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Vegetation Classification and Distribution Mapping Report

Canyon de Chelly National Monument

Natural Resource Technical Report NPS/SCPN/NRTR—2010/306



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Canyon de Chelly National Monument
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Natural Resource Technical Report NPS/SCPN/NRTR—2010/306

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Acronyms and Abbreviations

AA	Accuracy assessment
ac	acres
APFO	Aerial Photography Field Office
BLM	U.S. Bureau of Land Management
BOR	U.S. Bureau of Reclamation
CACH	Canyon de Chelly National Monument
CEGL	Community Element Code – Global
CIR	color infrared
cm	centimeter
DEM	Digital Elevation Model
DOQQ	Digital Orthophoto Quarter Quadrangle
drc	diameter at root collar
DVD	Digital Video Disk
ECW	Enhanced Compressed Wavelet
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
ft	foot/feet
GB	gigabytes
GCP	Ground Control Point
GIS	Geographic Information System
GISSAL	Geographic Information Systems Spatial Analysis Laboratory
GPS	Global Positioning System
ha	hectares
I&M	Inventory and Monitoring Program
in	inch
ISA	Indicator Species Analysis
ITIS	Integrated Taxonomic Information System
km	kilometer
m	meters
mi	miles
.mdb	Microsoft Access file format
MMU	Minimum Mapping Unit
MRPP	Multiple Response Permutation Procedure
n.d.	no date
NA	not applicable
NAD83	North American Datum of 1983
NAU	Northern Arizona University

Acronyms and Abbreviations *continued*

NBII	National Biological Information Infrastructure
NED	National Elevation Dataset
NMS	Non-metric Multi-dimensional Scaling
NNHP	Navajo Natural Heritage Program
NP	National Park
NPS	National Park Service
NS	not sampled
NVCS	National Vegetation Classification Standard
NVC	National Vegetation Classification
.pdf	Adobe Portable Document Format
RMGSC	Rocky Mountain Geographic Science Center
SCPN	Southern Colorado Park Network
SBSC	Southwest Biological Science Center
spp.	Species (plural)
TIF	Tagged Image Format
TNC	The Nature Conservancy
TSN	Taxonomic Serial Number
UNESCO	United Nations Education, Science, and Cultural Organization
USDA	U.S. Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VMP	Vegetation Mapping Program
.xls	Microsoft Excel file format

Executive Summary

The classification and distribution mapping of the vegetation of Canyon de Chelly National Monument (CACH) and surrounding environment was accomplished through a multi-agency effort between 2003 and 2007. The National Park Service's Southern Colorado Plateau Network facilitated the team that conducted the work, which comprised the U.S. Geological Survey's Southwest Biological Science Center and Fort Collins Science Center, Navajo Natural Heritage Program, Northern Arizona University, and NatureServe.

The project team described 48 plant communities for CACH—35 of which were described from quantitative classification based on field-relevé data collected in 2004. Five additional plant communities were based on field relevés collected in a previous study. The team derived four additional plant communities from field observations during the photointerpretation phase of the project, and field documented them during accuracy assessment. The National Vegetation Classification Standard served as a conceptual framework for assigning these plant communities to the alliance and association level. Ten of the 48 plant communities were designated "park specials", that is, plant communities with insufficient data to describe them as new alliances or associations.

The project team also developed a spatial vegetation map database representing CACH, with three different map-class schemas: base, group, and management map classes. The base map classes represented the finest level of spatial detail. Photointerpreters delineated initial polygons through manual interpretation of 2003/2004 1:12,000-scale true color aerial photography supplemented by occasional computer screen digitizing on a mosaic of digitized aerial photos. These polygons were labeled with base map classes during photointerpretation. Field visits verified interpretation concepts.

The vegetation map database includes

- 53 base map classes, which consist of associations and park specials classified with the quantitative analysis
- additional associations noted during photointerpretation
- non-vegetated land cover, such as infrastructure, land use, and geological land cover.

The base map classes consist of 4,718 polygons in the project area. A field-based accuracy assessment of the base map classes showed the overall accuracy to be 50.8%

The group map classes represent aggregations of the base map classes, approximating the group level of the National Vegetation Classification Standard, Version 2 (Federal Geographic Data Committee 2008). Terrestrial ecological systems, as described by NatureServe (Comer et al. 2003), were used as a first approximation of the group level. The project team identified 16 group map classes in this project. The overall accuracy of the group map classes was determined using the same accuracy assessment data as for the base map classes. The overall accuracy of the group representation of vegetation was 79.9%.

In consultation with park staff, the team developed management map classes that consisted of park-defined groupings of base map classes and were intended to represent a balance between maintaining required accuracy and providing a focus on vegetation of particular interest or import to park managers. The 28 management map classes have an overall accuracy of 77.1%.

While the main products of this project are the vegetation classification and the vegetation map database, a number of ancillary geographic information system and digital database products were also

produced that can be used independently, or to augment the main products. These products include shapefiles of the location of field-collected data and relational databases of field-collected data.

Acknowledgments

Behind the authors of this report are U.S. Geological Survey (USGS), National Park Service (NPS), Northern Arizona University (NAU), and Navajo Natural Heritage Program (NNHP) affiliates that were responsible for much of the project's execution. Daniella Roth and Dr. David Remucal of NNHP organized and directed the NNHP field crews that conducted accuracy assessment work. Glen Rink graciously provided us initial support and data from his previous study. We thank the classification field crew – Heather Folger, Rob Hunt, Rob Klotz, and Joe Martinez, and accuracy assessment field crew—Deb Kanter, Art Benally, Helena Roanhorse, Kalvin Watchman, and others for their hard work in the field. Heather Folger, Stacy McKnight, and Lakbir Singh of NAU provided data entry and quality control. Janet Coles of NatureServe provided valuable field and review advice for initial development of the vegetation classification. Technical support to the USGS Southwest Biological Science team was provided by Terry Arundel, Jered Hansen, and Mike Gishey. Hannah Moyer, ASRC Management Services, under contract to the U.S. Geological Survey, Fort Collins, Colorado, provided technical support to the Fort Collins Science Center. Patty Guertin of the USGS provided invaluable support during the compilation and publishing of the final products.

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Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

1 Introduction

1.1 Background

Vegetation is a primary resource of natural areas. Description of vegetation composition, structure, and distribution is fundamental to effective land management. The term "vegetation" encompasses plants at multiple scales, from the most refined floristic levels (referred to as "plant communities" in this report) to the broadest physiognomic or life form levels. This report describes the methods used and results obtained from a four-year project (2003-2007) to classify, describe, and develop a vegetation map database for Canyon de Chelly National Monument.

The National Park Service's (NPS) Southern Colorado Plateau Network (SCPN), part of the service-wide Inventory and Monitoring (I&M) Program, organized and coordinated vegetation classification, description, and mapping at Canyon de Chelly National Monument (CACH). The SCPN needed baseline vegetation data upon which to develop and implement specific monitoring programs for CACH, as well as its other 18 network parks. Park managers needed baseline data and information on park resources for management purposes.

In addition to the NPS, the project team included members from the U.S. Geological Survey (USGS) Southwest Biological Science Center (SBSC) and Fort Collins Science Center (FORT), Navajo Natural Heritage Program (NNHP), Northern Arizona University (NAU), and NatureServe. Arctic Slope Regional Corporation Management Services provided contractor services to FORT. The USGS-NPS Vegetation Mapping Program partially funded the project, and the project team used the Vegetation Mapping Program's programmatic standards.

1.2 Scope and Products

The scope of this project is Canyon de Chelly National Monument and its environs, consisting of an approximately 1-km buffer around the park's boundaries. The total project area was 59,739 ha (147,619 ac); lands within the park boundaries comprised 37,448 ha (92,537 ac) or 62.7 % of the project area.

A major goal of the project was to identify and classify plant communities in the project area, based on field-collected vegetation data and, to a lesser extent, observations made during fieldwork conducted in association with photointerpretation. The first step for the project team was to identify and quantitatively describe plant communities using the National Vegetation Classification Standard (NVCS) as a classification framework. The term "plant communities" refers to the finest floristic levels of the NVCS (associations and alliances) and to park specials (i.e., plant communities with insufficient data to describe them as new alliances or associations) (table 1).

Table 1. Terminology used to describe vegetation and map classes in Canyon de Chelly National Monument

Terminology	Definition	Derivation
Plant communities	Associations, alliances, and park specials	Field relevés or observations
Base map class	Individual plant communities or groupings of plant communities	Photointerpretation
Management map class	Groupings of base map classes reflecting management interests	Park defined
Group map class	Groupings of base map classes reflecting physiognomy and floristics	Based on ecological systems

The next step was to create a spatial database (the vegetation map database) documenting the park's vegetation and land cover. The vegetation map database represents three map-class schemas (table 1):

- The "base" map class, the finest level of floristic detail that could be mapped
- The "group" map class, a physiognomic-floristic view of the vegetation
- The "management" map class, park-defined groupings of base map classes intended to represent a balance between maintaining required accuracy and providing a focus on vegetation of particular interest or import to park managers

Finally, the team assessed each map-class schema for accuracy. The base map and group map classes were not changed. The management map classes were refined somewhat, following a meeting with park resource staff.

This report and its appendices include the results, methods, and findings for the CACH project. The project also generated a number of interrelated products, available on a DVD that accompanies the hard-copy version of this report or on the USGS-NPS Vegetation Mapping Program website, http://biology.usgs.gov/npsveg/. A full listing of project products, their availability, file name, and format appears in Appendix A.

1.3 The USGS-NPS Vegetation Mapping Program

The USGS-NPS Vegetation Mapping Program is a cooperative project between the USGS and the NPS to classify, describe, and map vegetation in more than 270 national park units within the United States.[1] The USGS Center for Biological Informatics administers the program in cooperation with the NPS Inventory and Monitoring Program. With the 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 made it possible for the NPS to move forward with dozens of new park-unit vegetation classification and mapping projects.

The Vegetation Mapping Program supports consistent vegetation classification, mapping, and accuracy assessment protocols and standards across all park-mapping projects. The program has established guidance for all vegetation-mapping projects in four documents:

- Standardized National Vegetation System** (The Nature Conservancy and Environmental Systems Research Institute 1994a)
- Methodology for Assessing the Utility of Existing Data for Vegetation Mapping (The Nature Conservancy and Environmental Systems Research Institute 1996)
- Field Methods for Vegetation Mapping (The Nature Conservancy and Environmental Systems Research Institute 1994b)
- Accuracy Assessment Procedures (Environmental Systems Research Institute et al. 1994)

In addition, the program has defined national standards for all park classification and mapping projects:

- Vegetation classification follows the Federal Geographic Data Committee (FGDC) standard, the National Vegetation Classification

[1]Language for the sections on the National Vegetation Mapping Program, National Vegetation Classification Standard, and Federal Geographic Data Committee is modified from von Loh et al. (2006)

** The words 'system' and 'standard' have been interchanged on some historical documents describing the National Vegetation Classification Standard. Here we use standard as is used by the FGDC.

Standard, for vegetation classification.

- Spatial data formatting follows the FGDC standards for spatial data transfer.
- Metadata for each spatial dataset is provided using the FGDC metadata standard.
- Spatial data is provided with a horizontal positional accuracy that meets National Map Accuracy Standards at the 1:24,000 scale; each well-defined object within the spatial database is within 1/50 of an inch display scale or 12.2 meters (40 ft) ground distance of its actual location.
- All plant names used in the classification are consistent with the Integrated Taxonomic Information System (ITIS).
- Each vegetated map class will meet or exceed 80% accuracy at the 90% confidence level.
- The minimum mapping unit (MMU) is 0.5 ha (1.24 ac).

1.4 The National Vegetation Classification Standard

Patterns of vegetation vary continuously over landscapes. Classification systems attempt to categorize those patterns by identifying and describing assemblages of plants that repeat in similar habitats. The National Vegetation Classification Standard (NVCS) provides the classification framework used for all NPS vegetation-mapping projects (Comer et al. 2003; The Nature Conservancy, and Environmental Systems Research Institute 1994a). In 1997, the FGDC formally adopted the NVCS Version 1 (Federal Geographic Data Committee 1997). During the course of this project, Version 2 of the NVCS (FGDC 2008) was approved, but it was not used in this project as the vegetation classification units were still under development.

The NVCS evolved from vegetation classification conducted over more than two decades, primarily by The Nature Conservancy (TNC), NatureServe, and the Natural Heritage Program network (Grossman et al. 1998). It derives in part from earlier vegetation classification produced by the United Nations Educational, Scientific and Cultural Organization (UNESCO) (UNESCO 1973, Driscoll et al. 1984). Use of this standardized classification framework helps to ensure data compatibility throughout the National Park Service and other agencies.

The NVCS provides a hierarchical classification of vegetation at multiple scales. Version 1 has seven levels—the upper five are based on the physiognomic characteristics of vegetation, and the lower two are based on the floristic characteristics of the plant community. Version 2 (FGDC 2008) has eight levels (table 2). The upper three levels (division, macrogroup, and group) indicate physiognomic characteristics that reflect geographically widespread (global) topographic and edaphic factors. The middle three, which are new to the NVCS hierarchy, focus largely on 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 basically the same in the first and second versions, with some changes to Version 2 alliances expected. Because the Group level in NVCS, Version 2 was still under development, NatureServe Ecological Systems were used to approximate the group level for the CACH group map classes.

