC	Yes
4	Forb	Verbesina encelioides	golden crownbeard	Asteraceae	VEEN	VERENC	Yes
4	Forb	Vicia americana	American vetch	Fabaceae	VIAM	VICAME	Yes
4	Forb	Woodsia oregana	Oregon woodsia	Dryopteridaceae	WOOR	WOOORE	No
4	Forb	Woodsia oregana ssp. cathcartiana	Oregon cliff fern	Dryopteridaceae	WOORC2	WOOORE C	Yes
4	Forb	Xanthisma spinulosum	lacy tansyaster	Asteraceae	MAPI	XANSPI2	Yes

Table B.2 Capulin Volcano National Monument Vegetation Map plant species list by lifeform and scientific name.

LFC	Life Form	Common Name	Scientific Name	Family	PLANTS Symbol	NHNM Acronym	C
1	Tree	common chokecherry	Prunus virginiana	Rosaceae	PRVI	PRUVIR	Yes
1	Tree	Gambel's oak	Quercus gambelii	Fagaceae	QUGA	QUEGAM	Yes
1	Tree	pinyon pine	Pinus edulis	Pinaceae	PIED	PINEDU	No
1	Tree	ponderosa pine	Pinus ponderosa	Pinaceae	PIPO	PINPON	No
1	Tree	ponderosa pine	Pinus ponderosa var. scopulorum	Pinaceae	PIPOS	PINPONS	Yes
1	Tree	quaking aspen	Populus tremuloides	Salicaceae	POTR5	POPTRE	Yes
1	Tree	Rocky Mountain juniper	Juniperus scopulorum	Cupressaceae	JUSC2	JUNSCO	Yes
2	Shrub	cliffbush	Jamesia americana	Hydrangeaceae	JAAM	JAMAME	Yes
2	Shrub	fourwing saltbush	Atriplex canescens	Chenopodiaceae	ATCA2	ATRCAN	Yes
2	Shrub	leadplant	Amorpha canescens	Fabaceae	AMCA6	AMOCAN	Yes
2	Shrub	mountain mahogany	Cercocarpus montanus	Rosaceae	CEMO2	CERMON	No
2	Shrub	mountain ninebark	Physocarpus monogynus	Rosaceae	PHMO4	PHYMON	Yes
2	Shrub	New Mexico locust	Robinia neomexicana	Fabaceae	RONE	ROBNEO	No
2	Shrub	New Mexico raspberry	Rubus neomexicana	Rosaceae	RUNE	RUBNEO	Yes
2	Shrub	rock clematis	Clematis columbiana var.columbiana	Ranunculaceae	CLCOC2	CLECOLC	Yes
2	Shrub	skunkbush sumac	Rhus trilobata	Anacardiaceae	RHTR	RHUTRI	Yes
2	Shrub	soapweed yucca	Yucca glauca	Agavaceae	YUGL	YUCGLA	No
2	Shrub	thicket creeper	Parthenocissus vitacea	Vitaceae	PAVI5	PARVIT	Yes
2	Shrub	trumpet gooseberry	Ribes leptanthum	Grossulariaceae	RILE	RIBLEP	Yes
2	Shrub	wavyleaf oak	Quercus ×pauciloba	Fagaceae	QUPA4	QUEPAU	Yes
2	Shrub	wax currant	Ribes cereum	Grossulariaceae	RICE	RIBCER	Yes
2	Shrub	western poison ivy	Toxicodendron rydbergii	Anacardiaceae	TORY	TOXRYD	Yes
2	Shrub	western snowberry	Symphoricarpos occidentalis	Caprifoliaceae	SYOC	SYMOCC	Yes
2	Shrub	Woods' rose	Rosa woodsii	Rosaceae	ROWO	ROSWOO	No
2.5	Sub-shrub	broom snakeweed	Gutierrezia sarothrae	Asteraceae	GUSA2	GUTSAR	Yes
2.5	Sub-shrub	false boneset	Brickellia eupatorioides var. chlorolepis	Asteraceae	BREUC2	BRIEUPC	Yes
2.5	Sub-shrub	Fendler's brickellbush	Brickelliastrum fendleri	Asteraceae	BRFE2	BRIFEN2	Yes
2.5	Sub-shrub	fringed sagewort	Artemisia frigida	Asteraceae	ARFR4	ARTFRI	Yes
2.5	Sub-shrub	nylon hedgehog cactus	Echinocereus viridiflorus	Cactaceae	ECVI2	ECHVIR	No
2.5	Sub-shrub	plains pricklypear	Opuntia polyacantha	Cactaceae	OPPO	OPUPOL	No
2.5	Sub-shrub	tasselflower brickellbush	Brickellia grandiflora	Asteraceae	BRGR	BRIGRA	Yes
2.5	Sub-shrub	tulip pricklypear	Opuntia phaeacantha	Cactaceae	OPPH	OPUPHA	No
3	Grass	Arizona fescue	Festuca arizonica	Poaceae	FEAR2	FESARI	No
3	Grass	bearded wheatgrass	Elymus trachycaulus ssp. subsecundus	Poaceae	ELTRS	ELYTRAS	Yes
3	Grass	big bluestem	Andropogon gerardii	Poaceae	ANGE	ANDGER	Yes

LFC	Life Form	Common Name	Scientific Name	Family	PLANTS Symbol	NHNM Acronym	C
3	Grass	blue grama	Bouteloua gracilis	Poaceae	BOGR2	BOUGRA	Yes
3	Grass	bottlebrush squirreltail	Elymus elymoides	Poaceae	ELEL5	ELYELY	Yes
3	Grass	bristly wolfstail	Lycurus setosus	Poaceae	LYSE3	LYCSET	Yes
3	Grass	buffalograss	Buchloe dactyloides	Poaceae	BUDA	BUCDAC	Yes
3	Grass	California brome	Bromus carinatus	Poaceae	BRCA5	BROCAR	Yes
3	Grass	Canada bluegrass	Poa compressa	Poaceae	POCO	POACOM	No
3	Grass	Canada wildrye	Elymus canadensis	Poaceae	ELCA4	ELYCAN	Yes
3	Grass	cheatgrass	Bromus tectorum	Poaceae	BRTE	BROTEC	No
3	Grass	false buffalograss	Munroa squarrosa	Poaceae	MUSQ3	MUNSQU	Yes
3	Grass	false quackgrass	Elymus x pseudorepens	Poaceae	ELPS	ELYPSE	Yes
3	Grass	Fendler's flatsedge	Cyperus fendlerianus	Cyperaceae	CYFE2	CYPFEN	No
3	Grass	green bristlegrass	Setaria viridis	Poaceae	SEVI4	SETVIR	Yes
3	Grass	hairy grama	Bouteloua hirsuta	Poaceae	BOHI2	BOUHIR	Yes
3	Grass	Japanese brome	Bromus japonicus	Poaceae	BRJA	BROJAP	Yes
3	Grass	Kentucky bluegrass	Poa pratensis	Poaceae	POPR	POAPRA	Yes
3	Grass	little bluestem	Schizachyrium scoparium	Poaceae	SCSC	SCHSCO	Yes
3	Grass	littleseed ricegrass	Piptatherum micranthum	Poaceae	PIMI7	PIPMIC	Yes
3	Grass	mountain muhly	Muhlenbergia montana	Poaceae	MUMO	MUHMON	No
3	Grass	muttongrass	Poa fendleriana	Poaceae	POFE	POAFEN	Yes
3	Grass	needle-and-thread grass	Hesperostipa comata	Poaceae	HECO26	HESCOM	Yes
3	Grass	needleleaf sedge	Carex duriuscula	Cyperaceae	CADU6	CARDUR	Yes
3	Grass	nodding brome	Bromus anomalus	Poaceae	BRAN	BROANO	Yes
3	Grass	pine dropseed	Blepharoneuron tricholepis	Poaceae	BLTR	BLETRI	Yes
3	Grass	Porter brome	Bromus porteri	Poaceae	BRPO2	BROPOR	Yes
3	Grass	Porter's melicgrass	Melica porteri	Poaceae	MEPO	MELPOR	Yes
3	Grass	poverty threeawn	Aristida divaricata	Poaceae	ARDI5	ARIDIV	Yes
3	Grass	prairie junegrass	Koeleria macrantha	Poaceae	KOMA	KOEMAC	Yes
3	Grass	purple threeawn	Aristida purpurea	Poaceae	ARPU9	ARIPUR	No
3	Grass	purple threeawn	Aristida purpurea var. purpurea	Poaceae	ARPUP6	ARIPURP	Yes
3	Grass	red threeawn	Aristida purpurea var. longiseta	Poaceae	ARPUL	ARIPURL	Yes
3	Grass	ring muhly	Muhlenbergia torreyi	Poaceae	MUTO2	MUHTOR	Yes
3	Grass	rough bentgrass	Agrostis scabra	Poaceae	AGSC5	AGRSCA	Yes
3	Grass	sand dropseed	Sporobolus cryptandrus	Poaceae	SPCR	SPOCRY	Yes
3	Grass	Scribner's needlegrass	Achnatherum scribneri	Poaceae	ACSC11	ACHSCR	Yes
3	Grass	sideoats grama	Bouteloua curtipendula	Poaceae	BOCU	BOUCUR	Yes
3	Grass	skyline blugrass	Poa fendleriana ssp. fendleriana	Poaceae	POFEF	POAFENF	Yes
3	Grass	sleepygrass	Achnatherum robustum	Poaceae	ACRO7	ACHROB	Yes
3	Grass	smooth brome	Bromus inermis	Poaceae	BRIN2	BROINE	Yes
3	Grass	spike muhly	Muhlenbergia wrightii	Poaceae	MUWR	MUHWRI	Yes
3	Grass	sun sedge	Carex inops ssp. heliophila	Cyperaceae	CAINH2	CARINOH	Yes
3	Grass	switchgrass	Panicum virgatum	Poaceae	PAVI2	PANVIR	Yes
3	Grass	tumblegrass	Schedonnardus paniculatus	Poaceae	SCPA	SCHPAN	Yes
3	Grass	western sedge	Carex occidentalis	Cyperaceae	CAOC2	CAROCC	Yes
3	Grass	western wheatgrass	Pascopyrum smithii	Poaceae	PASM	PASSMI	Yes
3	Grass	White Mountain sedge	Carex geophila	Cyperaceae	CAGE	CARGEO	Yes

LFC	Life Form	Common Name	Scientific Name	Family	PLANTS Symbol	NHNM Acronym	C
3	Grass	witchgrass	Panicum capillare	Poaceae	PACA6	PANCAP	Yes
3	Grass	woolly brome	Bromus lanatipes	Poaceae	BRLA6	BROLAN	Yes
4	Forb	American licorice	Glycyrrhiza lepidota	Fabaceae	GLLE3	GLYLEP	Yes
4	Forb	American vetch	Vicia americana	Fabaceae	VIAM	VICAME	Yes
4	Forb	beardlip penstemon	Penstemon barbatus	Scrophulariaceae	PEBA2	PENBAR	Yes
4	Forb	Bigelow's beggarticks	Bidens bigelovii	Asteraceae	BIBI	BIDBIG	Yes
4	Forb	black bindweed	Polygonum convolvulus	Polygonaceae	POCO10	POLCON	Yes
4	Forb	bractless blazingstar	Mentzelia nuda var. stricta	Loasaceae	MENUS	MENNUDS	Yes
4	Forb	branched noseburn	Tragia ramosa	Euphorbiaceae	TRRA5	TRARAM	Yes
4	Forb	broadbeard beardtongue	Penstemon angustifolius	Scrophulariaceae	PEAN4	PENANG	Yes
4	Forb	broom groundsel	Senecio spartioides	Asteraceae	SESP3	SENSPA	Yes
4	Forb	buffalobur nightshade	Solanum rostratum	Solanaceae	SORO	SOLROS	No
4	Forb	bush morningglory	Ipomoea leptophylla	Convolvulaceae	IPLE	IPOLEP	Yes
4	Forb	calcareous cryptantha	Cryptantha thyrsiflora	Boraginaceae	CRTH	CRYTHY	Yes
4	Forb	Canadian horseweed	Conyza canadensis	Asteraceae	COCA5	CONCAN	Yes
4	Forb	candle anemone	Anemone cylindrica	Ranunculaceae	ANCY	ANECYL	Yes
4	Forb	Carruth's sagewort	Artemisia carruthii	Asteraceae	ARCA14	ARTCAR	Yes
4	Forb	common dandelion	Taraxacum officinale	Asteraceae	TAOF	TAROFF	No
4	Forb	common kochia	Kochia scoparia	Chenopodiaceae	KOSC	KOCSCO	Yes
4	Forb	common mullein	Verbascum thapsus	Scrophulariaceae	VETH	VERTHA	No
4	Forb	common purslane	Portulaca oleracea	Portulacaceae	POOL	POROLE	No
4	Forb	common sunflower	Helianthus annuus	Asteraceae	HEAN3	HELANN	Yes
4	Forb	common yarrow	Achillea millefolium	Asteraceae	ACMI2	ACHMIL	No
4	Forb	cottonbatting cudweed	Pseudognaphalium stramineum	Asteraceae	PSST7	PSESTR	Yes
4	Forb	crownleaf evening-primrose	Oenothera coronopifolia	Onagraceae	OECO2	OENCOR	Yes
4	Forb	curlycup gumweed	Grindelia squarrosa	Asteraceae	GRSQ	GRISQU	Yes
4	Forb	cutleaf nightshade	Solanum triflorum	Solanaceae	SOTR	SOLTRI	Yes
4	Forb	Dakota mock vervain	Glandularia bipinnatifida	Verbenaceae	GLBI2	GLABIP	Yes
4	Forb	David's spurge	Euphorbia davidii	Euphorbiaceae	EUDA5	EUPDAV	Yes
4	Forb	desert goosefoot	Chenopodium pratericola	Chenopodiaceae	CHPR5	CHEPRA	Yes
4	Forb	dotted gayfeather	Liatris punctata	Asteraceae	LIPU	LIAPUN	Yes
4	Forb	Drummond's campion	Silene drummondii	Caryophyllaceae	SIDR	SILDRU	Yes
4	Forb	Fendler's penstemon	Penstemon fendleri	Scrophulariaceae	PEFE	PENFEN	No
4	Forb	Fendler's ragwort	Packera fendleri	Asteraceae	PAFE4	PACFEN	Yes
4	Forb	fetid goosefoot	Chenopodium graveolens	Chenopodiaceae	CHGR2	CHEGRA	Yes
4	Forb	fetid marigold	Dyssodia papposa	Asteraceae	DYPA	DYSPAP	Yes
4	Forb	field bindweed	Convolvulus arvensis	Convolvulaceae	COAR4	CONARV	Yes
4	Forb	flatspine stickseed	Lappula occidentalis	Boraginaceae	LAOC3	LAPOCC	Yes
4	Forb	Fremont's geranium	Geranium caespitosum var. fremontii	Geraniaceae	GECAF	GERCAEF	Yes
4	Forb	Fremont's goosefoot	Chenopodium fremontii	Chenopodiaceae	CHFR3	CHEFRE	Yes
4	Forb	Giant sumpweed	Iva xanthifolia	Asteraceae	IVXA	IVAXAN	Yes
4	Forb	golden crownbeard	Verbesina encelioides	Asteraceae	VEEN	VERENC	Yes
4	Forb	golden pea	Thermopsis rhombifolia	Fabaceae	THRH	THERHO	No
4	Forb	Golden prairieclover	Dalea aurea	Fabaceae	DAAU	DALAUR	Yes