The NVCS provides a framework for levels of vegetation classification, but does not provide definitions of vegetation types at each level. Work conducted primarily by TNC through 1999 provided initial definitions of plant communities at each level; NatureServe inherited that documentation when it branched

Table 2. The National Vegetation Classification Standard, Version 2, with definitions and examples

Level	Level name	Primary basis for classification	Example
Upper Level 1	Formation Class	Defined by broad combinations of dominant general growth forms adapted to basic moisture, temperature, and/or substrate or aquatic conditions.	Shrubland and grassland
Upper Level 2	Formation Subclass	Defined by 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 shrubland and grassland
Upper Level 3	Formation	Defined by combinations of dominant and diagnostic growth forms that reflect global macroclimatic conditions as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.	Temperate shrubland and grassland
Mid Level 4	Division	Defined by 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.	North American great plains grassland and shrubland
Mid Level 5	Macrogroup	Defined by combinations of moderate sets of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences in composition, and sub-continental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	Great Plains tall grassland and shrubland
Mid Level 6	Group	Defined by 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 mesoclimate, geology, substrates, hydrology, and disturbance regimes.	Great Plains mesic tallgrass prairie
Lower Level 7	Alliance	Defined by characteristic range of species composition, habitat conditions, physiognomy, and diagnostic species, typically at least one of which is found in the uppermost or dominant stratum of the vegetation. They reflect regional to subregional climate, substrates, hydrology, moisture/nutrient factors, and disturbance regimes.	Wet-mesic tallgrass prairie
Lower Level 8	Association	Defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habitat conditions and physiognomy. They reflect topo-edaphic climate, substrates, hydrology, and disturbance regimes.	Central wet-mesic tallgrass prairie

from TNC. The National Vegetation Classification (NVC) is the vegetation classification maintained by NatureServe and used by many federal agencies, including the NPS. The on-line database, NatureServe Explorer (http://www.natureserve.org/explorer/), provides public access to regularly updated versions of the NVC plant community listings and descriptions, which include the plant communities (associations and alliances) defined for the United States. NatureServe's documentation of alliances and associations is the most accessible national listing currently available. However, the plant community descriptions within the NVC are not complete, and projects, such as this, constantly add to the documentation and description of NVC types.

Alliances and associations are based on both the dominant (greatest-canopy-cover) species in the upper strata of a stand and on diagnostic species (those consistently found in some land-cover types but not others). Associations are the most specific classes and are hierarchically contained within alliances. Each association is included in only one alliance, while each alliance may include one or more associations. Alliance names are generally based on the dominant/diagnostic species in the uppermost stratum of the vegetation, with generally up to three species used in the alliance name, if necessary, to define the type. Prior to 2002, some exceptional alliances had a

maximum of five species in the name.

Associations are defined by distinct plant compositions that repeat across the landscape, and are generally named using both the dominant species in the uppermost stratum of the vegetation and one or more dominant species in the lower strata (or a diagnostic species in any stratum). Documentation from NatureServe Explorer (2009) describes the naming conventions and syntax for all NVC names:

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

The species nomenclature for all alliances and associations follows the Integrated Taxonomic Information System (http://www.itis.gov/). Examples of association names from CACH:

- *Pseudotsuga menziesii* / *Quercus gambelii* Forest
- *Amelanchier utahensis* Shrubland

Examples of alliances from CACH:

- *Pseudotsuga menziesii* Forest Alliance
- *Amelanchier utahensis* Shrubland Alliance

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

In addition to the NVC, NatureServe has created a standardized Terrestrial Ecological System Classification for describing sites. An ecological system is defined as a group of plant community types that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients (Comer et al. 2003). These mid-scale biological classification units describe vegetation communities that have existed for 50 years or more, and are composed of communities that occur in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. They are not conceptually a unit within the NVCS, but are linked directly through the association level. Ecological systems are broad-scale units that can embody a number of highly specific associations that might occur in a particular setting. An association may occur in any number of ecological systems.

1.5 Park Environment

Canyon de Chelly National Monument (CACH) is located within the Navajo Nation in the Four Corners region of the southern Colorado Plateau in northeastern Arizona (fig. 1). The visitor center is 4.8 km (approximately 3 mi) from Chinle, Arizona. CACH is comprised of two main canyons and their side canyons: Canyon de Chelly, joined by Monument Canyon; and Canyon del Muerto, joined by Black

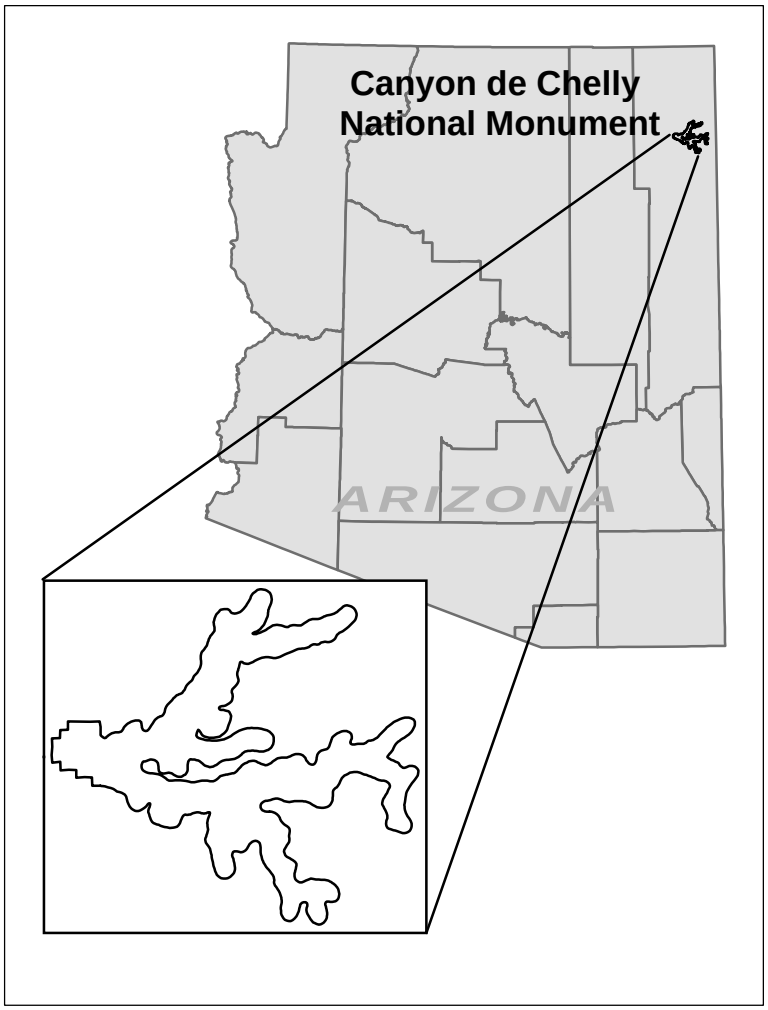


Figure 1. Location of Canyon de Chelly National Monument in Arizona.

Rock Canyon (fig. 2). The north rim drive follows the northern park boundary and overlooks Canyon del Muerto; the south rim drive follows the southern park boundaries and overlooks Canyon de Chelly

1.5.1 Park Establishment

The 1931 Presidential Proclamation establishing Canyon de Chelly National Monument states that "the public interest would be promoted by including the lands hereinafter described within a national monument for the preservation of a great number of cliff dwellings and for their archaeological interest." (Presidential Proclamation No. 1945—Apr. 1, 1931—47 Stat. 2448). In 1933, the boundaries of the monument were modified and expanded (Presidential Proclamation No. 2036—Mar. 3, 1933—47 Stat. 2562). The monument is unique in the NPS system in that the Navajo Nation and the NPS share management responsibilities for CACH, and Navajos continue to live there.

1.5.2 Pre-Park History

The Spanish were the first Europeans to visit the Canyon de Chelly region, although it is not clear exactly when they first arrived. The first map of the canyons was made by Don Bernardo de Miera y Pacheco in the late 1770s (Brugge and Wilson 1976). Early Anglo expeditions to the canyons in the 1800s located and mapped many of the larger and more spectacular archeological sites (Brugge and Wilson 1976); later archeological surveys and expeditions added to the knowledge of human occupation in Canyon de Chelly (Fall et al. 1981, Morris 1986 in Rink 2005).

The monument is now known to include and protect prehistoric and historic cultural and archeological resources representing 4,000-5,000 years of Ancestral Puebloan, historic, and modern-day Navajo settlement history (Leslie 2006). Archaic and Ancestral Puebloan people occupied the canyons and vicinity until around 1300 A.D., when they abandoned the monument area, perhaps due to a combination of drought and other factors. The canyons were re-occupied sporadically by Puebloan people until about 1700 A.D., when the Navajo, or Diné, began to settle in the area (Brugge and Wilson 1976; Andrews 1985 in Rink 2005). For most of the time since then, Navajo people have lived, farmed, and maintained livestock in Canyon de Chelly (Rink 2005).

Leslie (2006) provides a picture of the scope of cultural resources at CACH, including prehistoric, historic, and current resources:

> *In terms of the overall number or frequency of cultural resources, CACH*

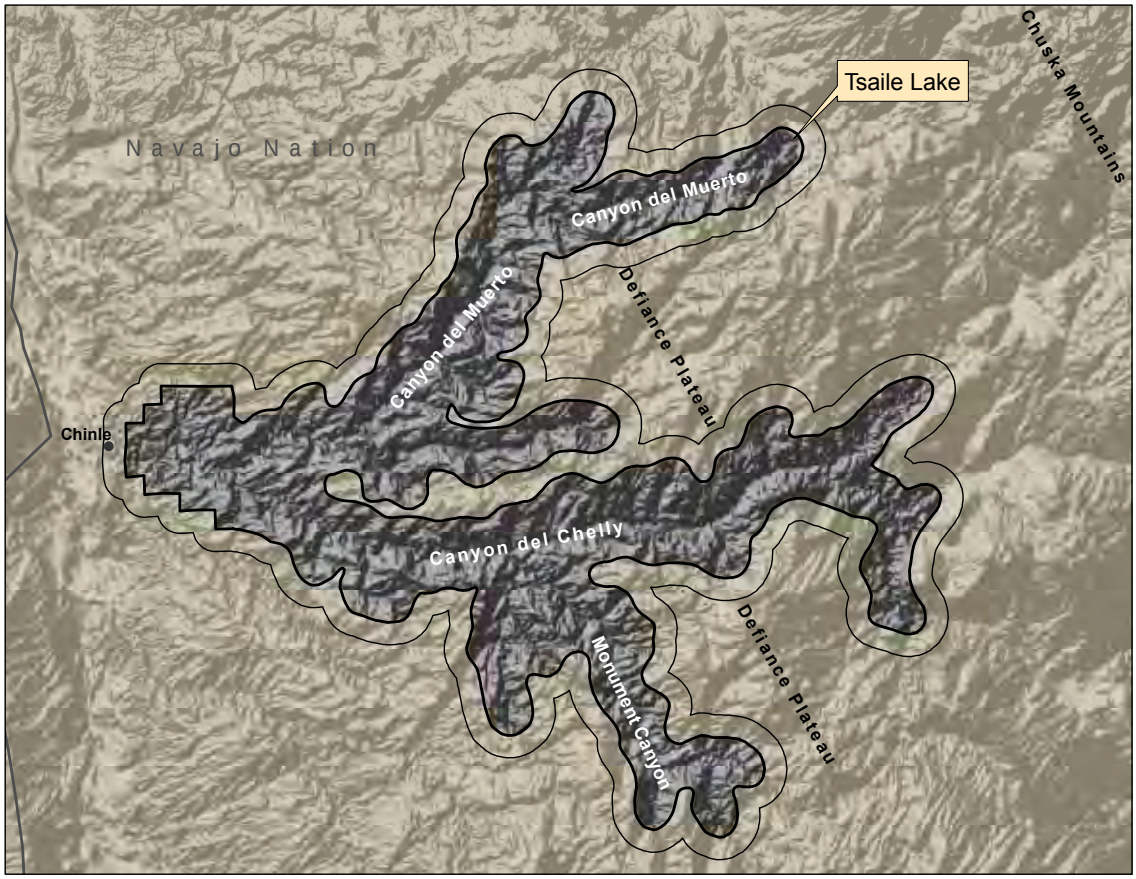


Figure 2. The Canyon de Chelly National Monument project area. The project environs boundary extends 1 km beyond the park boundaries.

presently has full to partial documentation covering 1,485 archeological sites with estimates in the range of 3,000 to 4,000 sites for the entire park. Equally significant, there are 164 prehistoric/historic structures included in the List of Classified Structures (again with estimates in the range of 400 additional structures yet to be added) along with roughly 1500 to 2000 rock art panels that potentially contain as many as 30,000+ individual elements. Of more recent origin, there are eight distinguishable Navajo cultural landscapes that include upwards of 150 distinct farmsteads, fields, orchards, trackways, irrigation systems, and so forth; . . . reflecting both Navajo and other affiliated American Indian communities, situated both on the canyon floor and rim.

1.5.3 Climate

CACH is located near the boundaries of two ecoregions described by Bailey et al. (1994): the Colorado Plateau Semi-desert Province and the Arizona-New Mexico Mountains Semi-desert-Open Woodland-Coniferous Forest-Alpine Meadow Province. The physiographic characteristics of the ecoregions have an influence on climate. The tablelands of the Colorado Plateau Semi-desert Province range in elevation from about 1,500 m to 2,100 m (5,000 ft to 7,000 ft). At these high elevations, winters are cold and summers, while hot during the day, are cool at night, creating a large diurnal temperature fluctuation. Annual average temperatures are 4° C to 13° C (39° F to 55° F); as elevations rise, average temperatures drop.

Average annual precipitation is about 51 cm (20 in) and increases with elevation, but some parts of the province receive less

than 25 cm (10 in). Summer rains arrive in the form of thunderstorms, with frontal-system rains and sometimes snow falling in winter. In the Arizona-New Mexico Mountains Semi-desert-Open Woodland-Coniferous Forest-Alpine Meadow Province (descriptive of the Chuska Mountains directly to the east of Canyon de Chelly), temperature and precipitation regimes are similar to those in the Colorado Plateau Semi-desert Province, except that in the mountains, most winter precipitation falls as snow.

The record of temperature and precipitation at Canyon de Chelly from 1970 to 2000 (Western Regional Climate Center 2007) offers a more or less continuous account of daily temperature and precipitation events. During this time, precipitation averaged 23.3 cm (9.17 in), with a high of 45.7 cm (18 in) occurring in 1982, and a low of 3.4 cm (3.29 in) in 1989. From this record we see that the greatest amount of precipitation occurs in the late summer and fall. Spring is the driest season. The daily extremes ranged from a low of -31° C (-24° F) in January 1974 to a high of 41° C (105° F) recorded in July 2002. Temperatures increased during the late spring and early summer months, as precipitation reached its lowest average level.

1.5.4 Geology, Hydrology, and Topography

Rink (2005) provided detailed descriptions of the geology, hydrology, and topography of CACH. The following descriptions are taken primarily from his summary of these topics.

The mouth of the canyon appears as a flat sand wash margined with low cliff walls. In the lower reaches, canyon bottoms are flat, sandy, and 0.2 to 1 km in width. Upstream, in much of the canyon system, the slopes and cliff walls attain heights of 250 m (820 ft), and, in a few areas, as high as 350 m (1,148 ft). In the upper reaches, canyon bottoms become increasingly U- and then V-shaped, and the walls decrease in height until at the heads of the five main tributaries the walls disappear close to the uppermost boundaries of the monument.

Elevation at CACH ranges over 650 m (2,132 ft), from 1,680 m (5,512 ft) at the mouth of the canyon to 2,320 m (7,612 ft) on the slopes, mesas, and ridges of the northern Defiance Plateau. At the rim of Canyon de Chelly, the Shinarump Conglomerate forms an erosion-resistant cap over beds of the softer, more easily eroded De Chelly Sandstone. This juxtaposition is largely responsible for the steep cliffs of Canyon de Chelly (Vandiver 1937 in Rink 2005). The Shinarump Conglomerate and De Chelly Sandstone act as aquifers, storing and transporting water, but underlying layers of finer-grained sandstones and shales are less permeable, causing water to reach the surface in the form of springs and seeps (Cooley et al. 1969 in Rink 2005).

The Colorado Plateau is dissected by permanent and intermittent streams, mainly tributaries of the Colorado River. Similarly, Canyon de Chelly and its tributary canyons are incised into the northern portion of the Defiance Plateau at the western edge of the Chuska Mountains (Barnes 1984 in Rink 2005). The canyon complex includes Canyon de Chelly with its major tributary Black Rock Canyon, and Canyon del Muerto and its smaller tributary, Monument Canyon. The junction of the two main canyons is close to the western boundary of CACH. The main tributaries drain watersheds in the uplands of the Chuska Mountains, which attain nearly 3,000 m (9,766 ft) in elevation. The most dependable flows are from snowmelt during the spring. Wheatfields, Whiskey, and Crystal Creeks are perennial most years through Canyon de Chelly to below the confluence of Wheatfields and Coyote Creeks (Rink 2005). Tsaile Creek drains through Canyon del Muerto and is perennial most years (although Tsaile Lake dam above the canyons alters the flow), with intermittent flows at lower elevations,

as well as subsurface flows all year (Stuart 2000).

Rink (2005) described the active erosion and deposition cycles that are still taking place in the canyon:

> *Canyon bottoms at Canyon de Chelly have undergone erosion and deposition cycles for thousands of years (Dolan 1993). These cycles may result from climate change, rates of sediment availability and transport, and/or plant community evolution. Erosion cycles may be exacerbated by human activities such as chaining, logging, woodcutting, grazing, fire, introduction of exotic plant species, tree planting, road building, placement of erosion control features or dams, and agriculture (Hereford 1986).*

1.5.5 Soils

A detailed soil survey is currently underway at CACH. Generally, the soils on the rims of Canyon de Chelly are shallow (26 to 52 cm or 10 to 20 in), and coarse textured. Formed in eolian and residual materials, they have low water holding capacities (Leslie 2006). Soils in the canyon floodplains and on stream terraces are generally deep (greater than 154 cm or 60 in) and nearly level to gently sloping. They are composed of stratified sands with layers of fine and medium gravel over sandy clay, gravelly clay or silty clay. These soils have medium to high water holding capacities.

Soils on the rim of Canyon del Muerto also formed in eolian and residual materials. They are sloping and shallow (10 to 52 cm or 4 to 20 in) to sedimentary bedrock, and coarse textured, with low water holding capacities. In the canyon, soils are nearly level to gently sloping stratified sands with layers of fine and medium gravel over sandy clay, gravelly clay or silty clays, forming in mixed alluvium. The soils have medium to high water holding capacities. Sloping areas along the canyon walls are deep to very deep (104 to greater than 154 cm or 40 to greater than 60 in) sands or sandy loams. Water holding capacities are medium to high. The soils of these sloping areas developed predominantly in eolian material (Leslie 2006).

1.5.6 Wildlife

1.5.6.1 Avifauna

Investigators recently documented a total of 152 avian species at CACH, with 99 species confirmed as breeding or probable breeders (LaRue and Mikesic 2006). The ash-throated flycatcher (*Myiarchus cinerascens*) and the black-throated gray warbler (*Dendroica nigrescens*) were the most commonly detected. In terms of bird species numbers, the richest habitats were pinyon-juniper, riparian, and desert-scrub.

Investigators found strong associations between pinyon-juniper habitats and Bewick's wren (*Thyromanes bewickii*), black-throated gray warbler, gray flycatcher (*Empidonax wrightii*), gray Vireo (*Vireo vicinior*), juniper titmouse (*Baeolophus ridgwayi)*, and pinyon jay (*Gymnorhinus cyanocephalus*). Strong associations existed between riparian habitat and plumbeous vireo (*Vireo plumbeus*), spotted towhee (*Pipilo maculates*), Virginia's warbler (*Vermivora virginiae*), warbling vireo (*Vireo gilvus*), and yellow-breasted chat (*Icteria virens*). Other species were more widespread—these included American robin (*Turdus migratorius*), ash-throated flycatcher, blue-gray gnatcatcher (*Polioptila caerulea*), chipping sparrow (*Spizella passerina*), common raven (*Corvus corax*), house finch (*Carpodacus mexicanus*), and mourning dove (*Zenaida macroura*).

The investigators documented significant winter use of the Russian olive- (*Eleagnus angustifolia)* dominated lower-canyon riparian woodlands by birds. Thirty species occurred there, with six species accounting for 66% of all individuals detected. These included northern flicker (*Colaptes auratus*), western bluebird (*Sialia mexicana*), yellow-rumped warbler

(*Dendroica coronata*), spotted towhee (*Pipilo maculatus*), dark-eyed junco (*Junco hyemalis*) and house finch (*Carpodacus mexicanus)*. LaRue and Mikesic (2006) believe that the large number of wintering birds feeding on the Russian olive fruits has contributed to the establishment and spread of Russian olive throughout the Canyon de Chelly canyon system.

1.5.6.2 Reptiles and Amphibians

A recent inventory of reptiles and amphibians detected 13 reptile species (9 lizards, 4 snakes) and 6 amphibian species (5 frogs/toads, 1 salamander) (Mikesic 2004). The eastern fence lizard (*Sceloporus undulatus*) was the most common and widespread reptile species, and was found in the uplands, as well as inside Canyon de Chelly, Canyon del Muerto, and Black Rock Canyon. The plateau striped whiptail (*Cnemidophorus velox*), also a common and widespread lizard, was found in riparian areas and pinyon-juniper grasslands/woodlands. Woodhouse's toad (*Bufo woodhousii*) was the most common and widespread amphibian detected during these surveys. The red-spotted toad (*Bufo punctatus*), was common in Tsaile Creek and its tributaries in CACH, and at permanent waters north of Black Rock Canyon.

Six species were detected less frequently during the two years of survey, and included the plains spadefoot (*Spea bombifrons*), western whiptail (*Cnemidophorus tigris*), many-lined skink (*Eumeces multivirgatus*), prairie rattlesnake (*Crotalus viridis*), striped whipsnake (*Masticophis taeniatus*), and gopher snake (*Pituophis catenifer*). These species occurred at three or fewer locations.

The riparian habitats along Whiskey and Wheatfields creeks provided the highest counts and highest diversity of herpetofauna.

1.5.6.3 Mammals

The diverse plant communities of the Canyon De Chelly region provide habitats for a variety of animals. Large mammals include mule deer (*Odocoileus hemionus*), black bear (*Ursus americanus*), coyote (*Canis latrans*), mountain lion (*Puma concolor*), porcupine (*Erithizon dorsatum*), and badger (T*axidea taxus*). Common lagomorphs of the area are jackrabbit (*Lepus californicus*) and cottontail (*Sylvilagus audubonii*), and common rodents include Abert's squirrel (*Sciurus aberti)* and pocket gopher (*Thomomys bottae*) (http://cpluhna.nau.edu/Places/canyon_de_chelly.htm).

Small mammals are also important components of the desert ecosystem (Clark 2007). In studies that began in 2005, investigators found that piñon mice (*Peromyscus truei*) and deer mice (*Peromyscus maniculatus*) were probably the most abundant small mammal species in CACH (Clark 2007), followed by the brush mouse (*Peromyscus boylii)*, pocket mouse (*Perognathus* spp.), woodrat (*Neotoma lepida*), and chipmunk (*Tamias* sp.).

Overall, there seemed to be more small mammals within the canyons than on the rims. Investigators believe that the denser vegetation along the riparian areas creates more places to forage and escape predation than the sparse vegetation on the canyon rims. Overall, fewer animals were captured in the western sections of CACH than in the traps farther east (Clark 2007).

In 2005, investigators captured 14 species of bats at CACH (Chambers 2005). The most commonly captured bats were western pipistrelles (*Pipistrellus hesperus*), big brown bats (*Epitesicus fuscus*), pallid bats *(Antrozous pallidus*), and long-legged myotis *(Myotis volans*). Investigators reported that CACH provides habitat for a diverse bat species community, including two species of conservation concern—Townsend's bigeared bat *(Corynorhynus townsendii)* and spotted bat (*Euderma maculatum*) (Chambers 2005).

1.5.7 Vegetation

The Colorado Plateau is a center of plant species endemism (Kartesz and Farstad 1999) and supports the highest numbers of terrestrial biotic associations (based largely on plant species associations) of any of the surrounding ecoregions, including the Sonoran Desert and Rocky Mountains (Stevens and Nabhan 2002). Information on plant communities from parks and monuments on the southern Colorado Plateau, many of which are not subject to the pressures of timber harvesting and grazing, may contribute new understanding of the region's plant communities and will be useful for comparing with other areas where multiple-use management may have led to changes over time.

1.5.7.1 Generalized ecoregion descriptions

Canyon de Chelly and its tributary canyons are located near the convergence of several ecoregions defined by Omernik (1987) and by Bailey et al. (1994). Generalized descriptions of vegetation for each ecoregion are applicable to CACH. Omernick described three ecoregions contributing to CACH vegetation: the Colorado Plateau, Arizona/New Mexico Plateau, and the Arizona New Mexico Mountains. The Colorado Plateau is marked by abrupt changes in relief and includes a broad extent of pinyon (*Pinus edulis*)-juniper (*Juniperus* spp.) woodlands in the mid to high elevations, and large areas of saltbush (*Atriplex* spp.) and greasewood (*Sarcobatus vermiculatus*) shrubs in low-lying areas. The Arizona New Mexico Mountains (including the Chuska Mountains directly to the east of the monument) are vegetated by ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), and occasionally fir (*Abies lasiocarpa*) and spruce (*Picea engelmanii*) at the highest elevations, pinyon-juniper woodlands at the mid-elevations, and mixed shrub vegetation in the lower elevations and foothills. The plains and mesa-tops of the Arizona/New Mexico Plateau, extending to the west of the Chuska Mountains, are transitional between the higher elevations of the Colorado Plateau, the Arizona/New Mexico Mountains, and the Chihuahuan and Sonoran deserts to the south.

Bailey et al. (1994) places CACH within two ecoregions: the Colorado Plateau Semi-desert Province and the Arizona-New Mexico Mountains Semi-desert-Open Woodland-Coniferous Forest-Alpine Meadow Province. Pinyon-juniper is the most extensive vegetation type in the Colorado Plateau Province. The montane zone vegetation varies in composition from place to place, but in Arizona is dominated by ponderosa pine. At lower elevations, grasses and shrubs are dominant—grama (*Bouteloua* spp.) grasses occur in association with shrubs and trees in the woodlands and forests, and big sagebrush (*Artemisia tridentata)* has an extensive distribution in the province.

The Arizona-New Mexico Mountains Semi-desert-Open Woodland-Coniferous Forest-Alpine Meadow Province consists mostly of steep foothills and mountains, and some deeply dissected high plateaus. Vegetation types of this province are similar to those of the Rocky Mountains, but occur at higher elevations. In the foothills up to 2,100 m (7,000 ft), there are mixed grasses, chaparral brush, oak -juniper woodland, and pinyon-juniper woodland. Ponderosa pine forests begin at about 2,100 m (7,000 ft). Douglas fir and aspen (*Populus tremuloides*) begin at about 2,400 m (8,000 ft) on north facing slopes, and in some areas at about 2,700 m (9,000 ft), the Douglas-fir zone merges into a zone of Engelmann spruce (*Picea engelmanii*) and corkbark fir (*Abies lasiocarpa*). The alpine zone occurs in areas where elevation is greater than 3,400 m (11,000 ft).

1.5.7.2 Previous Vegetation and Floristic Studies at Canyon de Chelly

J. F. Hammond began the first documented botanical studies in the canyons of CACH during the Washington expedition of 1849 (Simpson 1964). The next documented

collections were made in 1935, and various botanists and NPS staff continued to document intermittently through the 1970s (Rink 2005). An extensive botanical collection effort was made in association with the Antelope House archeological excavation. The purpose was to develop an understanding of the plant resources that may have been available to the early inhabitants of the canyons, and to provide material with which to compare archeological plant remains (Halse 1973). Various collectors visited the canyons in the 1980s and 1990s (Rink 2005). In 2001, the NPS funded a botanical inventory of the monument through the Southern Colorado Plateau Network (SCPN) Inventory and Monitoring Program. The final report on that project contains a comprehensive species list, including most of the specimens from earlier work as well as the specimens from a two-year, monument-wide survey (Rink 2005). The report also contains a comprehensive review of earlier work at the monument.

Other, earlier studies of vegetation communities in the monument had been conducted, including the NPS vegetation type map survey in 1936 (Bailey and Bailey 1941 in Rink 2005), and a survey of an isolated mesa top (Schmutz et al. 1976 in Rink 2005). Harlan and Dennis (1976) mapped potential plant resource communities in association with Antelope House excavations.

Harlan and Dennis (1976) describe seven plant assemblages at CACH:

- canyon bottom communities
- talus communities
- springs, seeps, and other wet places (including hanging gardens)
- pinyon-juniper continuum
- low-shrub grassland communities
- sagebrush communities
- canyon rims, cliffs, and edges.