LFC	Life Form	Common Name	Scientific Name	Family	PLANTS Symbol	NHNM Acronym	C
4	Forb	green prairie coneflower	Ratibida tagetes	Asteraceae	RATA	RATTAG	Yes
4	Forb	hairy goldenaster	Heterotheca villosa	Asteraceae	HEVI4	HETVIL	Yes
4	Forb	hairy rockcress	Arabis hirsuta	Brassicaceae	ARHI	ARAHIR	Yes
4	Forb	hoary tansyaster	Dieteria canescens var. glabra	Asteraceae	MACAG	DIECANG	Yes
4	Forb	Hopi tea greenthread	Thelesperma megapotamicum	Asteraceae	THME	THEMEG	Yes
4	Forb	horehound	Marrubium vulgare	Lamiaceae	MAVU	MARVUL	No
4	Forb	horned spurge	Euphorbia brachycera	Euphorbiaceae	EUBR	EUPBRA	Yes
4	Forb	hound's tongue	Cynoglossum officinale	Boraginaceae	CYOF	CYNOFF	No
4	Forb	James' buckwheat	Eriogonum jamesii	Polygonaceae	ERJA	ERIJAM	No
4	Forb	James' buckwheat	Eriogonum jamesii var. jamesii	Polygonaceae	ERJAJ	ERIJAMJ	Yes
4	Forb	Johnston's knotweed	Polygonum douglasii ssp. johnstonii	Polygonaceae	PODOJ2	POLDOUJ	Yes
4	Forb	lacy tansyaster	Xanthisma spinulosum	Asteraceae	MAPI	XANSPI2	Yes
4	Forb	lanceleaf sage	Salvia reflexa	Lamiaceae	SARE3	SALREF	Yes
4	Forb	lesser spikemoss	Selaginella densa	Selaginellaceae	SEDE2	SELDEN	Yes
4	Forb	littleleaf alumroot	Heuchera parvifolia	Saxifragaceae	HEPA11	HEUPAR	Yes
4	Forb	longleaf groundcherry	Physalis longifolia var. longifolia	Solanaceae	PHLOL3	PHYLONL	Yes
4	Forb	MacDougal verbena	Verbena macdougalii	Verbenaceae	VEMA	VERMAC	Yes
4	Forb	manyflowered gromwell	Lithospermum multiflorum	Boraginaceae	LIMU3	LITMUL	Yes
4	Forb	meadow salsify	Tragopogon pratensis	Asteraceae	TRPR	TRAPRA	Yes
4	Forb	mountain leaftail	Pericome caudata	Asteraceae	PECA10	PERCAU	Yes
4	Forb	mountain thermopsis	Thermopsis rhombifolia var. montana	Fabaceae	THRHM	THERHOM	No
4	Forb	narrowleaf four o'clock	Mirabilis linearis	Nyctaginaceae	MILI3	MIRLIN	Yes
4	Forb	narrowleaf goosefoot	Chenopodium leptophyllum	Chenopodiaceae	CHLE4	CHELEP	Yes
4	Forb	narrowleaf pectis	Pectis angustifolia	Asteraceae	PEAN	PECANG	No
4	Forb	narrowleaf pectis	Pectis angustifolia var. angustifolia	Asteraceae	PEANA	PECANGA	Yes
4	Forb	narrowleaf wirelettuce	Stephanomeria minor	Asteraceae	STMI13	STEMIN	Yes
4	Forb	New Mexican groundcherry	Physalis subulata var. neomexicana	Solanaceae	PHSUN	PHYSUBN	Yes
4	Forb	New Mexican nightshade	Solanum heterodoxum var. novomexicanum	Solanaceae	SOHEN	SOLHETN	Yes
4	Forb	New Mexico stickseed	Hackelia hirsuta	Boraginaceae	HAHI2	HACHIR	Yes
4	Forb	nodding onion	Allium cernuum	Liliaceae	ALCE2	ALLCER	Yes
4	Forb	oppositeleaf bahia	Picradeniopsis oppositifolia	Asteraceae	PIOP	PICOPP	Yes
4	Forb	Oregon cliff fern	Woodsia oregana ssp. cathcartiana	Dryopteridaceae	WOORC2	WOOORE C	Yes
4	Forb	Oregon woodsia	Woodsia oregana	Dryopteridaceae	WOOR	WOOORE	No
4	Forb	Pennsylvania cinquefoil	Potentilla pensylvanica	Rosaceae	POPE8	POTPEN	Yes
4	Forb	plains milkweed	Asclepias pumila	Asclepiadaceae	ASPU	ASCPUM	Yes
4	Forb	plains wallflower	Erysimum asperum	Brassicaceae	ERAS2	ERYASP	Yes
4	Forb	pleated gentian	Gentiana affinis	Gentianaceae	GEAF	GENAFF	No
4	Forb	plumed brickellbush	Brickellia brachyphylla	Asteraceae	BRBR2	BRIBRA	Yes

LFC	Life Form	Common Name	Scientific Name	Family	PLANTS Symbol	NHNM Acronym	C
4	Forb	prairie bluebells	Mertensia lanceolata var. lanceolata	Boraginaceae	MELAL2	MERLANL	Yes
4	Forb	prairie flax	Linum lewisii	Linaceae	LILE3	LINLEW	Yes
4	Forb	prickly lettuce	Lactuca serriola	Asteraceae	LASE	LACSER	Yes
4	Forb	prickly poppy	Argemone hispida	Papaveraceae	ARHI4	ARGHIS	Yes
4	Forb	prickly Russian thistle	Salsola tragus	Chenopodiaceae	SATR12	SALTRA	Yes
4	Forb	purple prairieclover	Dalea purpurea	Fabaceae	DAPU5	DALPUR	Yes
4	Forb	pygmyflower rockjasmine	Androsace septentrionalis	Primulaceae	ANSE4	ANDSEP	Yes
4	Forb	Rocky Mountain scorpionweed	Phacelia denticulata	Hydrophyllaceae	PHDE2	PHADEN	Yes
4	Forb	rose heath	Chaetopappa ericoides	Asteraceae	CHER2	CHAERI	Yes
4	Forb	running fleabane	Erigeron tracyi	Asteraceae	ERCO28	ERITRA	Yes
4	Forb	sandyseed clammyweed	Polanisia dodecandra ssp. trachysperma	Capparaceae	PODOT	POLDODT	Yes
4	Forb	scarlet beeblossom	Gaura coccinea	Onagraceae	GACO5	GAUCOC	Yes
4	Forb	scarlet gilia	Ipomopsis aggregata ssp. candida	Polemoniaceae	IPAGC	IPOAGGC	Yes
4	Forb	scarlet globemallow	Sphaeralcea coccinea	Malvaceae	SPCO	SPHCOC	Yes
4	Forb	showy goldeneye	Heliomeris multiflora	Asteraceae	HEMU3	HELMUL	Yes
4	Forb	silvery lupine	Lupinus argenteus	Fabaceae	LUAR3	LUPARG	Yes
4	Forb	silvery lupine	Oxytropis sericea	Fabaceae	OXSE	OXYSER	Yes
4	Forb	skyrocket gilia	Ipomopsis aggregata	Polemoniaceae	IPAG	IPOAGG	No
4	Forb	slender lipfern	Cheilanthes feei	Pteridaceae	CHFE	CHEFEE	Yes
4	Forb	slim amaranth	Amaranthus hybridus	Amaranthaceae	AMHY	AMAHYB	Yes
4	Forb	slimflower scurfpea	Psoralidium tenuiflorum	Fabaceae	PSTE5	PSOTEN	Yes
4	Forb	slimleaf plainsmustard	Schoenocrambe linearifolia	Brassicaceae	SCLI12	SCHLIN	Yes
4	Forb	smallleaf pussytoes	Antennaria parvifolia	Asteraceae	ANPA4	ANTPAR	No
4	Forb	smooth spreading four o'clock	Mirabilis oxybaphoides	Nyctaginaceae	MIOX	MIROXY	Yes
4	Forb	southern flax	Linum australe var. australe	Linaceae	LIAUA	LINAUSA	Yes
4	Forb	spreading dogbane	Apocynum androsaemifolium	Apocynaceae	APAN2	APOAND	Yes
4	Forb	spreading sandwort	Arenaria lanuginosa ssp. saxosa	Caryophyllaceae	ARLAS	ARELANS	Yes
4	Forb	starry false Solomon's seal	Maianthemum stellatum	Liliaceae	MAST4	MAISTE	Yes
4	Forb	sticky gilia	Gilia pinnatifida	Polemoniaceae	GIPI	GILPIN	Yes
4	Forb	stiff sunflower	Helianthus pauciflorus ssp. subrhomboideus	Asteraceae	HEPAS	HELPAUS	Yes
4	Forb	stinking milkvetch	Astragalus flexuosus	Fabaceae	ASFL2	ASTFLE	Yes
4	Forb	tall cinquefoil	Potentilla arguta	Rosaceae	POAR7	POTARG	No
4	Forb	tarragon	Artemisia dracunculus	Asteraceae	ARDR4	ARTDRA	Yes
4	Forb	threadleaf ragwort	Senecio flaccidus	Asteraceae	SEFL3	SENFLA	No
4	Forb	threepetal bedstraw	Galium trifidum ssp. subbiflorum	Rubiaceae	GATRS2	GALTRIS	Yes
4	Forb	threetooth ragwort	Packera tridenticulata	Asteraceae	PATR7	PACTRI	Yes
4	Forb	thymeleaf sandmat	Chamaesyce serpyllifolia	Euphorbiaceae	CHSE6	CHASER2	Yes
4	Forb	trailing fleabane	Erigeron flagellaris	Asteraceae	ERFL	ERIFLA	Yes
4	Forb	tufted eveningprimrose	Oenothera caespitosa	Onagraceae	OECA10	OENCAE	Yes

LFC	Life Form	Common Name	Scientific Name	Family	PLANTS Symbol	NHNM Acronym	C
4	Forb	upright prairie coneflower	Ratibida columnifera	Asteraceae	RACO3	RATCOL	Yes
4	Forb	varileaf phacelia	Phacelia heterophylla	Hydrophyllaceae	PHHE2	PHAHET	Yes
4	Forb	velvety goldenrod	Solidago mollis	Asteraceae	SOMO	SOLMOL	Yes
4	Forb	wavyleaf thistle	Cirsium undulatum	Asteraceae	CIUN	CIRUND	No
4	Forb	weakleaf bur ragweed	Ambrosia confertiflora	Asteraceae	AMCO3	AMBCON	Yes
4	Forb	western marbleseed	Onosmodium molle ssp. occidentale	Boraginaceae	ONMOO2	ONOMOLO	Yes
4	Forb	western yarrow	Achillea millefolium var. occidentalis	Asteraceae	ACMIO	ACHMILO	Yes
4	Forb	white prairieclover	Dalea candida var. oligophylla	Fabaceae	DACAO	DALCANO	Yes
4	Forb	white sagebrush	Artemisia ludoviciana	Asteraceae	ARLU	ARTLUD	Yes
4	Forb	wholeleaf Indian paintbrush	Castilleja integra	Scrophulariaceae	CAIN14	CASINT	Yes
4	Forb	wild potato	Solanum jamesii	Solanaceae	SOJA	SOLJAM	No
4	Forb	wildbergamot beebalm	Monarda fistulosa	Lamiaceae	MOFI	MONFIS	Yes
4	Forb	winged buckwheat	Eriogonum alatum	Polygonaceae	ERAL4	ERIALA	Yes
4	Forb	wishbone fiddleleaf	Nama dichotomum	Hydrophyllaceae	NADI	NAMDIC	Yes
4	Forb	woolly cinquefoil	Potentilla hippiana	Rosaceae	POHI6	POTHIP	Yes
4	Forb	yellow owlclover	Orthocarpus luteus	Scrophulariaceae	ORLU2	ORTLUT	Yes
4	Forb	yellow salsify	Tragopogon dubius	Asteraceae	TRDU	TRADUB	No
4	Forb	yellow sweetclover	Melilotus officinalis	Fabaceae	MEOF	MELOFF	No

Appendix C. Keys to Plant Associations

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

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

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

Key to the major classes:

A. Substrate of mostly rocks and boulders with total vegetation cover <10% or dominated by lithomorphic species: **KEY 4 – Lithmorphic Vegetation** (page C-4)
A. Total vegetation cover >10% and not dominated by lithomorphic species: (B)

B. Trees dominant, typically >25% canopy cover; or if <25%, clearly the dominant and/or the characteristic growth form: **KEY 1 – Forests and Woodlands** (page C-2)
B. Trees <10%, clearly not predominant: (C)

C. Shrubs >25%, or if <25%, clearly the dominant and/or the characteristic growth form: **KEY 2 — Shrublands** (page C-2)
C. Shrubs <25%, herbs clearly the dominant and/or characteristic growth form: **KEY 3 – Herbaceous Vegetation** (page C-3)

KEY 1 – Forests and Woodlands

1. *Pinus ponderosa* dominant or codominant: *Pinus ponderosa* / *Quercus gambelii* Woodland
1. *Pinus ponderosa* rare or absent: (2)

2. *Juniperus scopulorum* dominant; *Pinus edulis* poorly represented or absent, clearly subordinate: *Juniperus scopulorum* - *Quercus gambelii* Woodland

2 (1). *Pinus edulis* well represented, dominant or codominant: (3)

3 (2). Shrubs well represented: (4)
3. Shrubs poorly represented, herbaceous layer dominant: (6)

4 (3). *Quercus gambelii* well represented: (5)
Pinus edulis -- *Juniperus* spp. / *Quercus gambelii* Woodland
4. *Quercus gambelii* poorly represented or absent: (5)

5 (4). *Quercus* ×*pauciloba* well represented and dominant:
Pinus edulis / *Quercus* ×*pauciloba* Woodland
5. *Quercus* ×*pauciloba* poorly represented, not dominant; *Cercocarpus montanus* usually well represented, dominant shrub: *Pinus edulis* - *Juniperus spp. / Cercocarpus montanus* - Mixed Shrubs Woodland

6 (3). *Achnatherum scribneri* well represented:
Pinus edulis - *Juniperus scopulorum* / *Achnatherum scribneri* Woodland
6. *Achnatherum scribneri* poorly represented or absent: (7)

7 (6). *Muhlenbergia montana* well represented: (10)
Pinus edulis / *Muhlenbergia montana* Woodland
7. *Muhlenbergia montana* poorly represented:
Pinus Pinus edulis – (Juniperus monosperma) / Bouteloua gracilis Woodland

KEY 2 – Shrublands

1. *Quercus gambelii* abundant, dominant shrub: (2)
1. *Quercus gambelii* not dominant: (4)

2 (1). *Prunus virginiana,* or *Physocarpus monogynus* well represented, dominant shrub:
Quercus gambelii / *Prunus virginiana* Woodland
2. *Prunus virginiana* or *Physocarpus monogynus* poorly represented, clearly not dominant: (3)

3 (2). *Cercocarpus montanus* well represented:
Quercus gambelii - *Cercocarpus montanus / (Carex geyeri)* Shrubland
3. *Cercocarpus montanus* poorly represented:
Quercus gambelii / *Rhus trilobata* Woodland

4 (1). *Quercus* ×*pauciloba* well represented:
Quercus ×*pauciloba* - *Cercocarpus montanus* Shrubland
4. *Quercus* ×*pauciloba* poorly represented or absent: (5)

5 (4). *Cercocarpus montanus* well-represented to abundant, dominant:
Cercocarpus montanus / *Bouteloua gracilis* Shrubland
5. *Cercocarpus montanus* poorly represented or absent, not dominant not: (6)

6 (5). *Jamesia americana* well-represented to abundant:
Jamesia americana - *Physocarpus monogynus* Shrubland
6.. *Jamesia americana* poorly represented or absent:
Atriplex canescens / Ruderal Herbs Shrubland

KEY 3 – Herbaceous Vegetation

E. HERBACEOUS VEGETATION

1. *Muhlenbergia montana* and/or *Festuca arizonica* well represented, dominant:
    Festuca arizonica - Muhlenbergia montana Herbaceous Vegetation
1. *Muhlenbergia montana* poorly represented: (2)

2 (1). *Andropogon gerardii* well represented and dominant or commonly codominant with *Schizachyrium scoparium*:
    Andropogon gerardii - Schizachyrium scoparium Herbaceous Vegetation
2. *Andropogon gerardii* not dominant or codominant with *Schizachyrium scoparium*: (3)

3 (2). *Schizachyrium scoparium* well represented and dominant or codominant with *Bouteloua gracilis*:
    Schizachyrium scoparium - Bouteloua gracilis Herbaceous Vegetation
3. *Schizachyrium scoparium* not dominant or codominant with *Bouteloua gracilis*: (4)

4 (3). *Bouteloua gracilis* usually well represented and dominant: (5)
4. *Bouteloua gracilis* uncommon or absent: (8)

5 (4). *Yucca glauca* well represented:
Yucca glauca / Bouteloua gracilis Shrub Herbaceous Vegetation
5. *Yucca glauca* poorly represented: (6)

6 (5). *Pascopyrum smithii* common, codominant:
    Pascopyrum smithii - Bouteloua gracilis Herbaceous Vegetation
6. *Pascopyrum smithii* uncommon, not codominant: (7)

7 (6). *Bouteloua curtipendula* usually well represented, codominant:
    Bouteloua gracilis - Bouteloua curtipendula Herbaceous Vegetation
7. *Bouteloua curtipendula* uncommon or absent; weedy forbs well represented to abundant:
    Bouteloua gracilis / Ruderal Herbaceous Vegetation

8 (4)). *Pascopyrum smithii* well represented; forbs well represented to abundant:
    Pascopyrum smithii / Ruderal Herbaceous Vegetation
8. *Pascopyrum smithii* poorly represented or absent :
    Ruderal Disturbance Vegetation

KEY 4 – Lithmorphic Vegetation

1. 1. Substrate dominated by exposed bedrock or large boulders:
    Sparse Vegetation / Boulder Rockland
1. Substrate dominated by stream channel alluvial deposits:
    Sparse Vegetation / Bare Ground

Appendix D. Plant Community Descriptions

As part of the Capulin Volcano National Monument (CAVO) vegetation classification and mapping project, local plant association descriptions were written for 24 plant associations (PAs) identified for the park during the classification and mapping phase of the project (plant associations detected during the accuracy assessment phase are included). Local descriptions provide information on the park-level distribution, level of acceptable physiognomic and compositional variation, and the key ecological process and environmental/abiotic factors that are associated with a type (Grossman et al. 1998).