Rink (2005) reviewed the seven assemblages, updated the species composition, and noted other changes that may have occurred in the intervening years between the two studies. The plant asseblages are characterized as follows:

Canyon bottom communities - Harlan and Dennis (1976) divided the canyon bottom communities into two types—a lower region below 1,830 m (6,000 ft), which was characterized by a wide streambed and very little vegetation, and an upper region that was more densely vegetated. Rink observed that the upper canyon bottoms included boxelder (*Acer negundo*), birch (*Betula occidentalis*), alder (*Alnus* spp.), Rocky Mountain juniper (*Juniperus scopulorum*), Gambel oak (*Quercus gambelii*), and redosier dogwood (*Cornus sericea*).

Rink also observed that the lower canyon bottom communities had changed dramatically since Harlan and Dennis's (1976) study. At the time of his study, the lower canyon bottoms had dense riparian vegetation that included Russian olive (*Elaeagnus angustifolia*), and tamarisk (*Tamarix ramosissima*), both introduced, invasive species, as well as native plains cottonwood (*Populus deltoides*), Rio Grande cottonwood (*P. deltoides* ssp. *wislizeni*), and willow (*Salix* spp.). Rink explored these changes in the canyon bottom using comparative photography and reviewing management practices. The canyon bottoms are undergoing additional change today: the NPS and Navajo Nation are collaborating on the removal of stands of invasive riparian vegetation in an effort to restore stream flow, native species diversity, and accessibility to the canyon bottom (NPS 2005).

Talus communities – Rink described these as the most diverse areas in the canyons. The talus communities included box elder (*Acer negundo*), Gambel oak (*Quercus gambelii*), mock orange (*Philadelphus microphyllus*), fendlerbush (*Fendlera rupicola*), Utah juniper (*Juniperus osteosperma*), pinyon pine, and Douglas fir.

Springs, seeps and other wet places (including hanging gardens) – Springs,

seeps, and hanging gardens provide habitat for wetland and moist-soil species that cannot survive elsewhere in a semi-arid environment. Hanging gardens, which support unique plant communities at seeps and springs in canyons of the southwestern United States, are areas of special interest in parks of the SCPN (Thomas et al. 2006). Rink (2005) described the vegetation of hanging gardens at CACH as dominated by either maidenhair fern (*Adiantum capillus-veneris*), most prevalent in the lower canyons; or columbine (*Aquilegia micrantha*) and monkeyflower (*Mimulus eastwoodiae*), prevalent throughout.

Pinyon-juniper continuum – Rink observed that the pinyon-juniper continuum still covered the most area in CACH. He noted that while cover was sparse at lower elevations, it increased with increasing elevation, and that the ratio of pinyon to juniper also increased with increasing elevation.

Low shrub-grassland communities – Rink observed that low shrub-grassland communities still dominated the rims, the upper terraces and the slopes of the lower canyons. The communities included saltbush species (*Atriplex* spp.), Mormon tea (*Ephedra viridis*), snakeweed (*Gutierrezia sarothrae)*, pricklypear and cholla cactus species (*Opuntia* spp.), and various species of rabbitbrush (*Chrysothamnus* spp.).

Sagebrushland community – Sagebrush land (dominated by sagebrush species or *Artemisia* spp.) occupied about 9% of the land above 1,900m (6,200 ft) in the 1970s, but much of this community is being invaded by *Pinus edulis* and *Juniperus osteosperma*.

Canyon rim, cliffs and ledges – Rink noted that canyon rims, cliffs and ledges of the lower canyons supported Utah serviceberry (*Amelanchier utahensis*), scrub oak (*Quercus turbinella*), pinyon pine, Utah juniper, mountain mahogany (*Cercocarpus intricatus*), Cliff-rose (*Purshia stansburiana*), narrowleaf yucca (*Yucca angustissima*), and banana yucca (*Y. baccata*).

Rink also noted that Douglas-fir and aspen forests grew on north aspect slopes within the canyons at elevations as low as 1,830 m (6,000 ft), and that other plant communities occurred on active sand dunes and human-impacted agricultural and weedy areas.

Leslie (2006) noted that nonnative species of trees, shrubs, and grasses had spread throughout much of Canyon de Chelly. Nearly thirty nonnative invasive species have been identified growing in the park, including Russian knapweed (*Acroptilon repens*), field bindweed (*Convolvulus arvensis*), burclover (*Medicago polymorpha*), puncturevine (*Tribulus terrestris*), and others. Russian olive (*Eleagnus angustifolia*), tamarisk (*Tamarix* spp.), and Siberian elm (*Ulmus pumila*) dominate much of the riparian zone. Riparian areas have the highest cover of nonnative plants in the monument.

Humans have farmed in these canyons since prehistoric times (Leslie 2006). In modern times, pecan, black walnut, apple, peach, pear, cherry, and apricot trees have all been planted in the canyons. Farming still occurs in parts of the lower canyons and affects the types, location and distribution of native plants in these areas. It is estimated that approximately 1,500 to 2,000 acres are being farmed in the canyons today (Leslie 2006).

2 Identification and Classification of Plant Communities

2.1 Methods

M. L. McTeague classified plant communities of Canyon de Chelly National Monument (CACH) at the finest floristic level possible. She used three approaches:

1. reanalysis of existing relevé data collected from 2001-03
2. collection of new field-data (2004), analysis, and quantitative classification
3. direct field observation during photointerpretation for one plant community, (see Chapter 3).

All plant communities, whether identified through quantitative classification or direct observation, were reconciled with the current NatureServe Explorer registry of provisional NVCS alliances and associations, and reviewed for compatibility by K. Schulz of NatureServe. New plant-community types were identified as park specials if they were not supported by sufficient observation data to be identified to the alliance or association level.

2.1.1 Relevé data

2.1.1.1 Existing data

Glen Rink, working with the SCPN Inventory and Monitoring Program, obtained vegetation relevés at CACH from April 2001 through September 2003. His surveys made available cover and abundance data for 96 relevé samples for use in this project. McTeague reinterpreted the nomenclature to concur with NVC nomenclature. The team used this initial classification to estimate the number of relevés to sample in 2004.

2.1.1.2 Newly collected data

In 2004, a field team led by M. McTeague collected plant-community data using cover/abundance values of individual plant species in 145 relevé plots (Mueller-Dombois and Ellenburg 2002). The sampling design stratified the park landscape into unique biophysical types for relevé allocation. The biophysical-types approach assumed that environmental variables drive vegetation patterns at CACH, and that a stratification based on environmental variables would lead to adequate sampling across the range of plant-community variability on the ground. The biophysical types were created by layering spatial data for landscape position, geology, stream buffer, slope, and aspect in a GIS environment, and identifying each unique combination as one type. The number of polygons targeted for sampling within each biophysical type was proportional to the total area and frequency of occurrence of that type within the park. The team planned to conduct field sampling at the centroid of each selected polygon, but did not sample any biophysical types represented by data retained from the 2001/03 sampling effort.

At each sample site, the field crew established a 500 m^2 or 1000 m^2 square relevé, with the relevé size dependent upon vegetation cover. Sparsely vegetated communities, with less than 10% cover, were sampled at larger scales in order to capture species cover and variability. In addition to plant species cover/abundance, the field crew collected environmental data (table 3). McTeague examined the field data iteratively during the collection period to determine if adequate numbers of relevés were sampled for each expected and observed community type. Plant communities that were not adequately sampled using the stratified design were sampled opportunistically at the end of the 2004 field season.

2.1.1.3 Quantitative data analysis

Data from the 2004 classification relevés were entered into a Microsoft® Access 2000 database and quality checked. The classification team imported the data into

Table 3. Summary of data collected within 145 classification relevés

Type of information	Items noted
Plot documentation	Plot location and identification, geographic references, plot size, picture documentation, date surveyor's name, plot shape
Environmental description	Elevation, slope, aspect, position, landform, geology, soil texture, Cowardin system, hydrology
Surface cover	Fine particles, gravel, cobble, stone, boulders, bedrock; litter, moss, lichen, biotic crust; animal use; human/natural disturbance
Vegetation description	Leaf phenology, leaf type, physiognomic class
Vegetation strata	Height, cover class and dominant species within each strata
Plant species	Observed plant species on survey site
Other vegetation characteristics	Mortality, nurse plant function, etc.

an Excel spreadsheet and formatted it for use in PC-Ord, a multivariate statistical analysis program (McCune and Mefford 1999).

The first step of classification was to determine the descriptive statistics on the relevé dataset and examine whether statistical differences in compositional heterogeneity existed among the physiognomic groups represented in the relevé data. The team initially used non-metric multi-dimensional scaling (NMS) ordination (which provides a view of community organization in multi-dimensional space) to analyze the entire dataset of 145 relevé sites from the 2004 field efforts (fig. 3). The resulting descriptive statistics showed high beta-diversity (β=11.7), indicating a high degree of compositional heterogeneity. In order to minimize relevé heterogeneity, the data were stratified into three physiognomic groups: (1) a combined forest and woodland strata, (2) shrubland strata, and (3) an herbaceous strata. All analyses were then re-run on each stratum. Species occurring only once within a stratum were usually removed from the dataset in order to reduce noise. However, if a species occurred only once, but was the dominant species in a relevé, it was retained

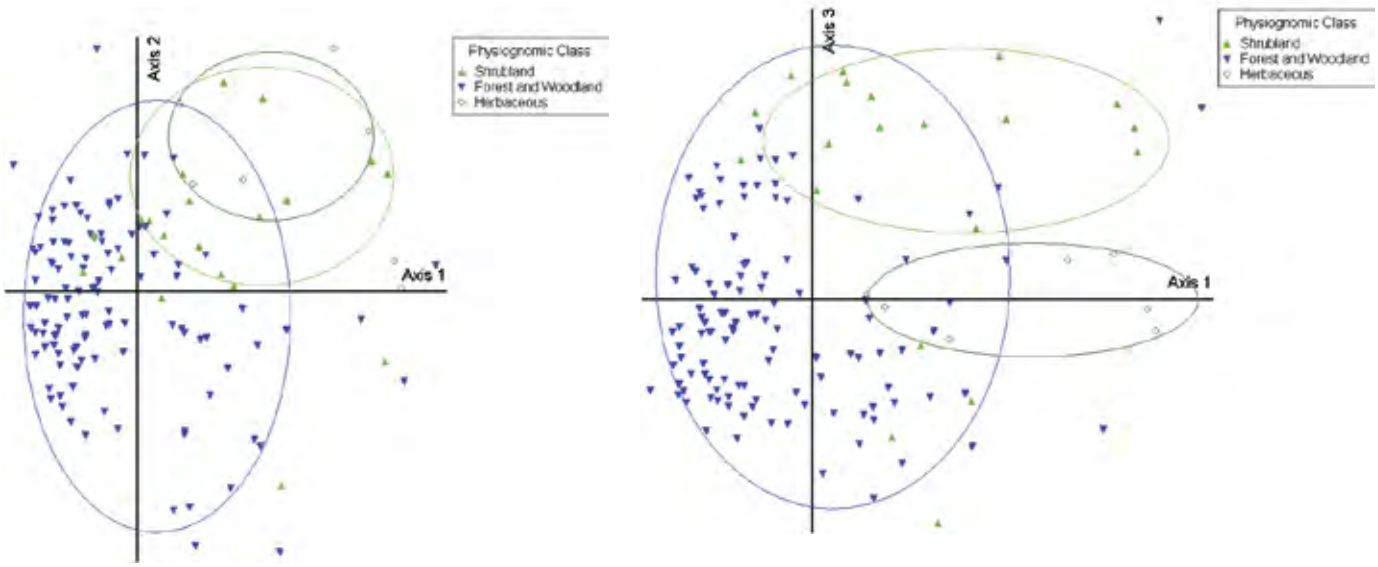


Figure 3. Non-metric multi-dimensional scaling (NMS) ordination of 145 classification relevés collected in 2004 illustrates separation of relevés by physiognomic type.

because of its influence within the plant community.

McTeague also conducted an outlier analysis to identify any outlying relevés that might skew the analysis. When it was determined that the outlier relevés were actually unique plant communities, the team retained those relevés (despite their introducing noise to the dataset) because of their importance in the community analysis.

McTeague then conducted a cluster analysis—a hierarchical, agglomerative classification of objects—for each stratum. Cluster analysis produces a dendrogram with relevés clustered within its levels, as illustrated for the shrubland stratum in Figure 4. To select "stopping points" in the cluster analysis dendrogram, the classifier used indicator species analysis (ISA) scores, which can identify species that characterize a group of relevés (Dufrêne and Legendre 1997, McCune and Grace 2002). The team used a method described by McCune and Grace (2002) to maximize the effectiveness of ISA scores in characterizing relevé groups. Assuming that indicator scores peak at an intermediate level of clustering, they used the change in the number of significant indictors as the criterion for grouping relevés. The team calculated ISA scores and values for each successive level of the cluster analysis, and plotted the number of significant indicators against the number of clusters at each level of the dendrogram (Decker and Coles 2003), as illustrated in Figure 5 for the shrubland stratum. This was done for each stratum in order to create a graphic that the team could evaluate and then use to choose the optimal level at which to group the relevés for that stratum. The stopping point for each group was interpreted as the finest level of ecological meaning for a cluster of relevés.

Optimal groupings were analyzed by looking at the statistically significant indicator species determined in the ISA, and identifying species with a p-value of <0.5 and indicator values of > 30. Only dominant and common native species were used—if the indicator species were exotic species or infrequent, ephemeral species that were not likely long-term community indicators, they were eliminated from the analysis. The classification team interpreted these groupings to represent provisional NVC vegetation associations.

Potential groups of relevés were cross-checked with established NVC associations and assigned a provisional association name using previously defined association nomenclature listed in NatureServe's Explorer website, http://www.natureserve.org/explorer/. When needed, McTeague developed new, proposed association names. Proposed associations that had similar species composition but occurred in more than one strata group were reassigned to the characteristic stratum for the association.

2.1.2 Photointerpreter observations

In June 2005, CACH mapping collaborators met to review the developing plant community classification and identify plant communities that were not well represented in the 2004 sampling, but had been observed in the field by the photointerpretation team.

2.1.3 NVC nomenclature

NatureServe reviewed the first iteration of plant community names and reconciled them with the NVC alliances and associations in their Biotics database (http://www.natureserve.org/prodServices/biotics.jsp). The SBSC and NatureServe teams consulted on the NVC nomenclature for each plant community before the naming was finalized.

2.2 Results

The team used the results of the reinterpretation of the 2001/2003 classification relevés, quantitative classification of the 2004 relevés, and photointerpreter observations to identify

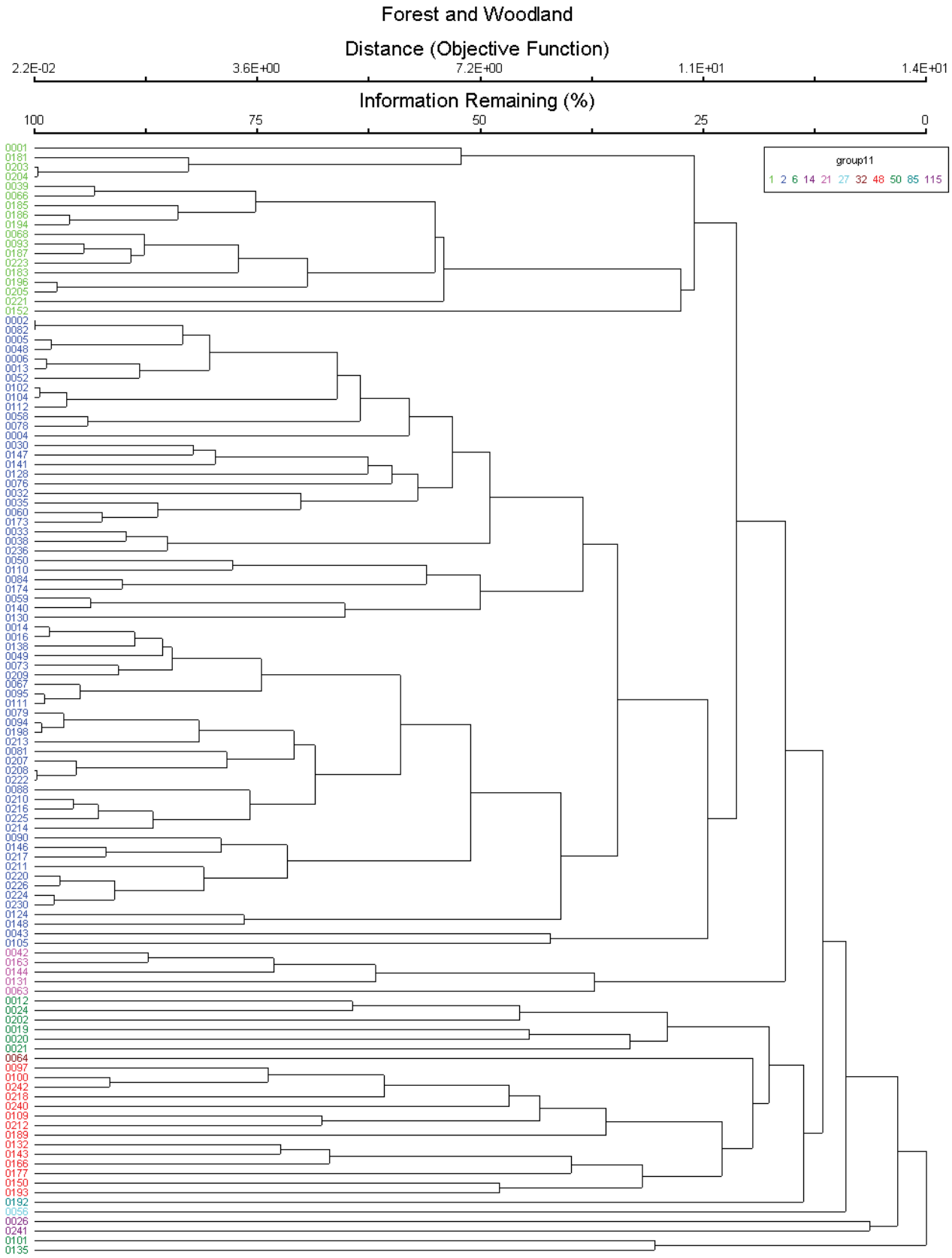


Figure 4. Cluster analysis of relevés produces a dendogram that separates relevés by information content. The dendrogram shows different levels at which the clusters might be grouped. This example shows provisional relevés for the forest/woodland stratum based on the 2004 data. The final classification was based on this quantitative analysis as well as information for the 2001/2002 relevés and field observations provided by the photointerpreter.

48 plant communities at CACH (table 4). Full descriptions of these communities can be found in Appendix C.

2.2.1 Field documentation for plant communities

Forty-four of the plant communities were based on field data newly collected in 2004 (145 relevés) (fig. 6) and/or from the 2001/2003 effort (96 relevés). Four additional plant communities were identified during photointerpretation field visits. Table 4 lists the strength of documentation for all plant communities. Many plant communities were also field-documented during accuracy assessment (see Chapter 4). The corresponding relevé and observation numbers are documented in Appendix B and full descriptions of these communities can be found in Appendix C.

2.2.2 Plant community characteristics

Thirty-eight of the 48 plant communities at CACH were identified as associations, all of which had been described previously in the NatureServe database and/or at other locations, except for *Juniperus scopulorum – Quercus gambelii* Woodland and *Quercus gambelii / Fendlera rupicola* Shrubland which were newly described from the park. These last two plant communities are identified as provisional associations in the NVC until NatureServe receives additional data from other studies. Ten other plant communities were classified as park specials (table 4). Their uniqueness does not imply rarity, but rather that they are assemblages of plant species for which data is insufficient to develop new NVC types.

The plant communities identified represented four major physiognomic types: Forest, Woodland, Shrubland, and Herbaceous. There was one forest association and two forest park special plant communities. For the woodlands, 25 plant communities were represented by seven alliances and two park special designations. The *Pinus edulis – (Juniperus* spp.) Woodland Alliance had the most associations (13 total), and was the dominant woody plant community in the park. Within the shrublands, 11 plant communities were represented by eight alliances and one park special. Nine herbaceous plant communities were represented by three alliances and five herbaceous park specials. Appendix C contains a detailed discussion of the expression of each plant community in the park and an overview of its global expression.

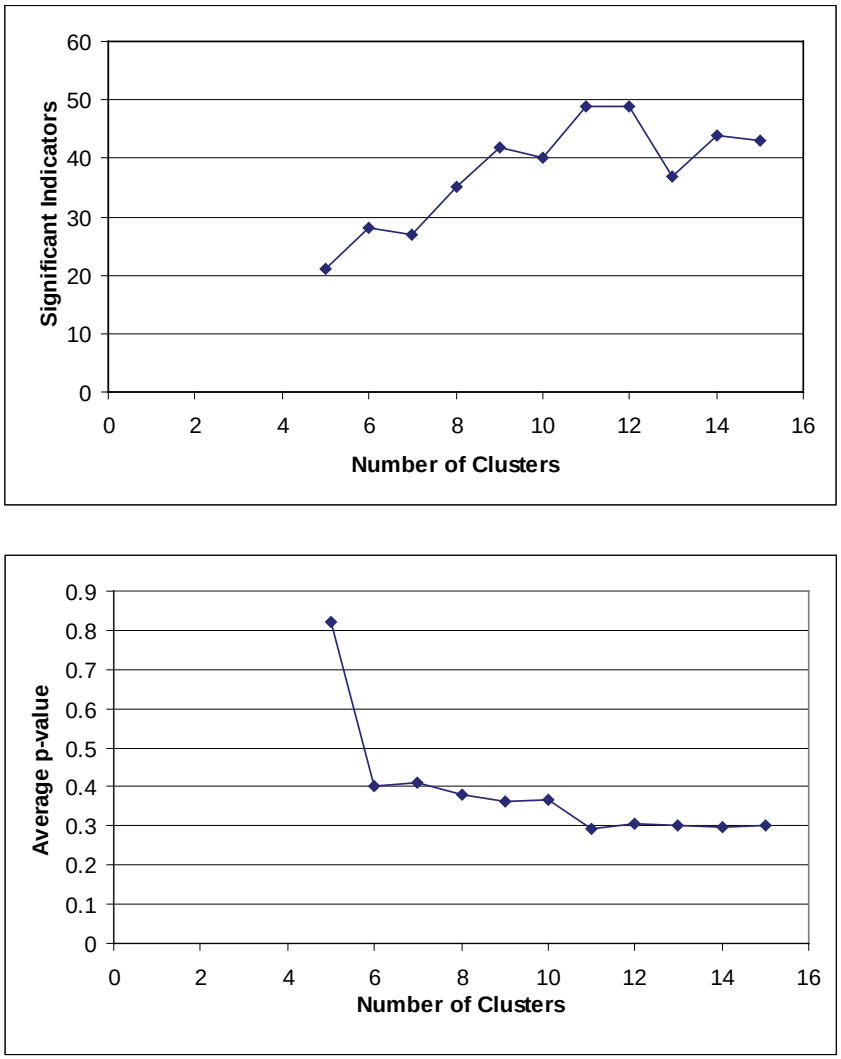


Figure 5. The number of significant indicators and the p-value for indicator species analysis scores, calculated for each level of the cluster dendrogram and plotted against the number of clusters in the dendrogram for that level. The highest value of significant indicators (49) and the minimum value for average p-value (0.29) were used to determine the number of clusters representing the best classification of relevés. Scores for the shrubland stratum are shown here.

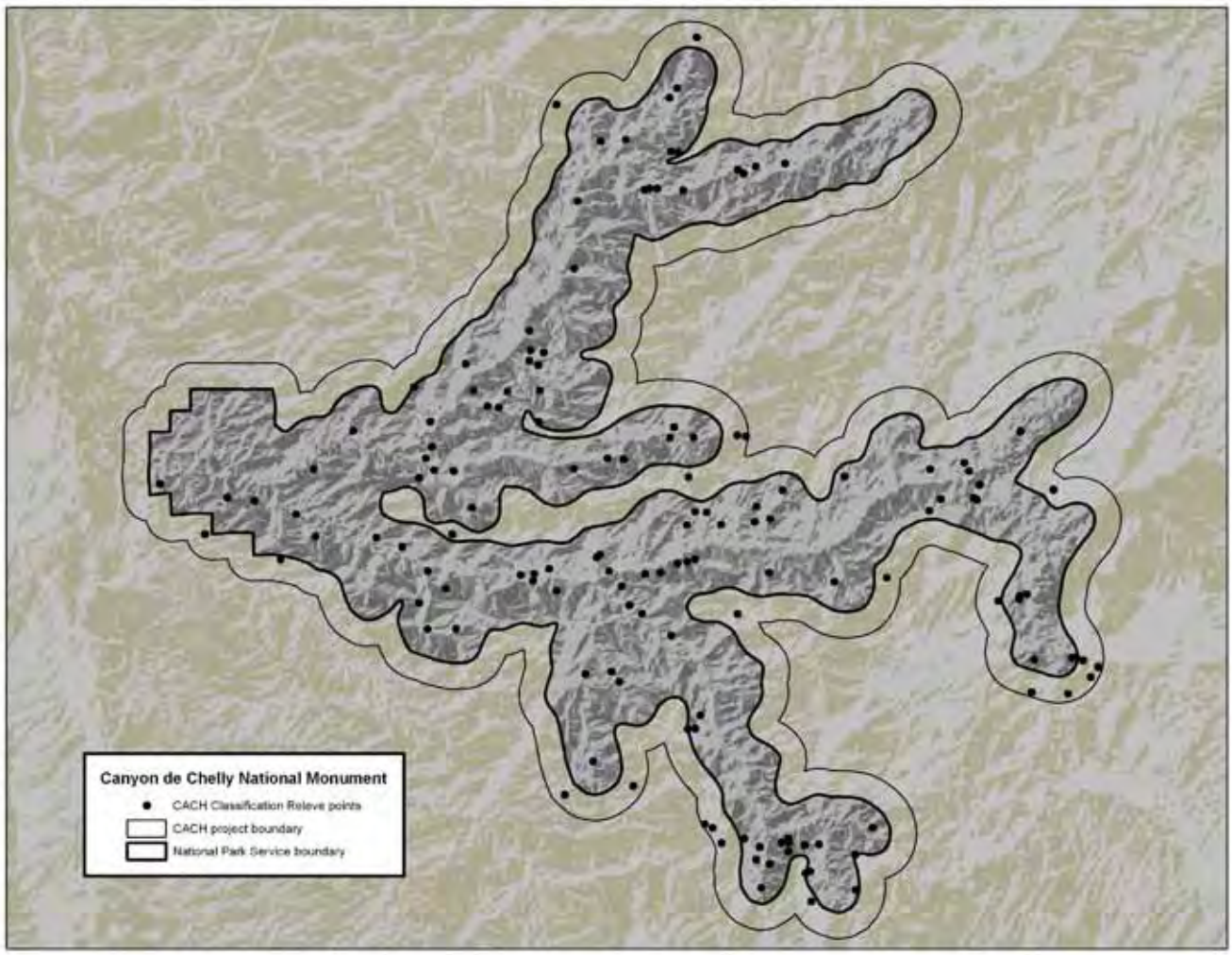


Figure 6. Locations of 145 classification relevés measured in 2004 and used to quantify plant communities at Canyon de Chelly National Monument

Invasive, non-native plants influenced the expression of some communities. Along the canyon-bottom riparian corridors, non-native dominated *Elaeagnus angustifolia* Semi-natural Woodland and Tamarisk spp. Temporarily Flooded Semi-natural Shrubland occur. Native riparian woodlands can also have significant invasive non-native understory, e.g. *Populus deltoides* ssp. *wislizeni* / Disturbed Understory Woodland. Other shrub (*Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland) and herbaceous (*Juniperus osteosperma* / *Ephedra viridis* / *Bromus tectorum* Wooded Herbaceous Vegetation) plant communities have a mix of native and non-native dominant species. Several herbaceous plant communities are dominated by invasive, non-native species: *Agropyron desertorum* Semi-natural Herbaceous Vegetation; *Bromus tectorum* Semi-natural Herbaceous Vegetation; and Mixed Weedy Herbaceous Vegetation.

Appendix D lists species found within the classification relevés and accuracy assessment sites. The key used to identify plant communities and map classes in the field is shown in Appendix E. Graphic results from the quantitative classification of the 2004 relevés for all plant community strata – Forest, Woodland, Shrubland, and Herbaceous – are included in the DVD that accompanies this report; see Appendix A for location information.