At this time, the CAVO descriptions have not been integrated into the national database maintained by NatureServe, but where a given association is recognized in the National Vegetation Classification, the NatureServe database code (codes beginning "CEGL") has been provided that can be used to query NatureServe's Explorer website for additional information at a global level (http://www.natureserve.org/explorer). In this appendix, the arrangement of the plant associations follows a new hierarchy per FGDC (2008) and table 2.5 of the main report.

1. Forest & Woodland

1.C.2. Cool Temperate Forest

1.C.2.b. Western North American Cool Temperate Forest

MG022. Southern Rocky Mountain Lower Montane Forest

G228. Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group

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Pinus ponderosa / Quercus gambelii Woodland

Ponderosa Pine / Gambel Oak Forest
Identifier: CEGL000870

NVC CLASSIFICATION

Division	Western North American Cool Temperate Forest (1.C.2.b)
Macrogroup	Southern Rocky Mountain Lower Montane Forest (MG022)
Group	Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group (G228)
Association	*Pinus ponderosa / Quercus gambelii* Woodland
Ecological System(s):	Southern Rocky Mountain Ponderosa Pine Woodland (CES306.648)

DISTRIBUTION

Capulin Volcano National Monument
This association was observed and mapped in the Boca Negra region of the park.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs at approximately 2250 m (7400 ft.) in elevation on southeasterly to northwesterly aspects of the lava flow emanating from the western side of the cinder cone. The slopes are moderate to steep (30 to 40%). The topography of the lava flow is uneven and fractured, with pressure ridges creating microsites for the establishment of tall trees. The ground surface is characterized by exposed basaltic lava and areas covered by leaf litter.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
In this woodland, the canopy is nearly closed and dominated by *Pinus ponderosa* with *Juniperus scopulorum* and *Pinus edulis* as common to abundant sub-canopy associates. The understory is characteristically shrubby with *Quercus gambelii* well represented as a shrub or short -statured tree. *Quercus ×pauciloba* can also be a common to well represented shrub associate, and occasionally the dominant. Total shrub cover may be as high as 30%. Graminoid cover can range from 2 to 20% with *Andropogon gerardii, Carex inops* ssp. *Heliophila, Festuca arizonica, Poa fendleriana,* and *Bouteloua gracilis* as the most abundant representatives. Forbs are variable in composition and usually low in cover (<3% cover) and may include scattered individuals of *Artemisia ludoviciana*, *Geranium caespitosum* var. *fremontii,* and *Solidago mollis.*

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tree canopy	*Pinus ponderosa*
Tree canopy	*Juniperus scopulorum, Quercus gambelii*
Tall shrub/sapling	*Quercus gambelii*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 02CV008 and 05CV009 (2 standard plots).
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

G253. Southern Rocky Mountain Pinyon - Juniper Woodland Group

Juniperus scopulorum - Quercus gambelii Woodland
Rocky Mountain Juniper - Gambel's Oak Woodland
Identifier: CEGL002967

NVC CLASSIFICATION

Division	Western North American Cool Temperate Scrub Woodland & Shrubland (1.C.2.c)
Macrogroup	Rocky Mountain Two-needle Pinyon - Juniper Woodland (MG027)
Group	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)
Association	*Juniperus scopulorum - Quercus gambelii* Woodland
Ecological System(s):	

DISTRIBUTION
Capulin Volcano National Monument
This extensive association is known from the visitor center area, the Boca Negra region, and near the Lava Trail.

ENVIRONMENTAL DESCRIPTION
Capulin Volcano National Monument
This association occurs from 2200 to 2260 m (7220 to 7400 ft) in elevation on predominantly northerly aspects, but occasionally on southerly. Slopes vary from gentle (15%) on the footslopes of the volcano to moderately steep (30%) on pressure ridges. Geologic substrates are composed of volcanic scoria of the cone or basalt lava flow. The ground surface is characterized by exposed basaltic lava and scoria gravels and soils, and areas covered by leaf litter.

VEGETATION DESCRIPTION
Capulin Volcano National Monument
This short-statured coniferous woodland is characterized by a tree canopies that range from moderately open to nearly closed (25 to 60% cover). The canopy is dominated by *Juniperus scopulorum*, with *Pinus edulis* as an uncommon or absent. The understory is characterized by shrub-statured *Quercus gambelii* and occasionally *Q. x pauciloba.* Overall shrub canopy cover can reach 70% and in addition to the oaks, *Rhus trilobata* and occasionally *Cercocarpus montanus* may be well represented. The herbaceous layer of this woodland is dominated by graminoids, with cover reaching as high as 50%. Overall, 23 graminoid species were recorded with *Andropogon gerardii*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Carex inops* ssp. *heliophila*, *Muhlenbergia montana*, and *Piptatherum micranthum* the most abundant. Forbs are variable in composition and cover generally less than 1%. While over 35 species have been recorded, most were represented by scattered individuals. The most consistent and abundant were *Artemisia ludoviciana* and *Solidago mollis*.

MOST ABUNDANT SPECIES
Capulin Volcano National Monument

Stratum	Species
Tree canopy	*Juniperus scopulorum*
Tall shrub/sapling	*Quercus gambelii*

OTHER NOTEWORTHY SPECIES
Capulin Volcano National Monument
Data are not available.

CLASSIFICATION COMMENTS
Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV011, 05CV027, 08YC052, 08YC053, 08YC058, 08YC059, and 08YC065.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Pinus edulis / Achnatherum scribneri Woodland

Pinyon Pine / Scribner's Needlegrass Woodland
Identifier: CEGL000798

NVC CLASSIFICATION

Division	Western North American Cool Temperate Scrub Woodland & Shrubland (1.C.2.c)
Macrogroup	Rocky Mountain Two-needle Pinyon - Juniper Woodland (MG027)
Group	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)
Association	*Pinus edulis / Achnatherum scribneri* Woodland
Ecological System(s):	Colorado Plateau Pinyon-Juniper Woodland (CES304.767)
	Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835)

DISTRIBUTION

Capulin Volcano National Monument
This association is known from the eastern slopes of the volcano.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs from 2420 to 2480 m (7930 to 8150 ft) in elevation on easterly aspects. Stands occur on steep (50 to 60%) upper to mid slopes of the cinder cone. Ground cover is characterized by exposed volcanic gravels with scattered grass leaf litter and bunch grasses.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This short-statured coniferous woodland is characterized by a closed canopy of *Pinus edulis* with *Juniperus scopulorum* as a common canopy associate. The understory and inter-tree spaces are characteristically grassy and exceed 25% cover in some stands. *Achnatherum scribneri* dominates the graminoids with *Piptatherum micranthum, Muhlenbergia montana,* and *Bromus lanatipes* as common to well represented associates. Forbs are variable in composition and cover (they seldom exceed 2% cover), and may include *Mirabilis oxybaphoides, Gilia pinnatifida, Pericome caudata, Eriogonum jamesii* var*. jamesii,* and *Mirabilis linearis*. In general, tall shrubs and sub-shrubs are poorly represented (<5% cover) and clearly subordinate to grasses in the understory. They may include scatted individuals of *Artemisia frigida*, *Rhus trilobata, Cercocarpus montanus*, *Ribes cereum*, and *Opuntia polyacantha*.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tree canopy	*Pinus edulis, Juniperus scopulorum*
Herb (field)	*Achnatherum scribneri, Piptatherum micranthum*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION COMMENTS

Capulin Volcano National Monument

ELEMENT SOURCES

Capulin Volcano National Monument Plots: NHNM plots 05CV007, 05CV024, and 05CV025.
Local Description Authors: E. Muldavin, A. Kennedy, and A. Fettes.

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

Two-needle Pinyon - (One-seed Juniper) / Blue Grama Woodland
Identifier: CEGL002151

NVC CLASSIFICATION

Division	Western North American Cool Temperate Scrub Woodland & Shrubland (1.C.2.c)
Macrogroup	Rocky Mountain Two-needle Pinyon - Juniper Woodland (MG027)
Group	Colorado Plateau Pinyon - Juniper Woodland Group (G250)
Association	*Pinus edulis - Juniperus scopulorum / Bouteloua gracilis* Woodland
Ecological System(s):	Colorado Plateau Pinyon-Juniper Woodland (CES304.767)

DISTRIBUTION

Capulin Volcano National Monument
This association is known from the northeast to southeast footslopes of the volcano.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs from 2160 to 2180 m (7090 to 7160 ft) in elevation on gentle footslopes (up to 20% slope) of the cone. Aspects range from cool northeasterly to moderately warm southeasterly. Geologic substrates are composed of volcanic scoria. Ground cover is typically characterized by exposed scoria gravels with scattered grass leaf litter and bunch grasses.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
In this short-statured coniferous woodland, tree canopies vary from very open (15% canopy cover) to closed (70%). *Pinus edulis* is the dominant and diagnostic and, while *Juniperus monosperma* is absent in this case, *Juniperus scopulorum* can be common and may co-dominate. The understory and inter-tree spaces are characteristically grassy and can reach 25% or more cover in some stands. *Bouteloua gracilis* dominates, while *Andropogon gerardii* and *Schizachyrium scoparium* are common to well represented associates. Forbs are variable in composition and range as high as 10% to 20% total cover; *Artemisia carruthii, Artemisia ludoviciana, Heterotheca villosa*, and *Heliomeris multiflora* are the most constant and abundant. Tall shrubs and sub-shrubs are generally poorly represented (<5% cover) and clearly subordinate to grasses in the understory but may include scatted individuals of *Cercocarpus montanus*, *Ribes cereum*, and *Yucca glauca*.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tree canopy	*Pinus edulis*
Herb (field)	*Bouteloua gracilis, Andropogon gerardii, Schizachyrium scoparium, Bouteloua curtipendula*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument

CLASSIFICATION COMMENTS

Capulin Volcano National Monument

ELEMENT SOURCES

Capulin Volcano National Monument Plots: NHNM plots 05CV032 and 08YC046.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Pinus edulis - Juniperus spp. / Cercocarpus montanus - Mixed Shrubs Woodland

Two-needle Pinyon - Juniper species / Alderleaf Mountain-mahogany - Mixed Shrubs Woodland
Identifier: CEGL000780

NVC CLASSIFICATION

Division	Western North American Cool Temperate Scrub Woodland & Shrubland (1.C.2.c)
Macrogroup	Rocky Mountain Two-needle Pinyon - Juniper Woodland (MG027)
Group	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)
Association	*Pinus edulis - Juniperus monosperma / Cercocarpus montanus* Woodland

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association was observed and mapped on the rim and upper slopes of the volcano.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs from 2370 to 2460 m (7780 to 8060 ft) in elevation mainly on upper northwesterly or northeasterly aspects, though occasionally on warmer southerly aspects. Slopes are steep, cinder-cone sideslopes (45 to 55%) composed of volcanic scoria. Ground surface is dominated by leaf litter with abundant volcanic gravel or rock.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
These short-statured coniferous woodlands have canopies ranging from sparse (10%) to open (40%) and are dominated by *Pinus edulis*; *Juniperus scopulorum* is uncommon or absent. The understory is characteristically shrubby, reaching as high as 40% total shrub canopy cover. *Cercocarpus montanus* dominates with relatively mesic shrubs such as *Rhus trilobata* and *Physocarpus monogynus,* among others, often common to well represented. The herbaceous layer is well represented to abundant, occasionally reaching 40% total cover, and is dominated by graminoids. *Muhlenbergia montana* is the most abundant graminoid representative, while *Bouteloua gracilis* and *Festuca arizonica* are frequent, though less abundant, associates. Forbs are variable with *Solidago mollis* the most prevalent. Overall, herbaceous species diversity is moderate with 17 graminoid and 29 forb species recorded.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tree canopy	*Pinus edulis, Juniperus scopulorum*
Herb (field)	*Achnatherum scribneri, Piptatherum micranthum*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION COMMENTS

Capulin Volcano National Monument

ELEMENT SOURCES

Capulin Volcano National Monument Plots: NHNM plots 05CV007, 05CV024, 08YC033, and 05CV025.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Pinus edulis - Juniperus spp. - Quercus gambelii Woodland

Pinyon Pine - Juniper species -Gambel's Oak Woodland
Identifier: CEGL000791

NVC CLASSIFICATION

Division	Western North American Cool Temperate Scrub Woodland & Shrubland (1.C.2.c)
Macrogroup	Rocky Mountain Two-needle Pinyon - Juniper Woodland (MG027)
Group	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)
Association	

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association was observed and mapped in the Boca Negra region and on the north slope of the volcano's crater.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs from 2250 to 2360 m (7390 to 7750 ft) in elevation on northwesterly aspects of steep, cinder-cone slopes (35 to 60%) extending down on to lava-tube pressure ridges of the Boca. Geologic substrates are composed of volcanic basalt or scoria. The ground surface is dominated by abundant leaf litter and grass canopies with low to moderate exposed soils and gravel.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This short-statured coniferous woodland is characterized by canopies that vary from open to closed (20 to 80% closure) depending on stand history and site conditions. Stands are dominated by *Pinus edulis* with *Juniperus scopulorum* as a well-represented associate. Shrub-statured *Quercus gambelii* is abundant and diagnostic. Other common shrubs are *Cercocarpus montanus* and *Rhus trilobata.* The understory and inter-tree spaces are characteristically grassy and exceed 20% cover in some stands. *Muhlenbergia montana* and *Carex inops* ssp*. heliophila* can both be well represented. Forbs are variable in composition and seldom exceed 3% cover. Of the 29 forb species recorded, *Solidago mollis, Artemisia ludoviciana, Eriogonum jamesii, Heliomeris multiflora*, and *Heuchera parvifolia* are the most prevalent.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tree canopy	*Pinus edulis, Juniperus scopulorum, Quercus gambelii*
Tall shrub/sapling	*Quercus gambelii*
Herb (field)	*Muhlenbergia montana*, *Carex rossii, Solidago mollis, Artemisia ludoviciana*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV019, 05CV020, 08YC056, and 08YC056.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Pinus edulis / Muhlenbergia montana Woodland

Pinyon Pine / Mountain Muhly Woodland
Identifier: NPS_NM070

NVC CLASSIFICATION

Division	Western North American Cool Temperate Scrub Woodland & Shrubland (1.C.2.c)
Macrogroup	Rocky Mountain Two-needle Pinyon - Juniper Woodland (MG027)
Group	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)
Association	

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association occurs along the upper slopes and rim of the cinder cone.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs at 2470 m (8100 ft) in elevation near the summit of the cider cone's various aspects. Slopes are steep (40%) and composed of volcanic scoria gravels. Up to 25% of the surface is exposed gravels and coarse soils and the remainder grass cover and leaf litter.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This short-statured coniferous woodland is characterized by an open canopy of *Pinus edulis*; *Juniperus scopulorum* is uncommon or absent. Inter-tree spaces are characteristically grassy and cover can exceed 30% in some stands. *Muhlenbergia montana* and *Bouteloua gracilis* are the dominants among the 11 graminoids reported for the association. Forbs are poorly represented and variable. Similarly, shrubs are a minor component, although *Rhus trilobata* and *Cercocarpus montanus* can be common.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tree canopy	*Pinus edulis*
Herb (field)	*Muhlenbergia montana, Bouteloua gracilis*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 02CV003.
Local Description Authors: A. Kennedy, E. Muldavin, and A. Fettes.

Pinus edulis / Quercus X pauciloba Woodland

Pinyon Pine / Wavyleaf Oak Woodland
Identifier: CEGL000793

NVC CLASSIFICATION

Division	Western North American Cool Temperate Scrub Woodland & Shrubland (1.C.2.c)
Macrogroup	Rocky Mountain Two-needle Pinyon - Juniper Woodland (MG027)
Group	Southern Rocky Mountain Pinyon - Juniper Woodland Group (G253)
Association	

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association occurs on the cinder cone.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs from 2175 to 2425 m (7140 to 7960 ft) in elevation on predominantly southerly aspects. It occurs from the lower to upper mid-slopes of the cinder cone where slopes can be as steep as 50%. Soils are derived from volcanic scoria and up to 25% of a site can be exposed soils and gravels with the remainder grass cover and leaf litter.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This short-statured coniferous woodland is characterized by a variably dense canopy (20 to 60% cover) dominated by *Pinus edulis* with *Juniperus scopulorum* occasionally a co-dominant. The understory is characteristically shrubby with coverage typically exceeding 30%. *Quercus ×pauciloba* is clearly the dominant and diagnostic shrub species with cover as high as 60% in some stands. Though significantly lower in cover, species such as *Cercocarpus montanus*, *Opuntia polyacantha*, *Rhus trilobata*, and *Yucca glauca* are frequent associates. The herbaceous layer is typically poorly represented. *Bouteloua gracilis* is the most frequent graminoid representative and *Muhlenbergia montana* and *Bouteloua curtipendula* are common. Forbs are scattered, with no representative greater than 1% cover.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tree canopy	*Pinus edulis*
Tall shrub/sapling	*Quercus ×pauciloba*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 02CV005, 05CV023, 05CV029, 08YC037, 08YC041, and 08YC047.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

2. Shrubland & Grassland

2.C.1. Temperate & Boreal Shrubland & Grassland

2.C.1.a. Vancouverian & Rocky Mountain Grassland & Shrubland

MG049. Southern Rocky Mountain Montane Grassland & Shrubland

G276. Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group

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***Cercocarpus montanus / Bouteloua gracilis* Shrubland**
Mountain Mahogany / Blue Grama Shrubland
Identifier: NPS_NM069

NVC CLASSIFICATION

Division	Vancouverian & Rocky Mountain Grassland & Shrubland (2.C.1.a)
Macrogroup	Southern Rocky Mountain Montane Grassland & Shrubland (MG049)
Group	Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group (G276)
Association	*Cercocarpus montanus / Bouteloua gracilis* Shrubland

Ecological System(s):

DISTRIBUTION
Capulin Volcano National Monument
This association is known from the Boca Negra area.

ENVIRONMENTAL DESCRIPTION
Capulin Volcano National Monument
This association is represented by a stand that occurs on a lava-tube pressure ridge at an elevation of 2260 m (7410 ft). Hence, the topography is rugged and uneven. The aspect is northwesterly and the slope moderate at 30%. Soil development is limited on the basalt lava. The ground is covered by leaf litter and grass canopy.

VEGETATION DESCRIPTION
Capulin Volcano National Monument
This shrubland is dominated by a closed canopy of *Cercocarpus montanus* with *Rhus trilobata* as a common associate. Grass cover beneath the shrubs can be moderate (up to 30% cover) with *Bouteloua gracilis* well represented and diagnostic, and *Piptatherum micranthum* a well represented associate. Forbs are poorly represented (<5% cover) and subordinate to graminoids with *Artemisia ludoviciana* and *Solidago mollis* the most prevalent.

MOST ABUNDANT SPECIES
Capulin Volcano National Monument

Stratum	Species
Tall shrub	*Cercocarpus montanus*
Herb (field)	*Bouteloua gracilis, Piptatherum micranthum*

OTHER NOTEWORTHY SPECIES
Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons:

CLASSIFICATION COMMENTS
Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV012.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Quercus ×pauciloba - Cercocarpus montanus Shrubland

Wavyleaf Oak - Mountain Mahogany Shrubland
Identifier: CEGL001118

NVC CLASSIFICATION

Division	Vancouverian & Rocky Mountain Grassland & Shrubland (2.C.1.a)
Macrogroup	Southern Rocky Mountain Montane Grassland & Shrubland (MG049)
Group	Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group (G276)
Association	*Quercus X pauciloba - Cercocarpus montanus* Shrubland

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from within the cinder cone's crater.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association is known from a stand within the cinder cone at an elevation of 2380 m (7800 ft). It occurs on a moderate slope (35%) with a southwestly aspect. Soils are derived from volcanic basalt and scoria. Exposed soils, gravels, and rock characterize up to 25% of the ground surface while the remainder is leaf litter and grass canopy.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This dry-mesic montane shrubland is characterized by a mix of *Quercus X pauciloba* and *Cercocarpus montanus* that form a moderate canopy (40% cover). The herbaceous layer is grassy with *Bouteloua gracilis* abundant and *Carex inops* ssp. *heliophila* well represented. Forbs are common to well represented with *Solidago mollis* and *Eriogonum jamesii var. jamesii* the most prevalent. *Artemisia frigida* is well represented as a dwarf-shrub associate that is intermixed among the grasses and forbs.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tall shrub	*Quercus pauciloba, Cercocarpus montanus*
Herb (field)	*Bouteloua gracilis, Carex inops* ssp. *heliophila*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV005.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

G277. Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland Group

Jamesia americana - Physocarpus monogynus Shrubland
Cliffbush - Mountain Ninebark Shrubland
Identifier: CEGL002783

NVC CLASSIFICATION

Division	Vancouverian & Rocky Mountain Grassland & Shrubland (2.C.1.a)
Macrogroup	Southern Rocky Mountain Montane Grassland & Shrubland (MG049)
Group	Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland Group (G277)
Association	*Jamesia americana - Physocarpus monogynus* Shrubland

Ecological System(s):

DISTRIBUTION
Capulin Volcano National Monument
This association is known from inside the crater of the cinder cone.

ENVIRONMENTAL DESCRIPTION
Capulin Volcano National Monument
This association is known from a stand near the bottom of the cinder cone which extends up the north-facing slope. The elevation was 2380 m (7820 ft) and the slope moderate at 35%. The stand occurs among basalt boulders and near the bottom of the crater and extends onto scoria upslope.

VEGETATION DESCRIPTION
Capulin Volcano National Monument
This mesic Southern Rocky Mountain shrubland is dominated by a mix of the tall shrubs *Jamesia americana* and *Physocarpus monogynus,* which form a dense canopy across the site (70% cover). Other common shrubs include *Rhus trilobata* and *Ribes cereum.* Overall, the herbaceous layer is poorly represented beneath the shrub canopy; *Carex occidentalis* was most common herbaceous associate.

MOST ABUNDANT SPECIES
Capulin Volcano National Monument

Stratum	Species
Tall shrub	*Jamesia americana, Physocarpus monogynus*

OTHER NOTEWORTHY SPECIES
Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons:

CLASSIFICATION COMMENTS
Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV003.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Quercus gambelii / Carex inops Shrubland

Gambel's Oak / Sun Sedge Shrubland
Identifier: CEGL001113

NVC CLASSIFICATION

Division	Vancouverian & Rocky Mountain Grassland & Shrubland (2.C.1.a)
Macrogroup	Southern Rocky Mountain Montane Grassland & Shrubland (MG049)
Group	Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland Group (G277)
Association	*Quercus gambelii / Carex inops* Shrubland

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association was observed and mapped in the Boca Negra region and on the cinder cone.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs above 2235 m (7330 ft) in elevation on volcanic lava-tube pressure ridges and up the northerly slopes of the cinder cone. Slopes range from 45 to 55%. Geologic substrates include volcanic scoria of the cone and/or basalt boulders of the lava-tube pressure ridges. About 25% of the ground surface is exposed rock, gravel, or soil with the remainder litter and grass canopy.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This mesic, short-statured Southern Rocky Mountain mixed shrubland is dominated by *Quercus gambelii* with *Cercocarpus montanus* as a co-dominant. Other common to well represented mesic shrubs include *Rhus trilobata, Prunus virginiana, Physocarpus monogynus, Ribes leptanthum, Ribes cereum,* and *Rubus neomexicana.* The herbaceous layer is characterized by scattered graminoids with *Piptatherum micranthum* and *Carex inops* ssp. *heliophila* the most prevalent. Forbs are also few and scattered and include *Solidago mollis* and *Eriogonum jamesii* var. *jamesii*. Trees such as *Juniperus scopulorum* or *Pinus edulis* may be scattered or accidental.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tall shrub/sapling	*Quercus gambelii, Cercocarpus montanus*
Herb (field)	*Piptatherum micranthum, Carex inops*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV017 and 08YC049.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Quercus gambelii / Prunus virginiana Woodland

Gambel Oak / Common Chokecherry Woodland
Identifier: CEGL005994

NVC CLASSIFICATION

Division	Vancouverian & Rocky Mountain Grassland & Shrubland (2.C.1.a)
Macrogroup	Southern Rocky Mountain Montane Grassland & Shrubland (MG049)
Group	Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland Group (G277)
Association	*Quercus gambelii / Prunus virginiana* Woodland

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from the cinder cone and the Boca Negra area.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
Stands occur from 2230 to 2415 m (7320 to 7920 ft) in elevation on northern aspects of steep slopes within the cinder cone and on the outer, upper slopes as well along the old lava-flow pressure ridges. Accordingly, geologic substrates include volcanic scoria and basalt lavas, respectively. The ground surface is dominated by leaf litter and grass canopy with some exposed rock and gravels.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This relatively mesic, Southern Rocky Mountain shrubland is dominated by *Quercus gambelii* with *Prunus virginiana* as a well represented codominant. Other common, relatively mesic shrubs include *Physocarpus monogynus, Ribes cereum, Ribes leptanthum, Rhus trilobata, Rosa woodsii,* and *Rubus neomexicana.* Forbs and graminoids are common to well represented, particularly in the inter-shrub spaces. The most common graminoids are *Muhlenbergia montana, Carex occidentalis, Bromus lanatipes, Carex inops* ssp. *heliophila,* and *Piptatherum micranthum*. Forbs are variable, with *Allium cernuum* the most constant among the 15 recorded.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tall shrub/sapling	*Quercus gambelii, Prunus virginiana*
Herb (field)	*Muhlenbergia montana*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV001, 05CV002, 05CV016, and 08YC050.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Quercus gambelii / Rhus trilobata Shrubland

Gambel's Oak / Skunkbush Sumac Shrubland
Identifier: CEGL002338

NVC CLASSIFICATION

Division	Vancouverian & Rocky Mountain Grassland & Shrubland (2.C.1.a)
Macrogroup	Southern Rocky Mountain Montane Grassland & Shrubland (MG049)
Group	Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland Group (G277)
Association	*Quercus gambelii / Rhus trilobata* Shrubland

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association was observed and mapped in the Boca Negra region.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association is represented by a stand at 2230 m (7320 ft) in elevation on a rugged basalt lava flow at the foot of the cinder cone. The slope is gentle (8%) and northwesterly in aspect. While the ground surface is dominated by leaf litter, there are exposed patches of lava rock.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This mesic, closed-canopy Southern Rocky Mountain shrubland is dominated by abundant *Quercus gambelii* with *Juniperus scopulorum* a well-represented associate. Other shrubs that are common to well represented include *Rhus trilobata*, *Ribes leptanthum*, and *Prunus virginiana*. Graminoids are generally poorly represented but may include *Carex inops* ssp. *heliophila*, *C. occidentalis*, and *Poa pratensis*. Forbs are few and scattered.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tree canopy	*Quercus gambelii*
Tall shrub/sapling	*Rhus trilobata*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 02CV007.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

G268. Southern Rocky Mountain Montane-Subalpine Grassland Group

Festuca arizonica - Muhlenbergia montana Herbaceous Vegetation
Arizona Fescue - Mountain Muhly Grassland
Identifier: CEGL001606

NVC CLASSIFICATION

Division	Vancouverian & Rocky Mountain Grassland & Shrubland (2.C.1.a)
Macrogroup	Southern Rocky Mountain Montane Grassland & Shrubland (MG049)
Group	Southern Rocky Mountain Montane-Subalpine Grassland Group (G268)
Association	*Festuca arizonica - Muhlenbergia montana* Herbaceous Vegetation

Ecological System(s):

DISTRIBUTION
Capulin Volcano National Monument
This association is known from the Boca Negra region and the volcano's rim.

ENVIRONMENTAL DESCRIPTION
Capulin Volcano National Monument
This association occurs at 2260 to 2470 m (7415 to 8100 ft) in elevation, extending from the footslopes of the cinder cone among the lava-tube pressure ridges of the Boca Negra upslope to the cinder-cone rim. Accordingly, slopes vary from gentle among the footslopes (5%) to steep slopes of the cinder cone (up to 50%). Geologic substrates are volcanic scoria and basalt. Up to 25% of the ground surface is exposed soil, gravel, and rock, with the remainder covered by leaf litter or grass canopy.

VEGETATION DESCRIPTION
Capulin Volcano National Monument
This Southern Rocky Mountain grassland is characterized by very abundant to luxuriant graminoid cover (often exceeding 50%). *Muhlenbergia montana* and *Festuca arizonica* are co-dominant and typically abundant. *Bouteloua gracilis, Schizachyrium scoparium, Andropogon gerardii,* and *Pascopyrum smithii* are common and frequent associates. Forbs are typically well represented although variable in composition and individual cover (over 45 forb species have been recorded for the association). The most frequent forbs are *Artemisia carruthii*, *Artemisia ludoviciana, Thermopsis rhombifolia, Eriogonum jamesii* var. *jamesii,* and *Solidago mollis*. While mature trees are generally absent, individuals of *Pinus edulis* regeneration may be scattered to common.

MOST ABUNDANT SPECIES
Capulin Volcano National Monument

Stratum	Species
Herb (field)	*Festuca arizonica, Muhlenbergia montana*

OTHER NOTEWORTHY SPECIES
Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons:

CLASSIFICATION COMMENTS
Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 02CV001, 05CV006, 05CV008, 08YC054, and 08YC055.
Local Description Authors: A. Kennedy, E. Muldavinand A. Fettes

2.C.1.b. Great Plains Grassland & Shrubland

MG051. Great Plains Mixedgrass Prairie & Shrubland

GSW6. Southwest Plains-Mesa Mixedgrass Prairie Group [Provisional]

Andropogon gerardii - Schizachyrium scoparium Western Great Plains Herbaceous Vegetation

Western Wheatgrass - Blue Grama Western Great Plains Herbaceous Vegetation
Identifier: CEGL001463

NVC CLASSIFICATION

Division	Great Plains Grassland & Shrubland (2.C.1.b)
Macrogroup	Great Plains Mixedgrass Prairie & Shrubland (MG051)
Group	Southwest Plains-Mesa Mixedgrass Prairie Group (G-TBD)
Association	*Andropogon gerardii - Schizachyrium scoparium* Western Great Plains Herbaceous Vegetation

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from the footslopes of the cinder cone on the west, east, and south sides.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
Stands of this association occur at elevations between 2140 and 2250 m (7020 to 7380 ft) along the gentle footslopes of the cinder cone, extending into the adjacent plains and intermixed among the lava flows of the Boca Negra Area. Geologic substrates are volcanic basalt or scoria. Exposed rock, gravel, and soil can comprise up to 25% of the ground surface with the remainder covered by leaf litter and grass canopies.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This mixedgrass grassland is dominated by the tall grass *Andropogon gerardii,* with the mid-grass *Schizachyrium scoparium* typically well represented and co-dominant. Overall grass cover can reach as high as 40%. *Bouteloua gracilis* and *Bouteloua curtipendula* can be common to well represented associates. Shrubs, while often common, are clearly subordinate to grasses and the sun-shrubs *Artemisia frigida* and *Yucca glauca* are the most abundant. Forbs are diverse and variable with over 60 species recorded. Individuals are generally scattered, with *Artemisia carruthii, Thelesperma megapotamicum, and Heterotheca villosa* the most abundant representatives found throughout.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Herb (field)	*Andropogon gerardii*, *Schizachyrium scoparium, Artemisia carruthii*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 02CV009, 05CV010, 05CV033, 05CV036, 08YC039, and 08YC040.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Schizachyrium scoparium - Bouteloua gracilis Herbaceous Vegetation

Little Bluestem - Blue Grama Grassland
Identifier: NPS_NM045

NVC CLASSIFICATION

Division	Great Plains Grassland & Shrubland (2.C.1.b)
Macrogroup	Great Plains Mixedgrass Prairie & Shrubland (MG051)
Group	Southwest Plains-Mesa Mixedgrass Prairie Group (G-TBD)
Association	*Schizachyrium scoparium - Bouteloua gracilis* Herbaceous Vegetation

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from the Boca Negra region and the east slope of the cinder cone.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument

This association occurs at 2160 to 2240 m (7090 to 7350 ft) in elevation on the gentle footslopes of the cinder cone extending into the adjacent plains and intermixed among the lava flows of the Boca Negra. Slopes vary from gentle footslopes (5%) to moderate , convex ridge line noseslopes (20%) of low hills. Geologic substrates are composed of volcanic scoria and basalt. Exposed rock, gravel, and soil can comprise up to 25% of the ground surface, with the remainder covered by leaf litter and grass canopies.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This mixedgrass grassland is dominated by *Schizachyrium scoparium,* a common mid-grass prairie dominant, along with *Bouteloua gracilis*, a shortgrass prairie dominant. While *Andropogon gerardii* may be common, it is clearly subordinate. Overall grass cover can be as high as 60%. Forbs, while well represented, are variable in composition and cover. Of the 30 forb species recorded, the most commonly represented include *Artemisia carruthii*, *Heterotheca villosa, Chenopodium pratericola,* and *Xanthisma spinulosum.* Although mature trees are typically absent, scattered *Juniperus scopulorum* and *Pinus edulis* seedlings and saplings may be present. Shrubs are poorly represented in this association.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Herb (field)	*Schizachyrium scoparium, Bouteloua gracilis*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV013, 05CV035, and 08YC043.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

MG053. Great Plains Shortgrass Prairie & Shrubland

GSW5. Southwest Plains-Mesa Grassland [Provisional]

Bouteloua gracilis - Bouteloua curtipendula Herbaceous Vegetation

Fringed Sagebrush / Blue Grama Dwarf-shrubland
Identifier: CEGL001754

NVC CLASSIFICATION

Division	Great Plains Grassland & Shrubland (2.C.1.b)
Macrogroup	Great Plains Shortgrass Prairie & Shrubland (MG053)
Group	Southwest Plains-Mesa Grassland (G-TBD)
Association	*Bouteloua gracilis - Bouteloua curtipendula* Herbaceous Vegetation