Table 4. Plant communities at Canyon de Chelly National Monument and source of supporting field documentation

	Plant community	Level	NVCS Alliance	NatureServe database code	2004 Veg. Mapping Field Relevés[1]	Glenn Rink Plot ID	Observed during photointerpretation
FOREST							
1	*Populus tremuloides* / *Rhus trilobata* Forest	Park Special	NA	NA	1	0	
2	*Pseudotsuga menziesii* / *Populus deltoides* Forest	Park Special	NA	NA	1	0	
3	*Pseudotsuga menziesii* / *Quercus gambelii* Forest	Association	*Pseudotsuga menziesii* Forest Alliance	CEGL000452	8	1	
WOODLAND							
4	*Acer negundo* / *Artemisia tridentata* Woodland	Park Special	NA	NA	1	0	
5	*Acer negundo* / Disturbed Understory Woodland	Association	*Acer negundo* Temporarily Flooded Woodland Alliance	CEGL002693	1	0	
6	*Elaeagnus angustifolia* Semi-natural Woodland	Association	*Elaeagnus angustifolia* Semi-natural Woodland Alliance	CEGL005269	1	1	
7	*Juniperus scopulorum* - *Quercus gambelii* Woodland	Provisional Association	*Juniperus scopulorum* Woodland Alliance	CEGL002967	1	0	
8	*Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL000778	10	8	
9	*Pinus edulis* - *Juniperus osteosperma* / *Amelanchier utahensis* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL002329	1	0	
10	*Pinus edulis* - *Juniperus osteosperma* / *Artemisia nova* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL002331	5	0	
11	*Pinus edulis* - *Juniperus osteosperma* / *Cercocarpus intricatus* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL000779	2	0	
12	*Pinus edulis* - *Juniperus osteosperma* / *Chrysothamnus greenei* Woodland	Park Special	NA	NA	1	0	
13	*Pinus edulis* - *Juniperus osteosperma* / *Ephedra viridis* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL002370	0	1	
14	*Pinus edulis* - *Juniperus osteosperma* / *Fendlera rupicola* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL004005	3	0	
15	*Pinus edulis* - *Juniperus osteosperma* / *Purshia stansburiana* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL000782	18	7	

Table 4, continued. Plant communities at Canyon de Chelly National Monument and source of supporting field documentation

	Plant community	Level	NVCS Alliance	NatureServe database code	2004 Veg. Mapping Field Relevés[1]	Glenn Rink Plot ID	Observed during photointerpretation
16	*Pinus edulis* - *Juniperus osteosperma* / *Quercus turbinella* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL004007	10	5	
17	*Pinus edulis* - *Juniperus osteosperma* / Sparse Understory Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL002148	9	3	
18	*Pinus edulis* - *Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL000776	15	15	
19	*Pinus edulis* - *Juniperus* spp. / Cercocarpus montanus Mixed Shrubs Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL000780	8	7	
20	*Pinus edulis* - *Juniperus* spp. / *Poa fendleriana* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL000787	1	0	
21	*Pinus edulis* - *Juniperus* spp. / *Quercus gambelii* Woodland	Association	*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance	CEGL000791	5	0	
22	*Pinus ponderosa* / *Artemisia nova* Woodland	Association	*Pinus ponderosa* Woodland Alliance	CEGL000846	2	1	
23	*Pinus ponderosa* / *Artemisia tridentata* ssp. *vaseyana* Woodland	Association	*Pinus ponderosa* Woodland Alliance	CEGL002794	2	0	
24	*Pinus ponderosa* / *Bouteloua gracilis* Woodland	Association	*Pinus ponderosa* Woodland Alliance	CEGL000848	0	2	
25	*Pinus ponderosa* / *Quercus gambelii* Woodland	Association	*Pinus ponderosa* Woodland Alliance	CEGL000870	5	2	
26	*Populus deltoides* ssp. *wislizeni* / Disturbed Understory Woodland	Association	*Populus deltoides* Temporarily Flooded Woodland Alliance	CEGL003810	1	1	
27	*Pseudotsuga menziesii* / *Poa fendleriana* Woodland	Association	*Pseudotsuga menziesii* Woodland Alliance	CEGL002809	1	1	
28	*Pseudotsuga menziesii* Scree Woodland	Association	*Pseudotsuga menziesii* Woodland Alliance	CEGL000911	1	1	
SHRUBLAND							
29	*Amelanchier utahensis* Shrubland	Association	*Amelanchier utahensis* Shrubland Alliance	CEGL001067	1	0	
30	*Artemisia tridentata* ssp. *wyomingensis* / *Artemisia nova* Shrubland	Park Special	NA	NA	0	0	Yes
31	*Artemisia tridentata* ssp. *wyomingensis* / *Bouteloua gracilis* Shrubland	Association	*Artemisia tridentata* ssp. *wyomingensis* Shrubland Alliance	CEGL001041	5	21	
32	*Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland	Association	*Artemisia tridentata* ssp. *wyomingensis* Shrubland Alliance	CEGL002083	5	5	
33	*Atriplex confertifolia* / *Pleuraphis jamesii* Shrubland	Association	*Atriplex confertifolia* Shrubland Alliance	CEGL001304	2	1	

Table 4, continued. Plant communities at Canyon de Chelly National Monument and source of supporting field documentation

	Plant community	Level	NVCS Alliance	NatureServe database code	2004 Veg. Mapping Field Relevés[1]	Glenn Rink Plot ID	Observed during photointerpretation
34	*Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland	Association	*Ericameria nauseosa* Shrubland	CEGL002937	2	4	
35	*Fendlera rupicola* Talus Shrubland	Association	*Fendlera rupicola* Shrubland Alliance	CEGL002765	2	0	
36	*Opuntia* (*fragilis*, *polyacantha*, *phaeacantha*) Shrubland	Association	*Opuntia* spp. Shrubland Alliance	CEGL004009	4	2	
37	*Quercus gambelii* / *Fendlera rupicola* Shrubland	Provisional Association	*Quercus gambelii* Shrubland Alliance	CEGL004010	1	0	
38	*Quercus gambelii* Shrubland	Association	*Quercus gambelii* Shrubland Alliance	CEGL002477	1	0	
39	*Tamarix* spp. Temporarily Flooded Semi-natural Shrubland	Association	*Tamarix* spp. Semi-natural Temporarily Flooded Shrubland Alliance	CEGL003114	0	0	Yes
HERBACEOUS							
40	*Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation	Association	*Achnatherum hymenoides* Herbaceous Alliance	CEGL002343	1	0	
41	*Agropyron desertorum* Semi-natural Herbaceous Vegetation	Park Special	NA	NA	0	1	
42	*Artemisia bigelovii* / *Bouteloua gracilis* Dwarf-shrub Herbaceous Vegetation	Association	*Bouteloua gracilis* Dwarf-shrub Herbaceous Alliance	CEGL001742	1	0	
43	*Bouteloua gracilis* Herbaceous Vegetation	Association	*Bouteloua gracilis* Herbaceous Alliance	CEGL001760	0	3	
44	*Brickellia californica* Shrubland	Park Special	NA	NA	3	0	
45	*Bromus tectorum* Semi-natural Herbaceous Vegetation	Association	*Bromus tectorum* Semi-natural Herbaceous Alliance	CEGL003019	0	0	Yes
46	*Juniperus osteosperma* / *Ephedra viridis* / *Bromus tectorum* Wooded Herbaceous Vegetation	Park Special	NA	NA	1	0	
47	Mixed Riparian Herbaceous Vegetation	Park Special	NA	NA	1	3	
48	Mixed Weedy Herbaceous Vegetation	Park Special	NA	NA	0	0	Yes

[1] From cachdata.mdb, tblVegetation, field Association

3 Base Map Class Development

3.1 Methods

3.1.1 Overview

To create the base map classes, the mapping team, consisting primarily of Monica McTeague (NAU), Lindsay Ogden (ARSC Management Services, under contract to the U.S. Geological Survey, Fort Collins, Colorado), and Tammy Fancher (FORT) developed GIS polygons and labeled them to the finest floristic level possible. The resultant base polygons are the finest-scale spatial data in the GIS database. Ideally, each polygon represents a map class that consists of one plant community; an association, alliance, or park special. However, one-to-one correspondence of a map class to a plant community was not always possible because mixed or indistinguishable photosignatures on the aerial photography made it difficult for the photointerpreter to distinguish every plant community. In such cases, the map class assigned represents a group of associations, alliances, and/or park specials.

Base polygons were manually drawn and labeled on transparent polyester sheets which were overlain onto the aerial photographs. Both the aerial photographs and the polyester sheets were orthorectified to the UTM Zone 12 projection and the North American Datum of 1983. The arcs comprising the polygons went through a raster-to-vector conversion, were edited in ArcINFO coverage format, and the resulting polygons were attributed with the base map class labels. These base map class polygons form the basic structure of the vegetation map database. The group and management map classes described in Chapter 4 are derived from these base map classes.

3.1.2 Base Data and Imagery

3.1.2.1 Imagery

Two sets of aerial photography were acquired for this vegetation mapping project. True color aerial photography was collected on 19 September 2003 by Horizons, Inc. From these aerial photographs Horizons derived 30 digital orthophoto quarter quadrangles (DOQQ) using USGS Digital Elevation Model data (10 meter resolution) and aero triangulation data. The DOQQ's were in the Universal Transverse Mercator projection for Zone 12 using the North American Datum of 1983. The FORT developed a mosaicked image of the DOQQ's.

The SCPN acquired new aerial photography of CACH through the U.S. Department of Agriculture's Aerial Photography Field Office (APFO) for the photo-interpretation of the base map classes. The APFO subcontractor, Photo Flight Geomatics of Tucson, Arizona, acquired the imagery on 24 June, 2 July, and 2 September 2004. The true color imagery was acquired at the scale of 1:12,000, with 20-40% sidelap and 50-60% forwardlap. The APFO provided two sets of 9 in x 9 in contact prints to the SCPN. The FORT used the DOQQ's as the basis for orthorectifying the 2004 true color aerial photographs and polyester sheet overlays (see below). At project completion, one set of contact prints will reside at CACH and one at the SCPN. Figure 7 shows the flight lines and photo centers.

3.1.3 Developing Base Map Polygons

3.1.3.1 Field reconnaissance

NAU photointerpreter Monica McTeague and FORT photointerpreter Lindsey Ogden conducted field reconnaissance of plant communities and their corresponding photosignatures in November and December 2004 and April 2005, both prior to and simultaneously with the delineating and labeling of map units. The two traveled together in the park for the first visits, to ensure that they had a mutually consistent understanding of the flora and plant communities. After the initial visits together, they divided the park into sections, and each took responsibility for different sections.

McTeague and Ogden visited sites with unique photosignatures that were not easily

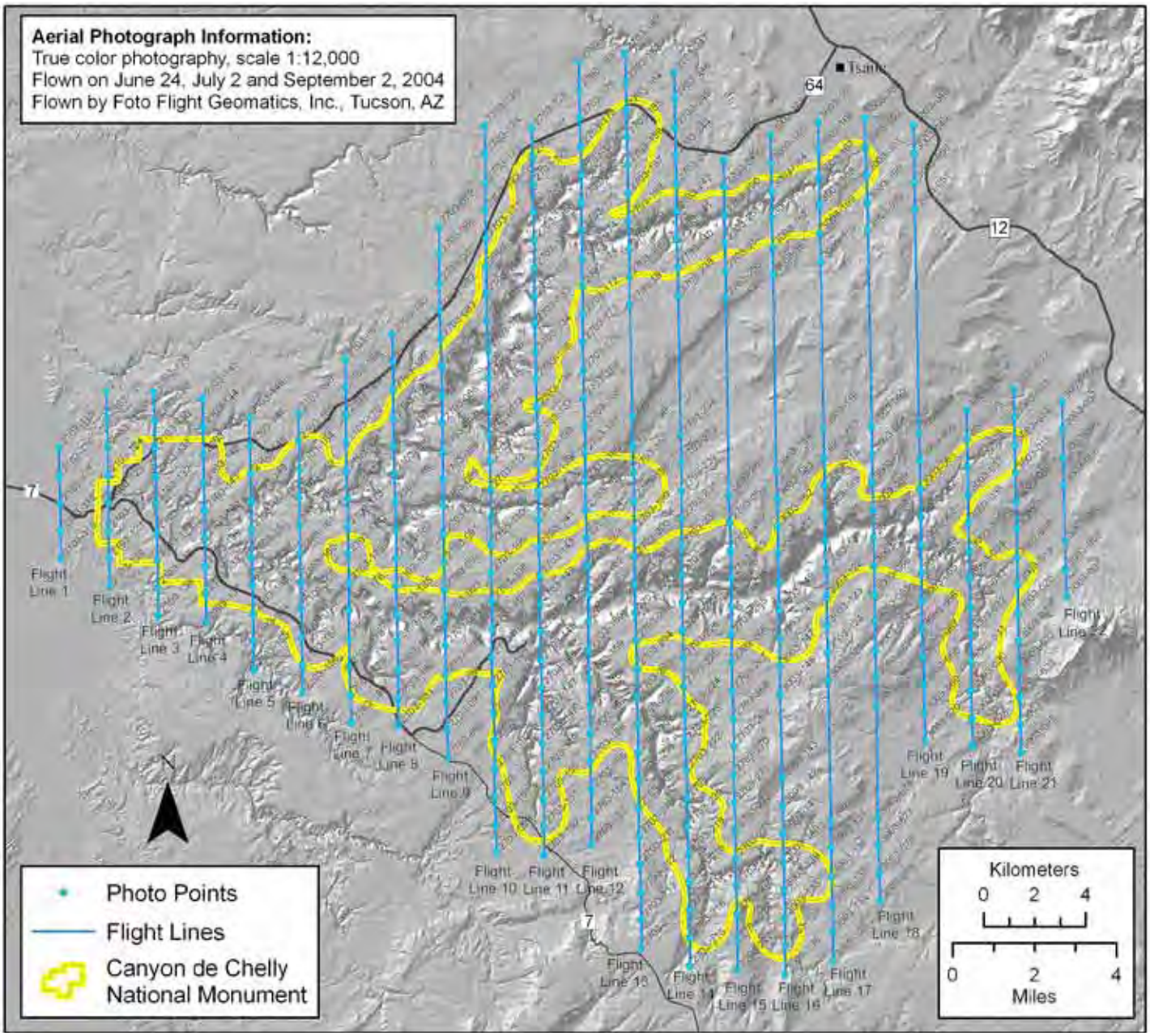


Figure 7. Flight lines and photo centers for true-color aerial photography acquired for the Canyon de Chelly National Monument vegetation mapping project

identifiable on the aerial photography, as well as areas with representative vegetation associations. They recorded the geographic coordinates of the site, the vegetation structure and composition (including dominant species cover estimates), and a brief description of the site's environmental characteristics. Two or more digital photographs of the site were also taken. In many cases the photointerpreters recorded additional field observations directly onto transparent polyester-sheets overlain on aerial photos, and used these later in the lab as a guide during photo interpretation. Fifty-three locations were visited, documented, and assigned a provisional plant community name (fig. 8). The observation data were entered into a Microsoft Access database and provided a quality control check.

3.1.3.2 Base map class polygons and labels

A polyester sheet overlay was attached to each of the 2004 1:12,000-scale true color

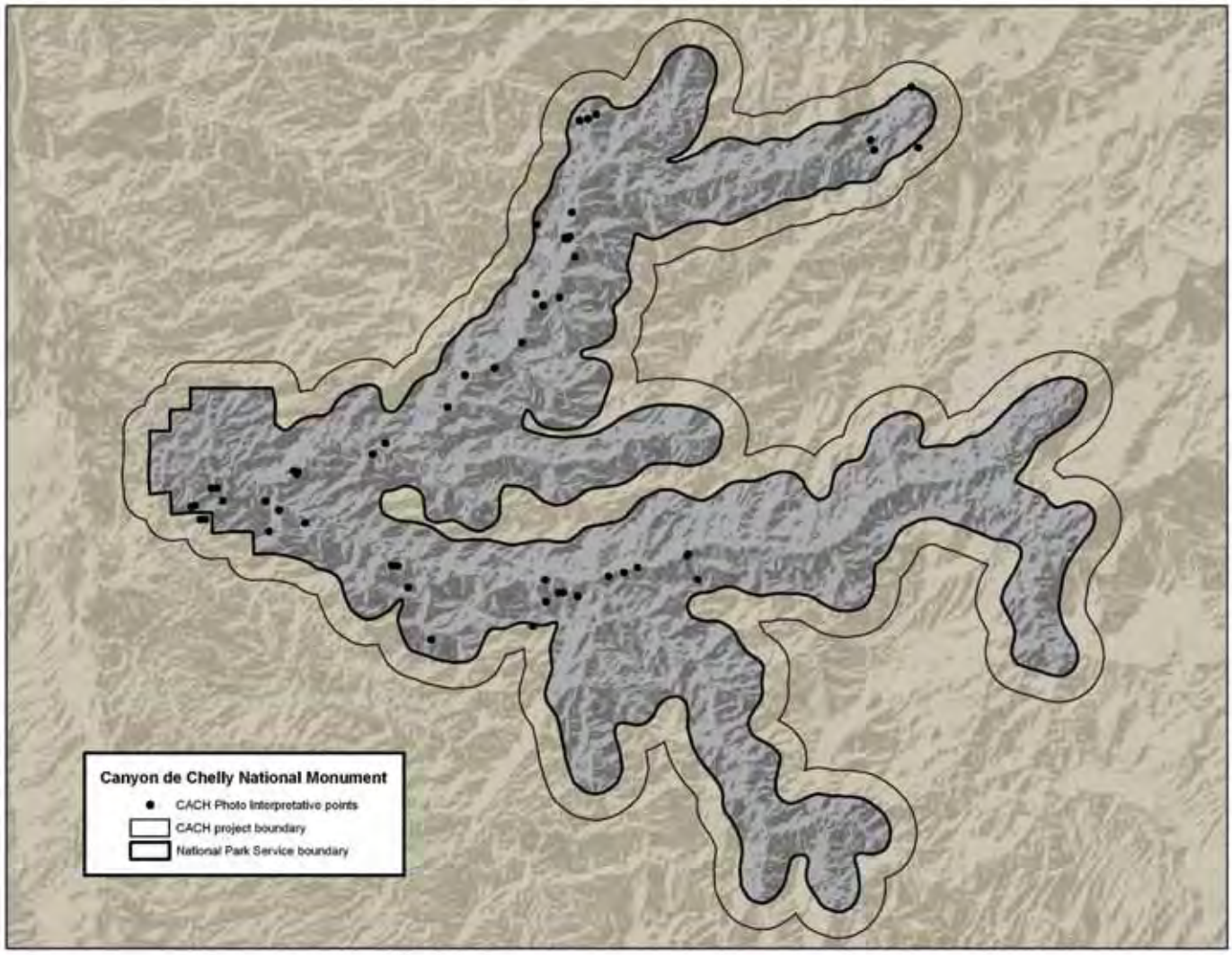


Figure 8. Location of 53 photointerpretation observation sites visited in November and December 2004 and April 2005.

aerial photographs. Standardized photo-interpretation techniques were used to prepare the aerial photograph (Crisco 1988). Fiducial marks were delineated on the polyester sheet overlay, along with the park code and photo number. The "effective area" was boxed in on the clear film and the photo-interpretation for each aerial photograph was completed within this "effective area." Stereoscopes were used throughout the photo-interpretation process.

The photo-interpreters delineated and labeled polygons using known and interpreted relationships between the photo signatures and base map classes. The base map classes consisted of associations, alliances, and park specials identified by the quantitative plant community classifications or groups, Anderson et al. (1976) Level II land-use classes, and additional communities identified during the photo-interpretation process.

Each interpreted polygon drawn on the polyester sheet overlay was labeled with a provisional base map class label and vegetation pattern and height modifiers, if applicable. They assigned a percent canopy cover modifier for all sagebrush communities. At CACH there were many instances of native vegetation disturbance, including traditional agriculture, residences, and grazing. For these polygons, the photo-interpreters added modifiers indicating the disturbance type

(table 5).

After all polygons had been assigned base map class labels, the team reviewed them for consistency and accuracy. The transparent polyester sheets were scanned by the FORT GIS team using a GraphTec CS2000 scanner and saved as TIFF images. A series of evenly distributed reference points (10-13) identified on both the DOQQ's and the aerial photographs were used to perform an orthorectificaiton of both the aerial photographs and the corresponding photo-interpreted polyester sheet overlays using OrthoMapper software (Image Processing Software 2005). Overall root mean square error for each image was less than 2 meters. The resulting images were moasicked to provide a complete orthorectified image for CACH.

The resulting raster files for the photo-interpreted polyester sheet overlays were vectorized using ArcScan version 9.0 software. The shapefiles were converted to ArcINFO coverage format and edited and attributed using ArcEdit (Environmental Systems Research Institute 2004).

Finally, all vector files for each aerial photograph were joined into a single map file. Neat lines were removed and attributes and arcs along map edges were verified. Topological relationships were validated by ensuring there were neither label nor node errors. Attribute accuracy was tested by comparing orthorectified scans of the source materials to the attribute data on-screen. In addition, the attributes were summarized and compared against a master set of valid attributes.

Subsequently, the ArcInfo coverage was converted back to a shapefile and the appropriate base, group, and management map classes were added (see Chapter 4).

3.2 Results

The vegetation map database for Canyon de Chelly National Monument has 53 base map classes (fig.9, table 6, and Appendix F). These include 11 classes describing land use and landforms, 9 describing herbaceous vegetation, 10 describing shrublands, 20 describing woodlands, and 3 describing forests. The vegetation map database uses the Universal Transverse Mercator (UTM) Zone 12 projection and the North American Datum of 1983 (NAD 83).

The vegetation map database consists of 4,718 polygons, of which 962 (20.6 %) are smaller than 0.5 ha (table 7). The majority of the vegetated polygons smaller than 0.5 ha in size occur in three base map classes:

- Big Sagebrush / Blue Grama Shrubland (197 polygons),
- Two-needle Pinyon – Juniper species / Big Sagebrush Woodland (166 polygons)
- Sandstone Rock (142 polygons)

In all but two map classes, the map class labels have a one-to-one relationship to an association or park special. The exceptions are Ponderosa Pine / Black Sagebrush – Big Sagebrush Woodland and Utah Serviceberry – Cliff Fendlerbush Shrubland. Three associations were not identifiable on the aerial photography, and are included within the larger, identifiable vegetation community surrounding the known location of the relevés.

Summary statistics for the base map classes, and for the group and management map classes aggregated from the base map classes are presented in Chapter 4. A key to the base map classes crosswalked to plant community and to group and management map classes, is presented in Appendix E. Appendix G contains photosignature examples for most of the base map classes, as well as summaries of the characteristics of each base map class.

Table 5. Modifiers used by photointerpreters to identify disturbance in delineated vegetation polygons.

Modifier	Modified codes	Interpretation
Coverage Density (Sagebrush Map Units Only)	A	Dense sagebrush canopy (>40% cover)
	B	Light sagebrush canopy (<10-40% cover)
	Z	Not interpreted or not applicable (all non-sagebrush map classes)
Coverage Pattern (all vegetation map units)	1	Clumped/bunched
	2	Linear (not assigned)
	3	Gradational/transitional (not assigned)
	4	Regularly alternating
	5	Homogenous (default value)
Height (F-J forest and woodland map classes, K-M shrub map classes)	F	>30 meters (not assigned)
	H	15-30 meters
	I	1-5 meters
	J	<1 meter
	K	1-5 meters
	L	0.5-1 meter
	M	0-0.5 meter
	Z	Not interpreted or not applicable
Environmental Modifier	a	Altered, applies when some alteration is evident, but the type is indistinguishable (not assigned)
	a1	Vegetated sand dunes
	b	Logged
	c	Mined, including gravel and sand quarries
	d	Chained, a method of tree removal that appears as striations on the ground
	e	Other vegetation treatments, applies to systems disturbed by other vegetation altering activities including tilling, disking, plowing and spraying. (not assigned)
	h	Over-grazed, applies to systems disturbed by excessive grazing
	l	Recently burned, a burn within 1-year of the photography, visible by blackened areas (not assigned)
	m	Older burn, a burn more than 1-year old (not assigned)
	o	Reservoir draw-down
	q	Bare talus and rockfall (not assigned)
	r	Bare exposed rock/sandstone cliffs
	t	Paved road
	u	Gravel/dirt road (not assigned)
	z	No modifier assigned

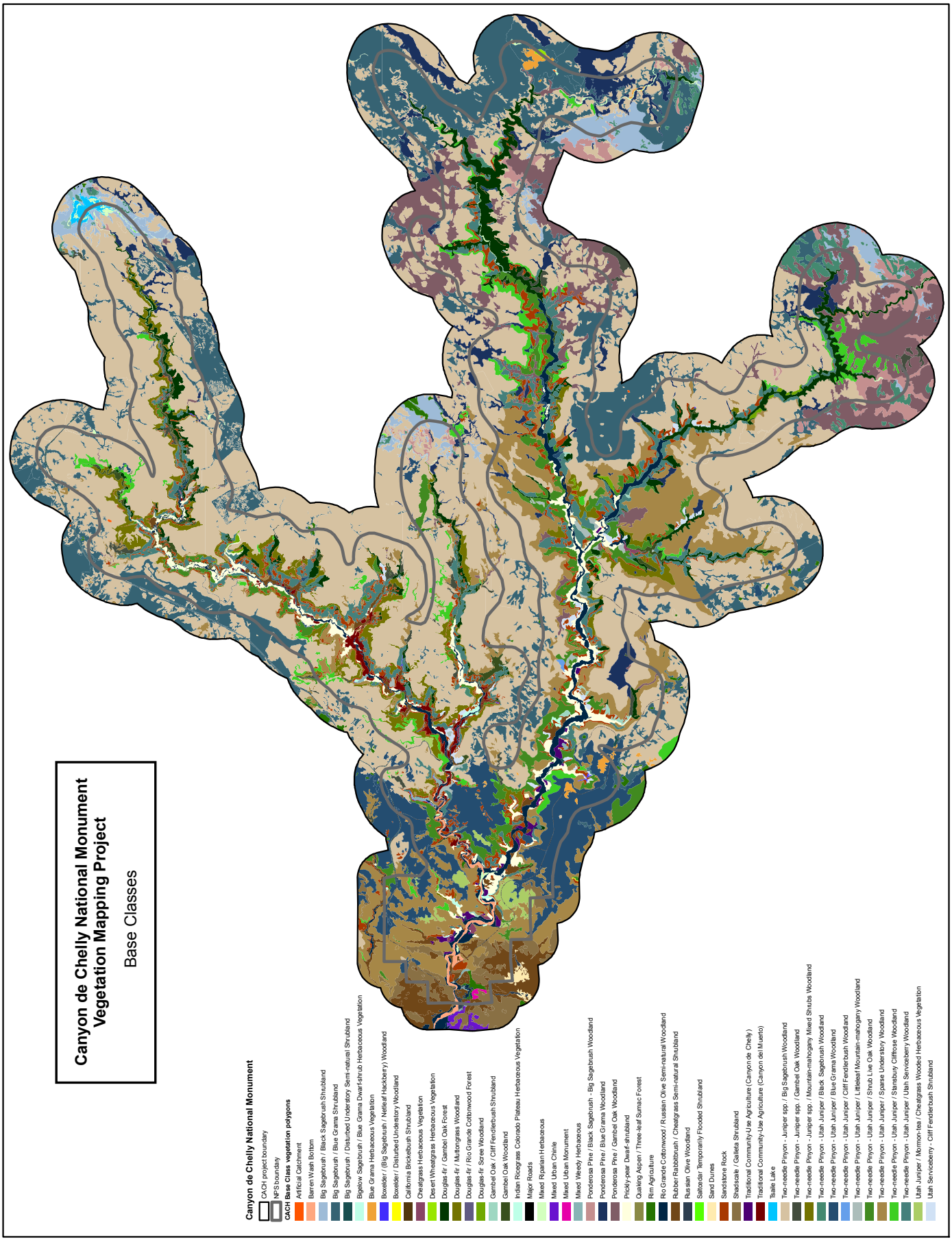


Figure 9. Base map classes at Canyon de Chelly National Monument

Table 6. Base map classes at Canyon de Chelly National Monument and the plant communities they represent