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from near the park entrance and the Boca Negra region.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs between 2200 and 2240 m (7220 to 7350 ft) in elevation on gently rolling footslopes of the cinder cone intermixed among the lava flows of the Boca Negra. Geologic substrates are composed of volcanic basalt or scoria. Exposed gravel and soil can comprise up to 25% of the ground surface, with the remainder covered by leaf litter and grass canopies.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This southwest plains grassland is dominated by the short grass *Bouteloua gracilis* with *Bouteloua curtipendula* typically well represented. *Muhlenbergia montana*, *Pascopyrum smithii*, and *Schizachyrium scoparium* are common associates, but clearly subordinate. Overall grass cover can reach as high as 50%, however, forbs are typically subordinate and scattered in comparison. Individuals of *Artemisia carruthii, Heterotheca villosa,* and *Verbena macdougalii* may be found throughout.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Herb (field)	*Bouteloua gracilis, Bouteloua curtipendula*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 08YC051.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Bouteloua gracilis / Ruderal Herbaceous Vegetation

Blue Grama / Weedy Herbaceous Vegetation
Identifier: NPS_NM043

NVC CLASSIFICATION

Division	Great Plains Grassland & Shrubland (2.C.1.b)
Macrogroup	Great Plains Shortgrass Prairie & Shrubland (MG053)
Group	Southwest Plains-Mesa Grassland (G-TBD)
Association	*Bouteloua gracilis*/Ruderal Herbaceous Vegetation

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from near the lava trail.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs between 2155 and 2195 m (7070 to 7200 ft) in elevation at moderately warm, southeasterly aspects of gentle footslopes (7 to 15%). Geologic substrates are composed of volcanic basalt. Sites commonly show signs of anthropogenic ground disturbance which may be a function of the livestock grazing history of the park or it may be natural (e.g., gophers or prairie dogs). Exposed gravel and soil can comprise up to 25% of the ground surface, with the remainder covered by leaf litter and grass canopies.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This southwest plains grassland is largely dominated by grasses and ruderal forbs. The short grass *Bouteloua gracilis* is the dominant and diagnostic graminoid while *Aristida divaricata* and *A. purpurea* are both frequent associates. Overall grass cover can be as high as 70%, however, a characteristic mix of disturbance-related forbs may exceed 20% cover in some locations. Of the 40 forb species recorded, ruderal species such as *Ambrosia confertiflora, Chamaesyce serpyllifolia, Physalis subulata* var. *neomexicana,* and *Chenopodium pratericola* were the most abundant. Although subordinate to grasses and forbs, the dwarf shrub *Artemisia frigida* is often well represented in this association.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Herb (field)	*Bouteloua gracilis*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 02CV004 and 02CV006.
Local Description Authors: A. Kennedy, E. Muldavin, and A. Fettes

Pascopyrum smithii - Bouteloua gracilis Herbaceous Vegetation

Western Wheatgrass - Blue Grama Grassland
Identifier: CEGL001578

NVC CLASSIFICATION

Division	Great Plains Grassland & Shrubland (2.C.1.b)
Macrogroup	Great Plains Shortgrass Prairie & Shrubland (MG053)
Group	Southwest Plains-Mesa Grassland (G-TBD)
Association	*Pascopyrum smithii - Bouteloua gracilis* Herbaceous Vegetation

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from the Visitor's Center, the Boca Negra region, and the southeast corner of the park.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs between 2200 and 2300 m (7220 to 7545 ft) in elevation on gently rolling slopes, often in depressions or swales. Geologic substrates are composed of volcanic basalt or scoria. Exposed gravel and soil can comprise up to 25% of the ground surface, with the remainder covered by leaf litter and grass canopies.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This southwest plains grassland is characterized by luxuriant grass cover typically exceeding 50% coverage. *Pascopyrum smithii* and *Bouteloua gracilis* are co-dominants and diagnostic. *Andropogon gerardii* and *Schizachyrium scoparium* may be present but clearly subordinate. Forbs are variable in composition and cover. Of the 42 species recorded, *Artemisia carruthii* and *Chamaesyce serpyllifolia* were the most frequent representatives. Shrubs and sub-shrubs other than *Artemisia frigida* are minor elements of this association.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Herb (field)	*Pascopyrum smithii, Bouteloua gracilis*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 08YC034 and 08YC044.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Pascopyrum smithii / Ruderal Herbaceous Vegetation

Western Wheatgrass / Weedy Herbaceous Vegetation Grassland
Identifier: NPS_NM045

NVC CLASSIFICATION

Division	Great Plains Grassland & Shrubland (2.C.1.b)
Macrogroup	Great Plains Shortgrass Prairie & Shrubland (MG053)
Group	Southwest Plains-Mesa Grassland (G-TBD)
Association	*Pascopyrum smithii* / Ruderal Herbaceous Vegetation

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from the Visitor's Center.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs at 2220 m (7280 ft) in elevation at a warm, southwesterly aspect on a steep slope of a lava-tube pressure ridge. Sites commonly show signs of anthropogenic ground disturbance which may be a function of the livestock grazing history of the park or it may be natural (e.g., gophers or prairie dogs). Exposed gravel and soil can comprise up to 50% of the ground surface, with the remainder covered by leaf litter and grass canopies.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This southwest plains grassland is dominated by *Pascopyrum smithii* and a mix of ruderal forbs that include *Ambrosia confertiflora, Chenopodium pratericola, Iva xanthifolia, Marrubium vulgare*, and *Salsola tragus*.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Herb (field)	*Pascopyrum smithii, Ambrosia confertiflora, Chenopodium pratericola*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 08YC034 and 08YC044.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy.

Bouteloua gracilis / Yucca glauca Shrub Herbaceous Vegetation

Blue Grama / Soapweed Yucca Grassland
Identifier: NPS_NM055

NVC CLASSIFICATION

Division	Great Plains Grassland & Shrubland (2.C.1.b)
Macrogroup	Great Plains Shortgrass Prairie & Shrubland (MG053)
Group	Southwest Plains-Mesa Grassland (G-TBD)
Association	*Bouteloua gracilis / Yucca glauca* Shrub Herbaceous Vegetation

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from footslopes of the cinder cone and adjacent plains.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association occurs at 2140 to 2160 m (7020 to 7090 ft) in elevation on northwesterly to southwesterly aspects of gentle, lower slopes (3-10%) of the cinder cone, extending out into the adjacent plains. The geologic substrates are the volcanic scoria and loess of the surrounding plains. Exposed gravel and soil can comprise up to 50% of the ground surface, with the remainder covered by leaf litter and grass canopies.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This grassland association is dominated by *Bouteloua gracilis* with *Yucca glauca* as a well represented to abundant diagnostic sub-shrub. *Aristida purpurea* and *Schizachyrium scoparium* may be common but are clearly subordinate. Forb species are generally variable in composition; *Penstemon angustifolius, Heterotheca villosa,* and *Ratibida columnifera* are representative examples. Although mature trees are typically absent, scattered *Juniperus scopulorum* and *Pinus edulis* seedlings and saplings may be present.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Dwarf Shrubs	*Yucca glauca*
Herb (field)	*Bouteloua gracilis*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 08YC034 and 08YC044.
Local Description Authors: A. Kennedy, E. Muldavin, and A. Fettes

MGSW1. Great Plains Ruderal Shrubland & Grassland

GSW7. Southwest Ruderal Shrubland & Grassland [Placeholder]

Atriplex canescens / Ruderal Herbs Shrubland

Fourwing Saltbush / Weedy Herbs Vegetation Shrubland
Identifier: NPS_NM072

NVC CLASSIFICATION

Division	Great Plains Grassland & Shrubland (2.C.1.b)
Macrogroup	Great Plains Ruderal Shrubland & Grassland (MG-TBD)
Group	Southwest Ruderal Shrubland & Grassland (G-TBD)
Association	*Atriplex canescens* / Ruderal Herbs Shrubland

Ecological System(s):

DISTRIBUTION

Capulin Volcano National Monument
This association is known from the south slope of the volcano.

ENVIRONMENTAL DESCRIPTION

Capulin Volcano National Monument
This association is known from a stand at 2190 m (7180 ft) in elevation on a southerly, steep slope (40%). Exposed gravel and soil can comprise up to 50% of the ground surface, with the remainder covered by leaf litter and grass canopies.

VEGETATION DESCRIPTION

Capulin Volcano National Monument
This southwestern plains shrubland is characterized by disturbance-related shrub and forb species and is dominated by the shrub *Atriplex canescens*. Other shrub species are largely scarce or absent. The herbaceous layer is dominated by weedy forbs that include a mix of native and non-native species such as: *Ambrosia confertiflora*, *Helianthus annuus, Kochia scoparia* (exotic), *Marrubium vulgare* (exotic), *Verbascum thapsus* (exotic), *Polygonum convolvulus, Bidens bigelovii,* and *Lappula occidentalis.* Among grasses, the exotic annual *Bromus tectorum* is well represented and the only graminoid recorded.

MOST ABUNDANT SPECIES

Capulin Volcano National Monument

Stratum	Species
Tall shrub	*Atriplex canescens*
Herb (field)	*Bouteloua gracilis, Helianthus annuus, Ambrosia confertiflora*

OTHER NOTEWORTHY SPECIES

Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK

Global Rank & Reasons:

CLASSIFICATION COMMENTS

Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES

Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV031.
Local Description Authors: E. Muldavin, A. Fettes, and A. Kennedy

Ruderal Disturbance Vegetation

Ruderal Disturbance Vegetation
Identifier: NPS_NM027

NVC CLASSIFICATION

Division	Great Plains Grassland & Shrubland (2.C.1.b)
Macrogroup	Great Plains Ruderal Shrubland & Grassland (MG-TBD)
Group	Southwest Ruderal Shrubland & Grassland (G-TBD)
Association	Ruderal Disturbance Vegetation

Ecological System(s):

DISTRIBUTION
Capulin Volcano National Monument
Throughout

ENVIRONMENTAL DESCRIPTION
Capulin Volcano National Monument

Disturbed-ground sites associated with development and treatments.

VEGETATION DESCRIPTION
Capulin Volcano National Monument

This association is characterized by the dominance of ruderal (weedy) forbs. Of the 27 forbs recorded, 21 are annuals or weak perennials (e.g., *Chenopodium pratericola, Ambrosia confertiflora*, and *Helianthus annuus*), and some are introduced exotics (e.g., *Marrubium vulgare* and *Salsola tragus*). Grasses are common but subordinate to forbs. *Aristida purpurea, Elymus elymoides*, and *Bromus tectorum* are the most prevalent.

MOST ABUNDANT SPECIES
Capulin Volcano National Monument

Stratum	Species
Herb (field)	*Chenopodium pratericola,, Helianthus annuus, Ambrosia confertiflora*

OTHER NOTEWORTHY SPECIES
Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons:

CLASSIFICATION COMMENTS
Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: NHNM plots 05CV030, 08YC045, 08YC048, and 08YC042
Local Description Authors: E. Muldavin.

6. Nonvascular & Sparse Vascular Rock Vegetation (Litomorphic Vegetation)

6.B.2. Temperate & Boreal Cliff, Scree & Rock Vegetation

6.B.2.c. Great Plains Cliff, Scree & Rock Vegetation

MG116. Great Plains Cliff, Scree & Rock Vegetation

G-TBD. Southwest Cliff, Scree & Rock Vegetation

Sparse Vegetation / Bare Ground
Sparse Vegetation / Bare Ground
Identifier: NPS_NM073

NVC CLASSIFICATION

Division	Great Plains Cliff, Scree & Rock Vegetation (6.B.2.c)
Macrogroup	Great Plains Cliff, Scree & Rock Vegetation (MG116)
Group	Southwest Cliff, Scree & Rock Vegetation (G-TBD)
Association	Sparse Vegetation / Bare Ground

Ecological System(s):

DISTRIBUTION
Capulin Volcano National Monument
Sparse vegetation of disturbed ground associated with development and roads (usually less than 1% cover).

ENVIRONMENTAL DESCRIPTION
Capulin Volcano National Monumentn.

***VEGETATION* DESCRIPTION**
Capulin Volcano National Monument
No description.

MOST ABUNDANT SPECIES
Capulin Volcano National Monument

Stratum	**Species**

No description.

OTHER NOTEWORTHY SPECIES
Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons:

CLASSIFICATION COMMENTS
Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots:
Local Description Authors:

Sparse Vegetation / Cinder Cone

Sparse Vegetation / Cinder Cone
Identifier: NPS_NM066

NVC CLASSIFICATION

Division	Great Plains Cliff, Scree & Rock Vegetation (6.B.2.c)
Macrogroup	Great Plains Cliff, Scree & Rock Vegetation (MG116)
Group	Southwest Cliff, Scree & Rock Vegetation (G-TBD)
Association	Sparse Vegetation / Cinder Cone

Ecological System(s):

DISTRIBUTION
Capulin Volcano National Monument
Located on the cinder cone.

ENVIRONMENTAL DESCRIPTION
Capulin Volcano National Monument

Sparse vegetation on cinder cone scoria substrate (usually less than 1% cover).

VEGETATION DESCRIPTION
Capulin Volcano National Monument
No description.

MOST ABUNDANT SPECIES
Capulin Volcano National Monument

Stratum	Species

No description.

OTHER NOTEWORTHY SPECIES
Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons:

CLASSIFICATION COMMENTS
Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots: *Local Description Authors:*

Sparse Vegetation / Lava Flow

Sparse Vegetation / Lava Flow
Identifier: NPS_NM067

NVC CLASSIFICATION

Division	Great Plains Cliff, Scree & Rock Vegetation (6.B.2.c)
Macrogroup	Great Plains Cliff, Scree & Rock Vegetation (MG116)
Group	Southwest Cliff, Scree & Rock Vegetation (G-TBD)
Association	Sparse Vegetation / Lava Flow

Ecological System(s):

DISTRIBUTION
Capulin Volcano National Monument
Boca Negra.

ENVIRONMENTAL DESCRIPTION
Capulin Volcano National Monument
Sparse vegetation on lava flow basalt substrate (usually less than 1% cover).

VEGETATION DESCRIPTION
Capulin Volcano National Monument
No description.

MOST ABUNDANT SPECIES
Capulin Volcano National Monument

Stratum	Species

No description.

OTHER NOTEWORTHY SPECIES
Capulin Volcano National Monument
Data are not available.

CONSERVATION STATUS RANK
Global Rank & Reasons:

CLASSIFICATION COMMENTS
Capulin Volcano National Monument
Data are not available.

CLASSIFICATION CONFIDENCE:

ELEMENT SOURCES
Capulin Volcano National Monument Inventory Notes: Data are not available.
Capulin Volcano National Monument Plots:
Local Description Authors:

Appendix E. Annotated Vegetation Map Legend

Below is the annotated map legend for the vegetation map of Capulin Volcano National Monument based on Table 3.3 of the main report. For each Level 2 unit, we provide a description with the following:

- A list of primary and secondary plant association components plus related and contrasting inclusions (see main report for definitions);
- Elevation range derived from the GIS;
- A summary of the distribution, environment, and floristic composition of the unit;
- One or two representative ground photographs;
- A distribution map of the unit with black polygons shown for each unit;
- An image map showing the delineation of a representative polygon(s) in the 2006 color aerial photography (Photo Map Detail);
- The total hectares and acres of the unit and number of polygons as derived from the GIS.

1	Southern Rocky Mountain Ponderosa Pine Forest and Woodland
A	Ponderosa Pine/Oak Lava Forest

Primary Component Associations:
- *Pinus ponderosa / Quercus gambelii* Woodland

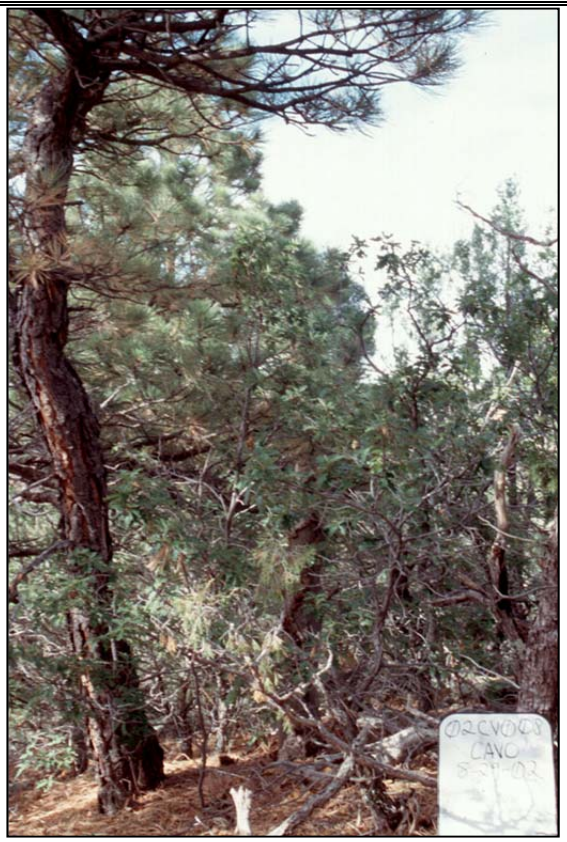
Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,316 to 7,503 ft (2,230 to 2,287 m)

Summary: These open, tall woodlands are dominated by ponderosa pine with Rocky Mountain juniper usually in the understory. The understory and Inter-tree spaces are typically shrubby and dominated by Gambel oak and other montane shrubs with scattered grasses such as Arizona fescue and blue grama along with deer sedges. Stands occur on the western side of the volcano, mostly as small patches on the uneven, rough lava areas in the Boca.



Distribution

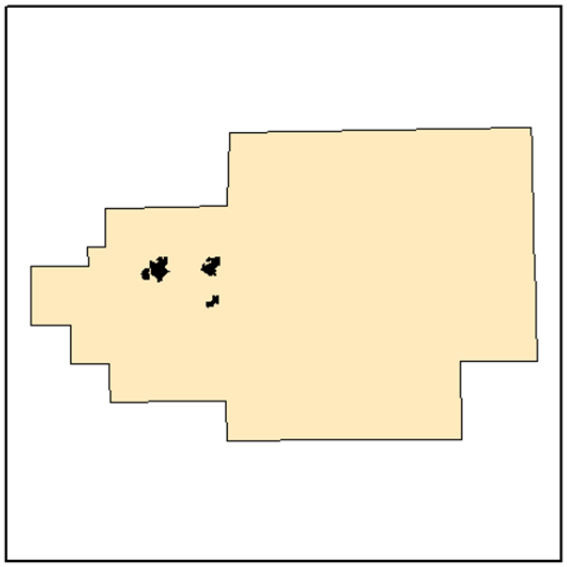
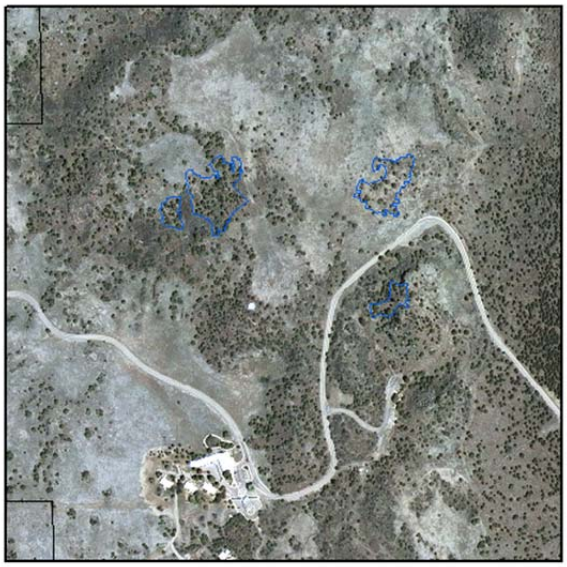


Photo Map Detail



Ha: 1.5	Acres: 3.6	Polygons: 4	

2	Southern Rocky Mountain Piñon-Juniper Woodland
A	Piñon/Gambel Oak Cinder Woodland

Primary Component Associations:

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

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,188 to 8,110 ft (2,191 to 2,472 m)

Summary: These moderately open to closed woodlands are dominated by two-needle piñon with Rocky Mountain juniper as a codominant. The understory and inter-tree spaces are typically shrubby and dominated by Gambel oak along with other montane shrubs such a mountain mahogany, skunkbush sumac, and mountain ninebark. Mesic grasses such as muttongrass, littleseed ricegrass, and mountain muhly are common or sometimes abundant under the canopies. Stands mostly occur on the steep, north-facing cinder slopes of the volcano crater and outer side slopes extending downslope on to the lava flow to the northwest.

Distribution

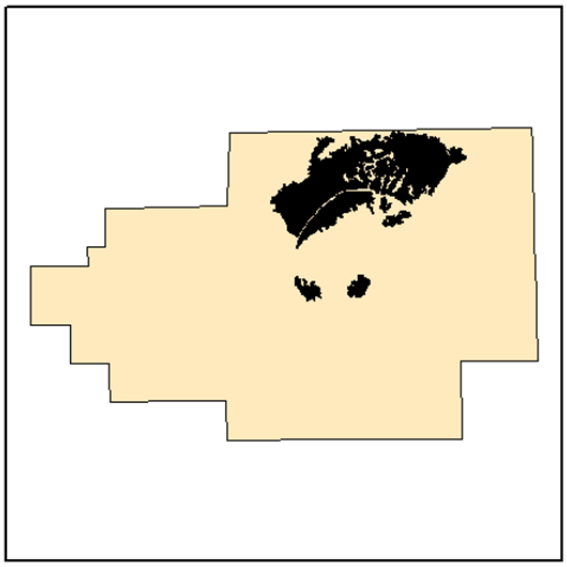


Photo Map Detail

Ha: 25.3	Acres: 62.6	Polygons: 7

2	Southern Rocky Mountain Piñon-Juniper Woodland
B	Piñon/Mountain Muhly Cinder Woodland

Primary Component Associations:
- *Pinus edulis / Muhlenbergia montana* Woodland

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,438 to 8,074 ft (2,267 to 2,461 m)

Summary: These moderately open to closed woodlands are dominated by two-needle piñon along with scattered Rocky Mountain junipers. The understory and inter-tree spaces are typically grassy and dominated by mountain muhly. Shrubs are few and scattered. Stands occur mostly on steep and southwest-facing, upper, outer slopes of the volcano.

Distribution

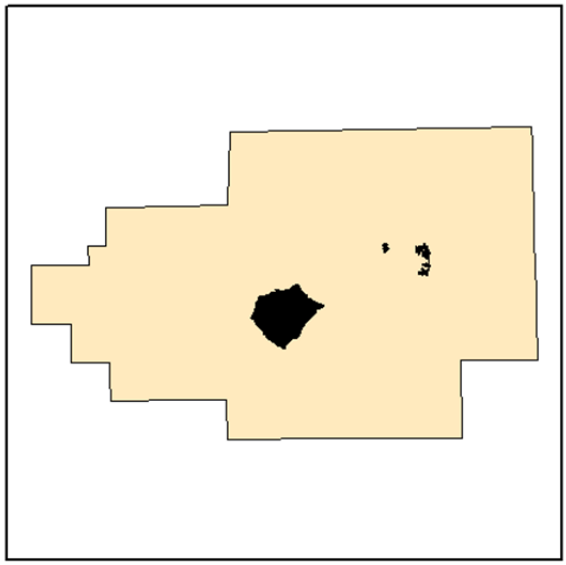


Photo Map Detail

Ha: 7.2	Acres: 17.9	Polygons: 5	

2	Southern Rocky Mountain Piñon-Juniper Woodland
C	Piñon/Scribner Needlegrass-Mountain Muhly Cinder Woodland

Primary Component Associations:
- *Pinus edulis / Achnatherum scribneri* Woodland

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,323 to 8,179 ft (2,232 to 2,493 m)

Summary: These moderately open to closed woodlands are dominated by two-needle piñon along with scattered Rocky Mountain junipers. The understory and Inter-tree spaces are typically grassy and dominated by Scribner's needlegrass. Shrubs are few and scattered. Stands occur mostly on the steep, east-facing, outer slopes of the volcano (and upper west slopes of the crater).

Distribution

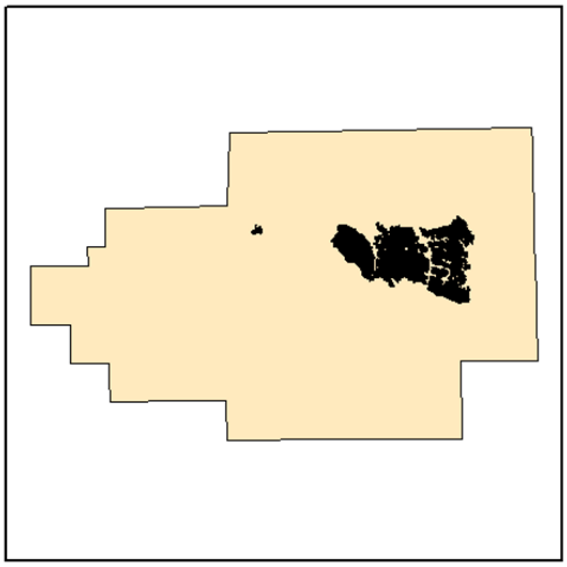
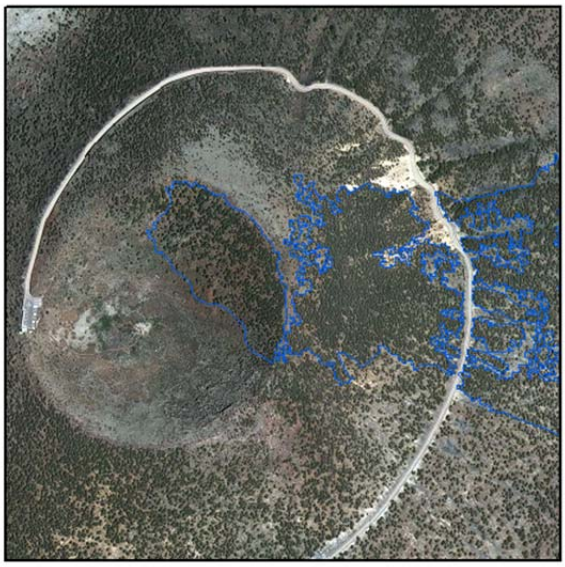


Photo Map Detail



Ha: 14.8	Acres: 36.6	Polygons: 8	

2	Southern Rocky Mountain Piñon-Juniper Woodland
D	Piñon/Wavyleaf Oak-Mountain Mahogany Woodland

Primary Component Associations:

- *Pinus edulis - Juniperus spp. / Cercocarpus montanus* - Mixed Shrubs Woodland

Secondary Component Associations:

- *Pinus edulis / Quercus ×pauciloba* Woodland

Related inclusions:

Contrasting inclusions:

Elev.: 7,034 to 8,123 ft (2,144 to 2,476 m)

Summary: These moderately open woodlands are dominated by two-needle piñon along with scattered Rocky Mountain junipers. The understory and inter-tree spaces are typically shrubby and dominated by wavyleaf oak and mountain mahogany. While shrubs predominate, grasses such as mountain muhly and blue grama can be common. Stands dominate the east to western outer cider slopes of volcano.

Distribution

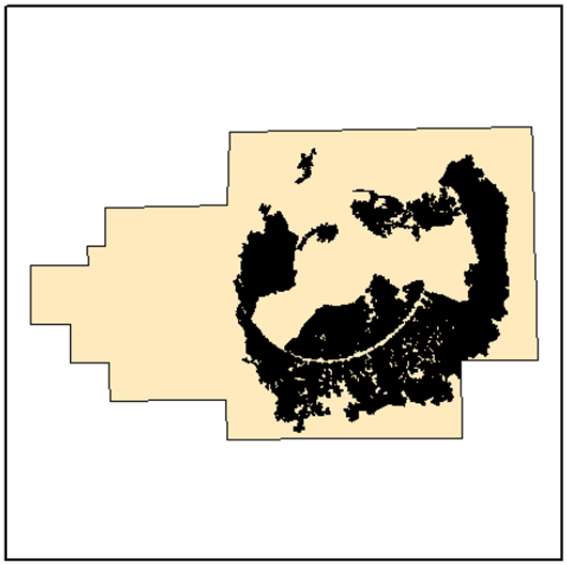
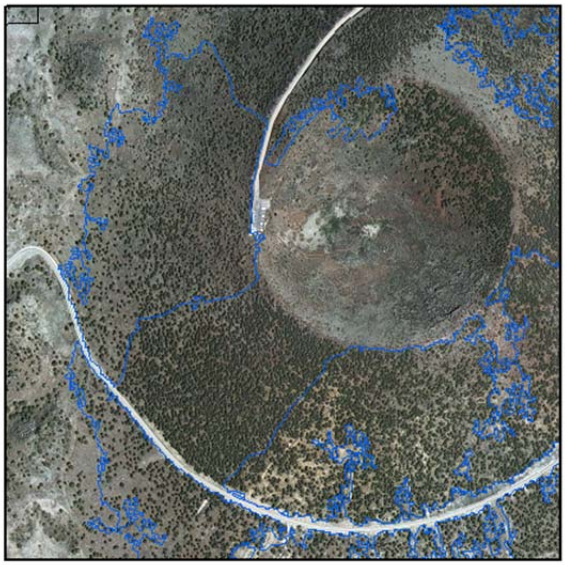


Photo Map Detail



Ha: 78.2	Acres: 193.2	Polygons: 14

2	Southern Rocky Mountain Piñon-Juniper Woodland
E	Rocky Mountain Juniper/Gambel Oak Lava Woodland

Primary Component Associations:
- *Juniperus scopulorum - Quercus gambelii* Woodland

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,077 to 7,526 ft (2,157 to 2,294 m)

Summary: These moderately open woodlands are dominated by Rocky Mountain junipers, with two-needled piñon few or absent. The understory and inter-tree spaces are typically shrubby and dominated by Gambel oak and wavyleaf oak along with other montane shrubs such a mountain mahogany, skunkbush sumac, wax currant, and Woods' rose. Grasses are common with littleseed ricegrass and deer sedges found under the tree canopies, and prairie species such as big bluestem, sideoats grama, blue grama, and little bluestem more common in the inter-tree spaces. Stands are common on lava of the Boca and are the most common woodland of the western portion of park.

Distribution

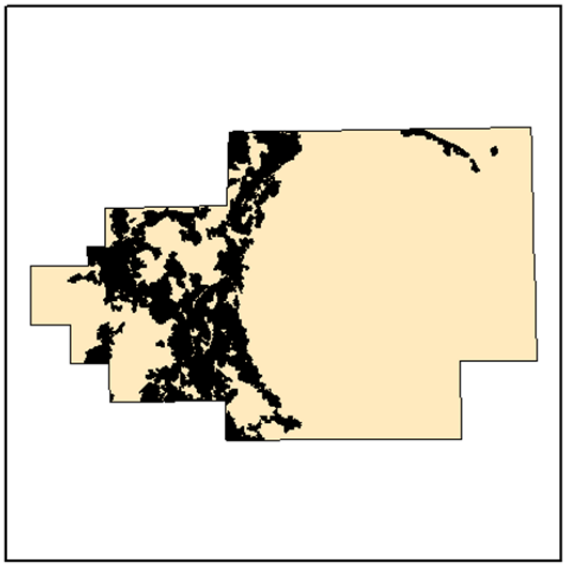
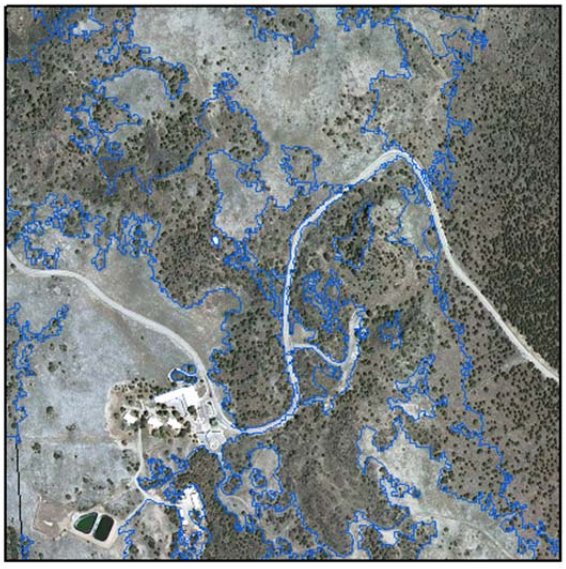


Photo Map Detail



Ha: 48.8	Acres: 120.5	Polygons: 36

2	Southern Rocky Mountain Piñon-Juniper Woodland
F	Piñon/Blue Grama Lava Savanna

Primary Component Associations:
- *Pinus edulis – (Juniperus monosperma) / Bouteloua gracilis* Woodland

Secondary Component Associations:

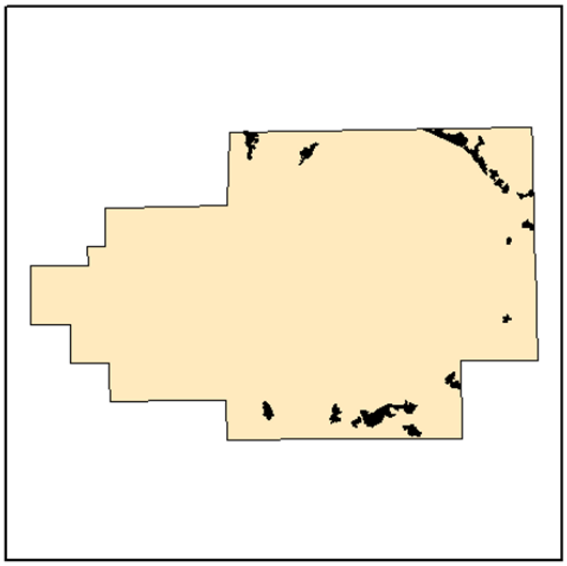
Related inclusions:

Contrasting inclusions:

Elev.: 7,008 to 7,516 ft (2,136 to 2,291 m)

Summary: These moderately open to very open woodlands are dominated by two-needle piñon along with scattered Rocky Mountain junipers. The understory and inter-tree spaces are typically grassy and dominated by blue grama along with other prairie species such as big bluestem, little bluestem, and sideoats grama. Tall shrubs are few and scattered, but subshrubs and succulents such as fringed sagewort, tulip pricklypear, and plains prickly pear can be prevalent. Stands occur on the southeastern to northwestern toe slopes of the volcano and extend out on lava into the prairie.

Distribution



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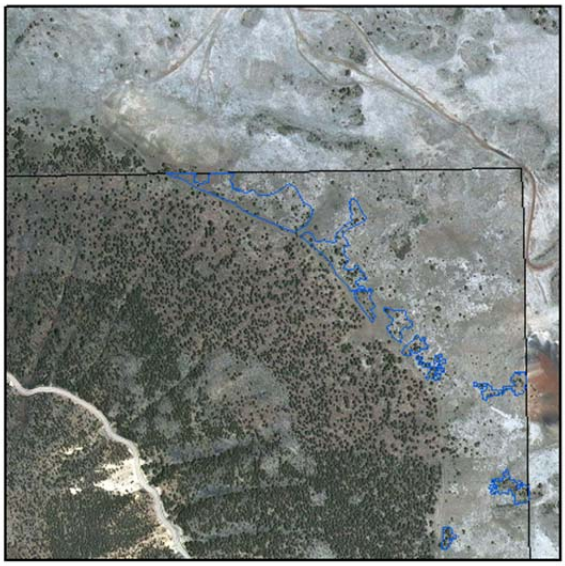


Ha: 5.0	Acres: 12.3	Polygons: 20

3	Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland
A	Gambel Oak Shrubland

Primary Component Associations:
- *Quercus gambelii - Cercocarpus montanus / (Carex geyeri)* Shrubland
- *Quercus gambelii - Prunus virginiana* Shrubland

Secondary Component Associations:

Related inclusions:
- *Quercus gambelii / Rhus trilobata* Shrubland

Contrasting inclusions:

Elev.: 7,100 to 8,058 ft (2,164 to 2,456 m)

Summary: These relatively mesic montane shrublands are characterized by a dense cover of Gambel oak and mountain mahogany along with a variety of other relatively mesic shrubs such as mountain ninebark, skunkbush sumac, trumpet gooseberry, New Mexico raspberry, common chokecherry, and wax currant. Grasses are scattered, with littleseed ricegrass and deer sedges the most common. These shrublands are most prevalent on the north-facing slopes of the volcano crater and outer slopes, but also occur on lava outcrops of the Boca.

Distribution

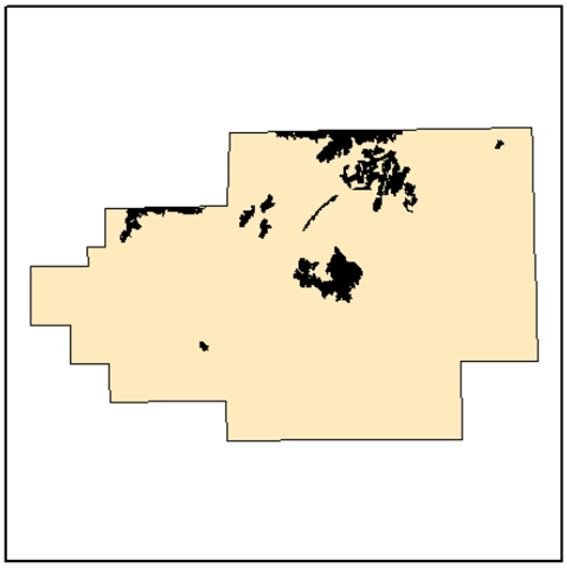
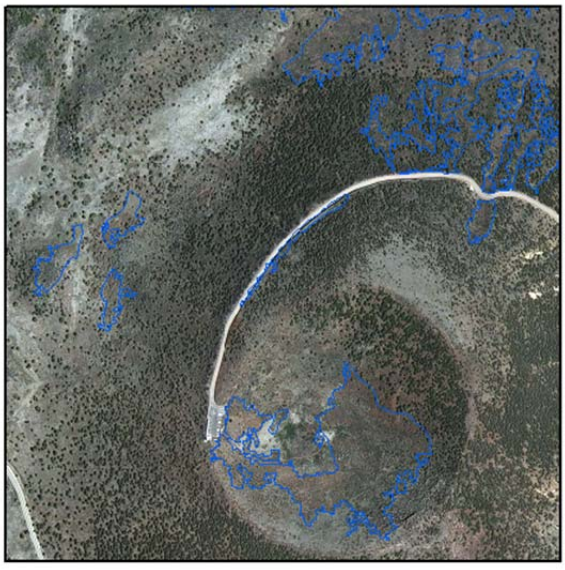


Photo Map Detail



Ha: 12.9	Acres: 32.0	Polygons: 18

3	Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland
B	Fivepetal Cliffbush Cinder Shrubland

Primary Component Associations:

Secondary Component Associations:
- Jamesia americana - *(Physocarpus monogynus, Holodiscus dumosus*) Rock Outcrop Shrubland

Related inclusions:

Contrasting inclusions:
- *Quercus gambelii - Prunus virginiana* Shrubland

Elev.: 7,772 to 7,831 ft (2,369 to 2,387 m)

Summary: These montane shrublands are dominated by mountain ninebark and cliffbush; oak shrubs are uncommon or absent. Grasses are scattered, with deer sedges the most common. These shrublands are known from the bottom of the volcano crater.

Distribution

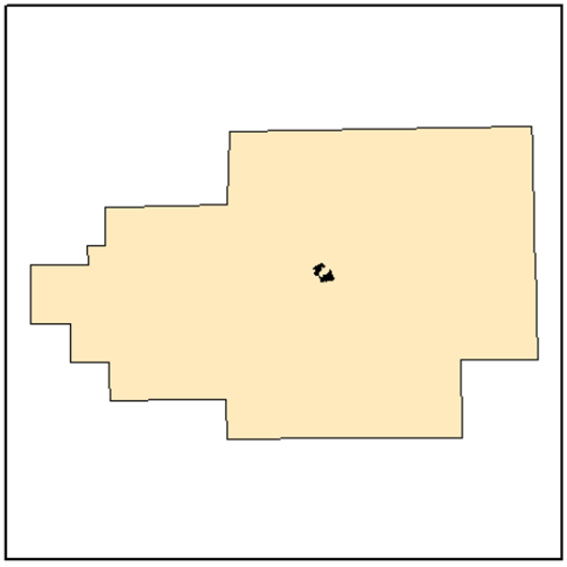


Photo Map Detail

Ha: 0.3	Acres: 0.8	Polygons: 2	

4	Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland
A	Mountain Mahogany-Wavyleaf Oak Shrubland

Primary Component Associations:
- *Cercocarpus montanus / Bouteloua gracilis* Shrubland
- *Quercus x pauciloba / Cercocarpus montanus* Shrubland

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,067 to 8,120 ft (2,154 to 2,475 m)

Summary: These dry-mesic montane shrublands are characterized by a dense cover of wavyleaf oak and/or mountain mahogany, along with a variety of other relatively mesic shrubs. Grasses are scattered, with littleseed ricegrass and deer sedges the most common. These shrublands are most prevalent on the south-facing slopes of the volcano crater and outer slopes, but also occur on lava outcrops of the Boca.

Distribution

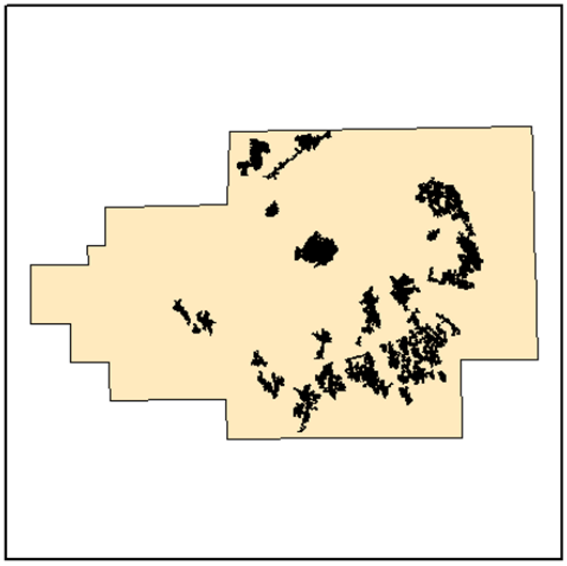
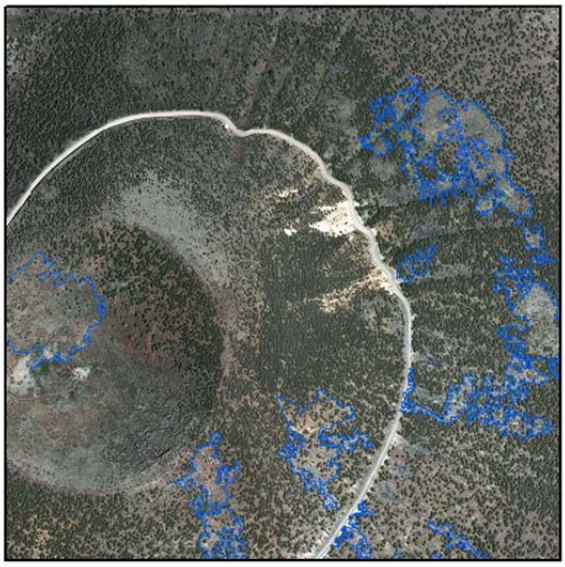


Photo Map Detail



Ha: 18.1	Acres: 44.8	Polygons: 41

5	Southwest Ruderal Shrubland and Grassland
A	Fourwing Saltbush Shrubland

Primary Component Associations:
- *Atriplex canescens* / Ruderal Herbs Shrubland

Secondary Component Associations:
- Ruderal Disturbance Vegetation

Related inclusions:

Contrasting inclusions:

Elev.: 7,096 to 7,280 ft (2,163 to 2,219 m)

Summary: These disturbance-related shrublands are dominated by fourwing saltbush along with a suite of weedy grasses and forbs such as cheatgrass, common sunflower, weakleaf burr ragweed, common kochia, common mullein, and horehound. These shrublands are known from the lower, south-facing outer toe slopes of the volcano.

Distribution

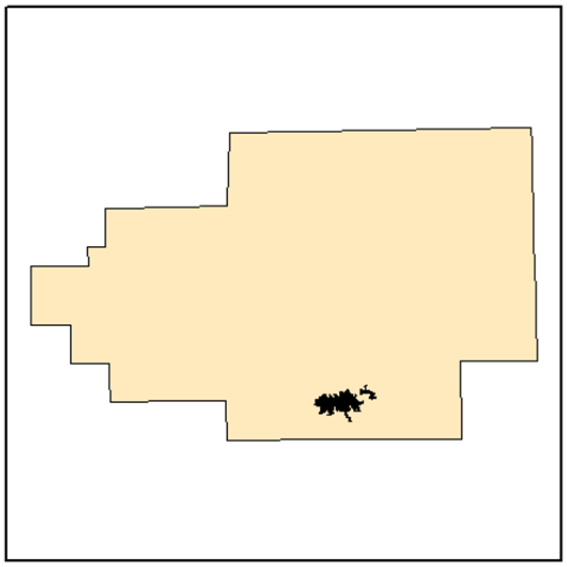
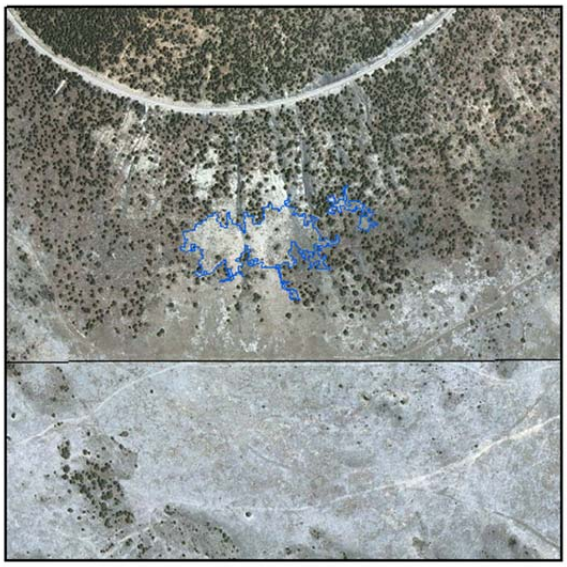


Photo Map Detail



Ha: 1.7	Acres: 4.1	Polygons: 3

6	Southern Rocky Mountain Montane-Subalpine Grassland
A	Arizona Fescue-Mountain Muhly Grassland

Primary Component Associations:
- *Festuca arizonica - Muhlenbergia montana* Herbaceous Vegetation

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,244 to 8,159 ft (2,208 to 2,487 m)

Summary: These relatively mesic grasslands are dominated by Arizona fescue along with mountain muhly. Prairie species such as blue grama and little bluestem can be common, but not dominant. Shrubs are few and scattered. Stands occur both on the steep slopes of the volcano and in the undulating terrain of the Boca between lava outcrops.

Distribution

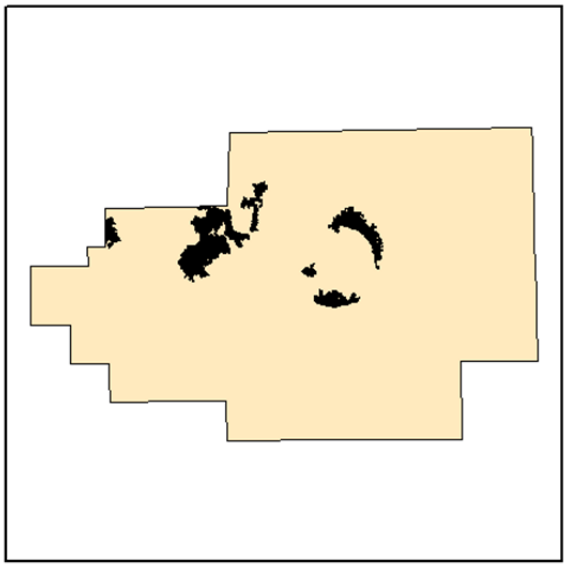
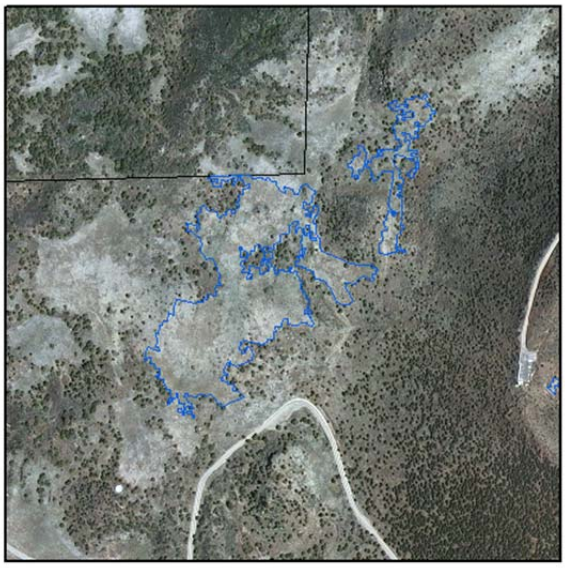


Photo Map Detail



Ha: 9.9	Acres: 24.5	Polygons: 7

7	Southwest Plains-Mesa Mixedgrass Prairie
A	Big Bluestem-Little Bluestem Lava Grassland

Primary Component Associations:
- *Andropogon gerardii - Schizachyrium scoparium* Herbaceous Vegetation
- *Schizachyrium scoparium – Bouteloua gracilis* Herbaceous Vegetation

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:
- *Bouteloua gracilis - Bouteloua curtipendula* Herbaceous Vegetation

Elev.: 6,985 to 7,431 ft (2,129 to 2,265 m)

Summary: These tall- and medium-grass grasslands are dominated by big bluestem and little bluestem, respectively. Tall shrubs are few and scattered, but the subshrubs such as fringed sagewort and soapweed yucca are often common. Stands occur mostly along the southern and eastern toe slopes of the volcano extending out on the lava into the prairie, but they may also occur in the undulating terrain of the Boca between lava outcrops.

Distribution

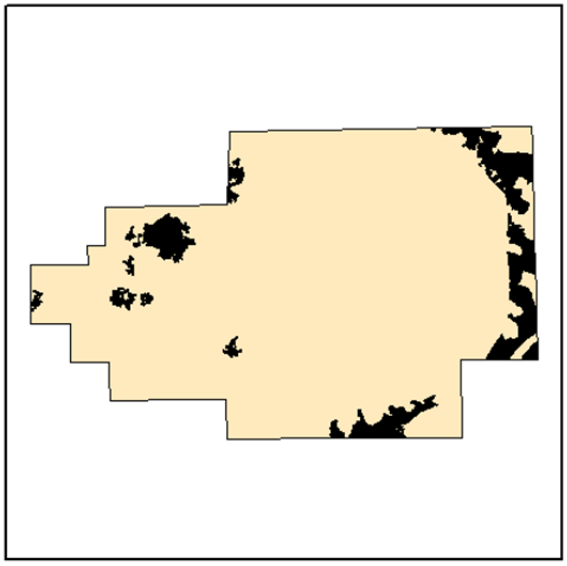
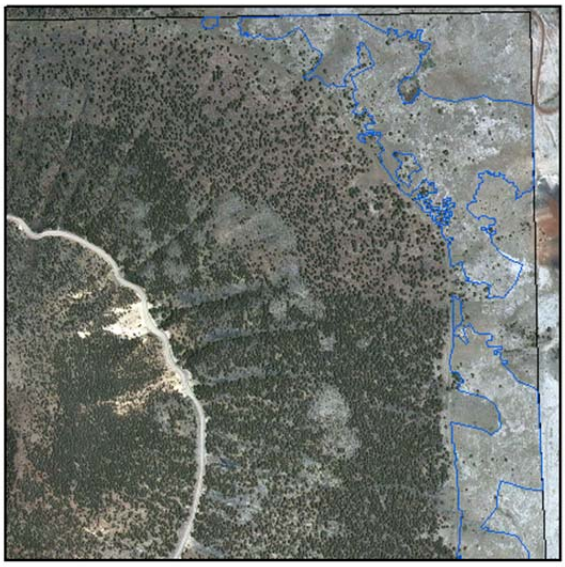


Photo Map Detail



Ha: 23.6	Acres: 58.4	Polygons: 22

8	Southwest Plains-Mesa Grassland
A	Blue Grama Shortgrass Steppe

Primary Component Associations:
- *Bouteloua gracilis - Bouteloua curtipendula* Herbaceous Vegetation

Secondary Component Associations:
- *Yucca glauca / Bouteloua gracilis* Shrub Herbaceous Vegetation

Related inclusions:

Contrasting inclusions:
- *Schizachyrium scoparium – Bouteloua gracilis* Herbaceous Vegetation

Elev.: 6,988 to 7,431 ft (2,130 to 2,265 m)

Summary: These grasslands are dominated by blue grama with sideoats grama and little bluestem as common associates. Tall shrubs are few and scattered, but the subshrubs such as fringed sagewort and soapweed yucca are often common to abundant. Stands occur mostly along the southern and eastern toe slopes of the volcano extending out on the lava into the prairie, but they may also occur in the undulating terrain of the Boca between lava outcrops.

Distribution

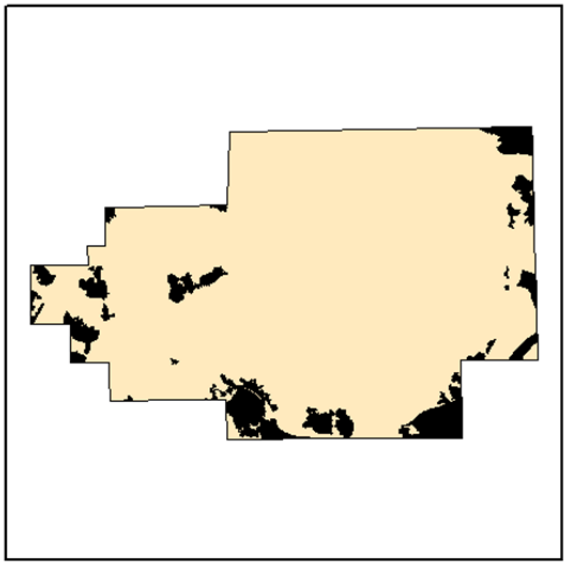


Photo Map Detail

Ha: 24.1	Acres: 59.7	Polygons: 33	

8	Southwest Plains-Mesa Grassland
B	Blue Grama-Western Wheatgrass Swale Shortgrass Steppe

Primary Component Associations:
- *Pascopyrum smithii - Bouteloua gracilis* Herbaceous Vegetation

Secondary Component Associations:
- *Pascopyrum smithii* / Ruderal Herbaceous Vegetation

Related inclusions:
- *Bouteloua gracilis* / Ruderal Herbaceous Vegetation

Contrasting inclusions:

Elev.: 7,100 to 7,562 ft (2,164 to 2,305 m)

Summary: These grasslands are dominated by western wheatgrass and blue grama. Tall shrubs are few and scattered, but the subshrubs and succulents such as fringed sagewort, soapweed yucca, plains pricklypear, tulip pricklypear, and broom snakeweed are often common to abundant. Some stands are associated with ground disturbance and can have a significant weedy forb component (e.g., weakleaf burr ragweed, New Mexican groundcherry, Canadian horseweed, etc.). Stands tend to occur in swales and low-lying areas in the western portion of the park, but they may also occur in the undulating terrain of the Boca between lava outcrops.

Distribution

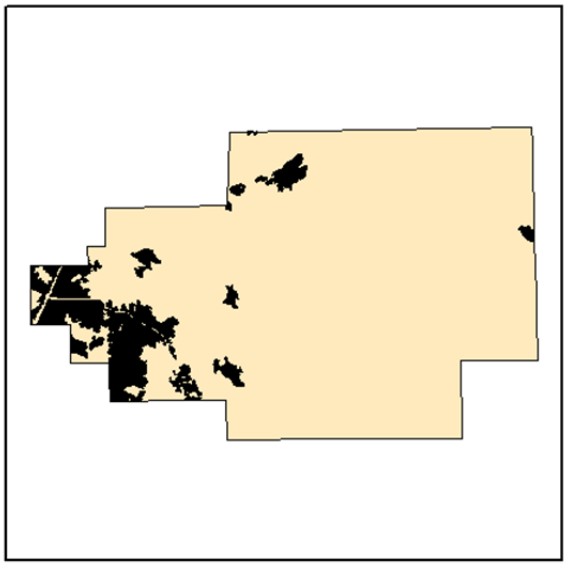
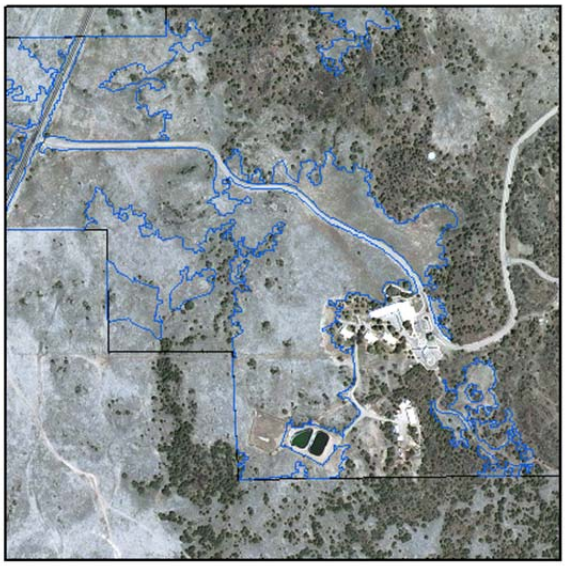


Photo Map Detail



Ha: 24.0	Acres: 59.2	Polygons: 22

9	Southwest Cliff, Scree and Rock Vegetation
A	Lava Rockland

Primary Component Associations:
- Sparse Vegetation / Lava Flow

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,267 to 7,421 ft (2,215 to 2,262 m)

Summary: Sparsely vegetated outcrops of collapsed lava tubes and push-ups of the Boca .

Distribution

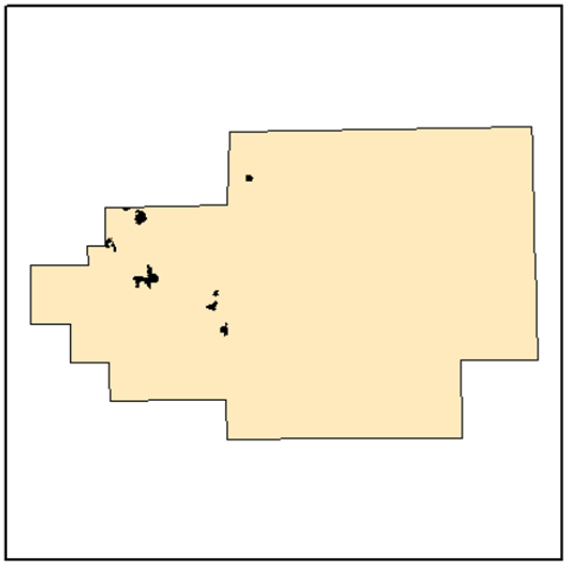
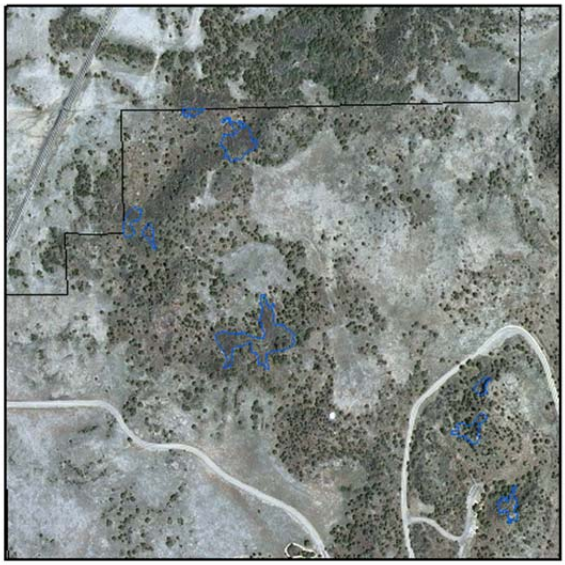


Photo Map Detail



Ha: 1.1	Acres: 2.8	Polygons: 9

9	Southwest Cliff, Scree and Rock Vegetation
B	Cinder/Scoria Rockland

Primary Component Associations:
- Sparse Vegetation / Cinder Cone

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,539 to 7,825 ft (2,298 to 2,385 m)

Summary: Sparsely vegetated scoria cinder substrates on the outer, often unstable, slopes of the volcano.

Distribution

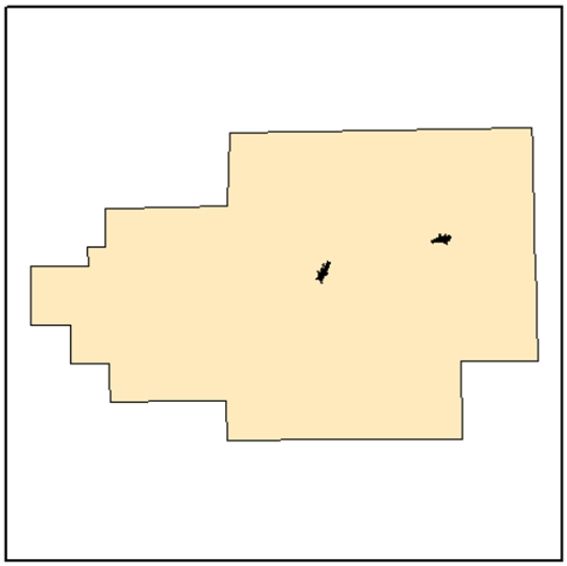
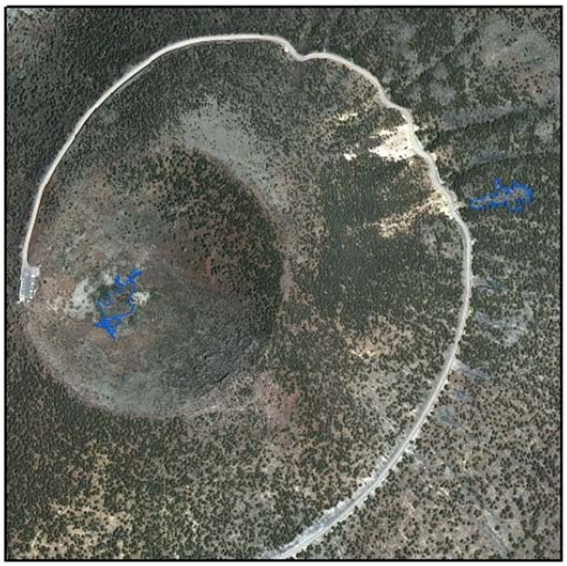


Photo Map Detail



Ha: 0.4	Acres: 1.1	Polygons: 3

9	Southwest Cliff, Scree and Rock Vegetation
C	Barren Ground/Ruderal Vegetation

Primary Component Associations:
- Sparse Vegetation / Bare Ground
- Ruderal Disturbance Vegetation

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,018 to 7,926 ft (2,139 to 2,416 m)

Summary: Bare ground, often disturbed with weedy forbs and grasses often common.

Distribution

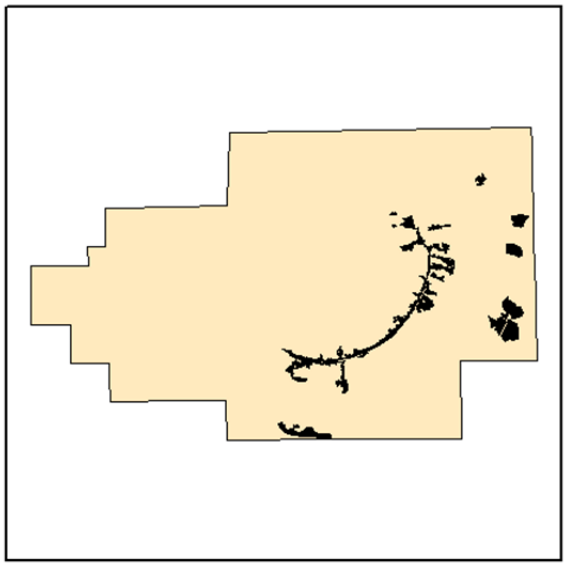
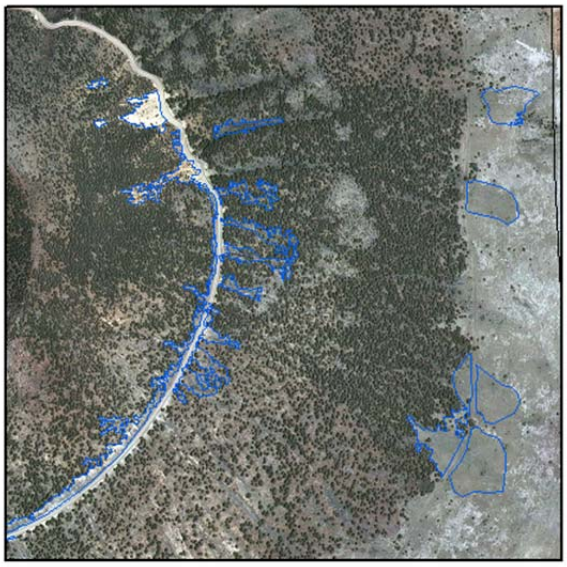


Photo Map Detail



Ha: 6.8	Acres: 16.9	Polygons: 21

10	Urban or Built-up Land
A-D	Residential Vegetation; Structure/Building; Road; Trail

Primary Component Associations:

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,014 to 7,871 ft (2,138 to 2,399 m)

Summary: Built-up areas that include park headquarters and residential areas, along with paved and dirt roads and major trails.

Distribution

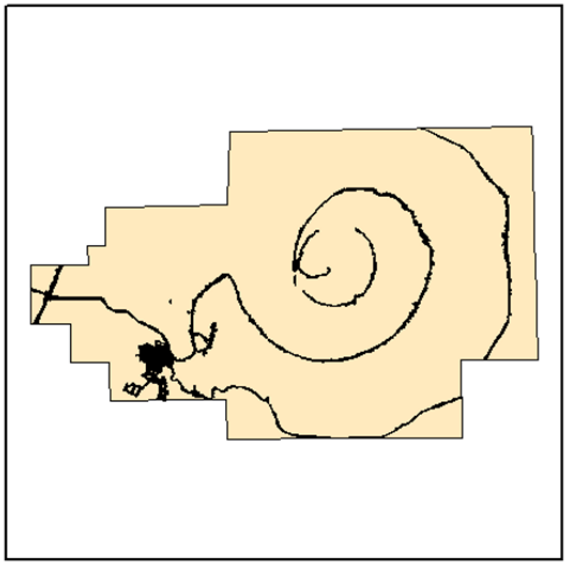


Photo Map Detail

Ha: 11.6	Acres: 28.6	Polygons: 29

11	Water
A	Open water - Pond/Tank

Primary Component Associations:

Secondary Component Associations:

Related inclusions:

Contrasting inclusions:

Elev.: 7,211 to 7,218 ft (2,198 to 2,200 m)

Summary: Open water associated with the park sewage facilities.

Distribution

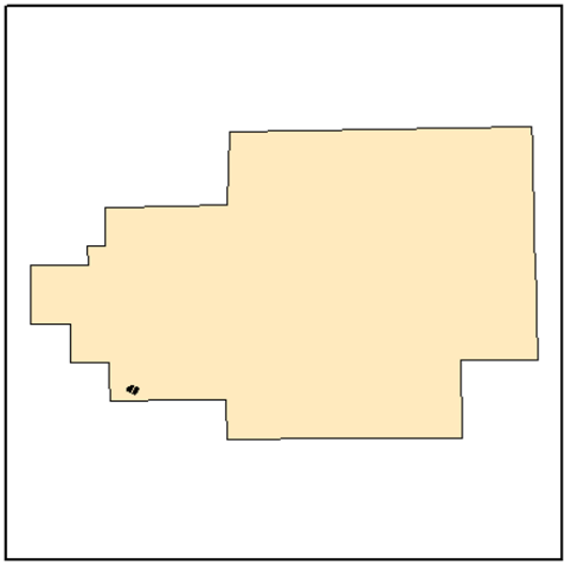


Photo Map Detail

Ha: 0.2	Acres: 0.4	Polygons: 2	

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
U.S. Department of the Interior

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