Base map class		Plant community		Type
FOREST				
B1	Douglas-fir / Gambel Oak Forest	3	*Pseudotsuga menziesii* / *Quercus gambelii* Forest	Association
B2	Douglas-fir / Rio Grande Cottonwood Forest	2	*Pseudotsuga menziesii* / *Populus deltoides* Forest	Park Special
B3	Quaking Aspen / Three-leaf Sumac Forest	1	*Populus tremuloides* / *Rhus trilobata* Forest	Park Special
WOODLAND				
B4	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland	4	*Acer negundo* / *Artemisia tridentata* Woodland	Park Special
B5	Boxelder / Disturbed Understory Woodland	5	*Acer negundo* / Disturbed Understory Woodland	Association
B6	Douglas-fir / Muttongrass Woodland	27	*Pseudotsuga menziesii* / *Poa fendleriana* Woodland	Association
B7	Douglas-fir Scree Woodland	28	*Pseudotsuga menziesii* Scree Woodland	Association
B8	Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland	22	*Pinus ponderosa* / *Artemisia nova* Woodland; 23 *Pinus ponderosa* / *Artemisia tridentata* ssp. *vaseyana* Woodland	Association
B9	Ponderosa Pine / Blue Grama Woodland	24	*Pinus ponderosa* / *Bouteloua gracilis* Woodland	Association
B10	Ponderosa Pine / Gambel Oak Woodland	25	*Pinus ponderosa* / *Quercus gambelii* Woodland	Association
B11	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland	26	*Populus deltoides* ssp. *wislizeni* / Disturbed Understory Woodland	Association
B12	Russian Olive Woodland	6	*Elaeagnus angustifolia* Semi-natural Woodland	Association
B13	Two-needle Pinyon - Juniper spp. / Big Sagebrush Woodland	18	*Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland	Association
B14	Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland	21	*Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland	Association
B15	Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland	19	*Pinus edulis - Juniperus* spp. / Cercocarpus montanus Mixed Shrubs Woodland	Association
B16	Two-needle Pinyon - Utah Juniper / Black Sagebrush Woodland	10	*Pinus edulis - Juniperus osteosperma* / *Artemisia nova* Woodland	Association
B17	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland	8	*Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland	Association
B18	Two-needle Pinyon - Utah Juniper / Cliff Fendlerbush Woodland	14	*Pinus edulis - Juniperus osteosperma* / *Fendlera rupicola* Woodland	Association
B19	Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland	11	*Pinus edulis - Juniperus osteosperma* / *Cercocarpus intricatus* Woodland	Association
B20	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland	16	*Pinus edulis - Juniperus osteosperma* / *Quercus turbinella* Woodland	Association
B21	Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland	17	*Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland	Association
B22	Two-needle Pinyon - Utah Juniper / Stansbury Cliffrose Woodland	15	*Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland; 20 *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland	Association
B23	Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland	9	*Pinus edulis - Juniperus osteosperma* / *Amelanchier utahensis* Woodland	Association
SHRUBLAND				
B24	Big Sagebrush / Black Sagebrush Shrubland	30	*Artemisia tridentata* ssp. *wyomingensis* / *Artemisia nova*	Park Special
B25	Big Sagebrush / Blue Grama Shrubland	31	*Artemisia tridentata* ssp. *wyomingensis* / *Bouteloua gracilis* Shrubland	Association
B26	Big Sagebrush / Disturbed Understory Semi-natural Shrubland	32	*Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland	Association
B27	Gambel Oak / Cliff Fendlerbush Shrubland	37	*Quercus gambelii* / *Fendlera rupicola* Shrubland	Provisional

Table 6, continued. Base map classes at Canyon de Chelly National Monument and the plant communities they represent

Base map class		Plant community		Type
SHRUBLAND *continued*				
B28	Gambel Oak Woodland	38	*Quercus gambelii* Shrubland	Association
B29	Prickly-pear Dwarf-shrubland	36	*Opuntia* (*fragilis*, *polyacantha*, *phaeacantha*) Shrubland	Association
B30	Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland	34	*Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland	Association
B31	Saltcedar Temporarily Flooded Shrubland	39	*Tamarix* spp. Temporarily Flooded Semi-natural Shrubland	Association
B32	Shadscale / Galleta Shrubland	33	*Atriplex confertifolia* / *Pleuraphis jamesii* Shrubland	Association
B33	Utah Serviceberry - Cliff Fendlerbush Shrubland	29	*Amelanchier utahensis* Shrubland; 35 *Fendlera rupicola* Talus Shrubland	Association
HERBACEOUS				
B34	Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation	42	*Artemisia bigelovii* / *Bouteloua gracilis* Dwarf-shrub Herbaceous Vegetation	Association
B35	Blue Grama Herbaceous Vegetation	43	*Bouteloua gracilis* Herbaceous Vegetation	Association
B36	California Brickelbush Shrubland	44	*Brickellia californica* Shrubland	Park Special
B37	Cheatgrass Herbaceous Vegetation	45	*Bromus tectorum* Semi-natural Herbaceous Vegetation	Association
B38	Desert Wheatgrass Herbaceous Vegetation	41	*Agropyron desertorum* Semi-natural Herbaceous Vegetation	Park Special
B39	Indian Ricegrass Colorado Plateau Herbaceous Vegetation	40	*Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation	Association
B40	Mixed Riparian Herbaceous	47	Mixed Riparian Herbaceous Vegetation	Park Special
B41	Mixed Weedy Herbaceous	48	Mixed Weedy Herbaceous Vegetation	Park Special
B42	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation	46	*Juniperus osteosperma* / *Ephedra viridis* / *Bromus tectorum* Wooded Herbaceous Vegetation	Park Special
LAND USE/LANDFORMS				
B43	Artificial Catchment			
B44	Barren Wash Bottom			
B45	Major Roads			
B46	Mixed Urban Chinle			
B47	Mixed Urban Monument			
B48	Rim Agriculture			
B49	Sand Dunes			
B50	Sandstone Rock			
B51	Traditional Community-Use Agriculture (Canyon del Chelly)			
B52	Traditional Community-Use Agriculture (Canyon del Muerto)			
B53	Tsaile Lake			
	Not mapped as separate unit	7	*Juniperus scopulorum* - *Quercus gambelii* Woodland [Provisional]	Provisional
	Not mapped as separate unit	13	*Pinus edulis* - *Juniperus osteosperma* / *Ephedra viridis* Woodland	Association
	Not mapped as separate unit	12	*Pinus edulis* - *Juniperus osteosperma* / *Chrysothamnus greenei* Woodland	Park Special

Table 7. Base map classes at Canyon de Chelly National Monument occurring in polygons smaller than the MMU size

Base map class		Map units <MMU[1]	All map units	Area< MMU[1] (%)	Total area(ha)
B1	Douglas-fir / Gambel Oak Forest	17	137	0.3	6
B2	Douglas-fir / Rio Grande Cottonwood Forest	3	5	41.7	1
B4	Box-elder / (Big Sagebrush / Netleaf Hackberry) Woodland	7	11	22.1	2
B6	Douglas-fir / Muttongrass Woodland	1	13	0.8	<1
B8	Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland	16	69	0.6	4
B9B	Ponderosa Pine / Blue Grama Woodland	13	157	0.3	4
B10	Ponderosa Pine / Gambel Oak Woodland	11	95	0.1	3
B11	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland	34	121	1.2	10
B12	Russian Olive Woodland	2	9	2.6	1
B13	Two-needle Pinyon - Juniper spp. / Big Sagebrush Woodland	166	631	0.2	46
B14	Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland	3	52	0.3	1
B15	Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland	7	88	0.2	2
B16	Two-needle Pinyon - Utah Juniper / Black Sagebrush Woodland	17	94	0.7	4
B17	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland	13	86	0.1	3
B18	Two-needle Pinyon - Utah Juniper / Cliff Fendlerbush Woodland	1	3	5.3	<1
B19	Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland	17	42	5.0	5
B20	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland	13	110	0.2	3
B21	Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland	48	301	0.3	15
B22	Two-needle Pinyon - Utah Juniper / Stansbury Cliffrose Woodland	3	102	0.1	1
B23	Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland	49	280	0.7	12
B24	Big Sagebrush / Black Sagebrush Shrubland	24	112	0.6	7
B25	Big Sagebrush / Blue Grama Shrubland	197	738	0.8	59
B26	Big Sagebrush / Disturbed Understory Semi-natural Shrubland	6	27	3.4	2
B28	Gambel Oak Woodland	14	73	1.8	5
B29	Prickly-pear Dwarf-shrubland	18	128	0.7	5
B30	Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland	35	159	1.0	10
B31	Saltcedar Temporarily Flooded Shrubland	6	7	69.6	2
B32	Shadscale / Galleta Shrubland	3	50	0.1	1
B33	Utah Serviceberry - Cliff Fendlerbush Shrubland	2	32	0.4	<1
B34	Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation	5	15	4.7	1
B35	Blue Grama Herbaceous Vegetation	8	28	2.5	3
B36	California Brickelbush Shrubland	2	9	4.9	1
B37	Cheatgrass Herbaceous Vegetation	3	12	2.9	1
B40	Mixed Riparian Herbaceous	19	59	4.2	5
B41	Mixed Weedy Herbaceous	3	16	1.5	1
B43	Artificial catchment	8	11	47.8	2
B46	Mixed Urban Chinle	2	9	0.4	<1
B48	Rim Agriculture	11	62	2.8	4
B50	Sandstone Rock	142	620	3.4	48
B51	Traditional Community-Use Agriculture (Canyon de Chelly)	1	29	0.2	<1
B52	Traditional Community-Use Agriculture (Canyon del Muerto)	10	50	2.3	4
B53	Tsaile Lake	2	6	0.8	1

[1]MMU = minimum mapping unit of 0.5 ha

4 Accuracy Assessment and Additional Map Classes

The SBSC team completed the vegetation map database by coordinating with the Navajo Natural Heritage Program for field collection of accuracy assessment observations, developing accuracy assessment statistics for the base map classes, developing the group and management map classes, and developing additional accuracy assessment statistics for those map schemas. In this step, the team used the accuracy assessment guidelines and protocols developed by the USGS-NPS Vegetation Mapping Program (Environmental Systems Research Institute et al. 1994). They developed the accuracy assessment by comparing the identification of base map-class polygons, as mapped, with field-collected data at the location of those polygons.

4.1 Methods

To conduct the accuracy assessment, the team 1) developed a sampling design, 2) collected field reference data with on-the-ground field sampling, and 3) developed map performance statistics. As is common practice in measuring uncertainty in mapped classes, a sample of polygon locations representing each map class (the sample data) was compared to the reference data. The higher-level group and management map classes are aggregations of base map classes and were assessed using the same reference data as for the base map. Finally, the team developed summary statistics describing the characteristics of the base, group and management map classes.

4.1.1 Field Sampling Design

The map database with base map classes was made available to the SBSC team as a shapefile for development of the sample design. The sampling design generally limited accuracy assessment sampling to within the park boundary, although the accuracy assessment field team was able to access some areas outside the park boundary. With the approval of park management, the field team did not field-assess land use or geology map classes. These map classes are generally well known and often easier to identify on the aerial photography than the vegetated classes. Furthermore, the field-team had limited field-season time to sample the vegetated map classes. All vegetated map classes, including those based solely on photointerpretation and park specials, were included in the sampling design.

The SBSC team used the 'scenario' table recommended by the Vegetation Mapping Program (Environmental Systems Research Institute et al. 1994) to estimate the number of sample sites needed for each map class to achieve a statistical measure of class accuracy with a confidence level of 90% and acceptable sample error of 10%. Each scenario was based on the number of polygons and total area of a map class. The team assigned each map class to one of five different scenarios to determine the target number of sampling sites needed (table 8). Depending upon its scenario assignment, a map class could be sampled at one to 30 sampling sites.

Table 8. Sampling design scenarios to determine target number of field accuracy assessment observation sites

Scenario	Class	Area	Number of polygons	Sample size
A	Abundant	> 50 ha	>= 30	30
B	Relatively Abundant	> 50 ha	< 30	20
C	Relatively Rare	< 50 ha	> 30	20
D	Rare	< 50 ha	> 5 but <= 30	5
E	Very Rare	< 50 ha	<= 5	visit every polygon

The location of each accuracy assessment site was determined randomly using Hawth's Analysis Tools v3.26 (http://www.spatialecology.com/htools/tooldesc.php). In addition to the targeted number of polygons to be sampled for each class, 5-20 secondary polygons per map class were included in the random sample in case the field team could not access the originally targeted polygons. Polygons larger than 0.5 ha (the MMU) had priority as field sampling sites. Accuracy assessment sites were 15 m or more from the edge of the polygon.

4.1.2 Field Data Collection

The project team developed a dichotomous key for the CACH plant communities and map classes to aid in the field-based accuracy assessment (Appendix E). SBSC ecologist Monica McTeague visited the park prior to the commencement of accuracy assessment to review the plant community/ map class key and the accuracy assessment field sampling methodologies. During this trip, she revised the plant community/ map class key to better reflect the field expression of associations and map class relationships.

The Navajo Natural Heritage Program (NNHP) accuracy assessment field crew began their work on August 1, 2006 and completed sampling on December 7, 2006. The SBSC project coordinator and NNHP ecologist trained the field crew in order to familiarize them with the park, logistical concerns, and field methodologies. Targeted accuracy assessment sites were identified as either primary or secondary. The crew attempted to access all primary sites; however, if they were not accessible, the crew sampled the pre-selected secondary sites.

Each field team carried a GPS unit (Garmin 5, Garmin 3+, or Garmin GPSMAP 76 (WAAS enabled)) pre-loaded with the geographic coordinates for the center of the designated sampling site. In addition, each team had a hard-copy list of the geographic coordinates for each target site, area and perimeter length of the map unit containing the target site, and distance to the nearest edge of an adjacent polygon, as well as two sets of maps to help orient them to the site. The first was a large area topographic map with all of the sampling sites drawn at 1:24,000 scale. The second showed each site within its associated polygon outline on a DOQQ base. These fine-scale maps allowed each field team to locate specific polygons on the ground and to visualize the size and shape of the polygon they were assessing.

The field team navigated to each site and then examined the polygon, using the field maps as a guide to the polygon's shape. They recorded site data (table 9) and took at least one photo from the site waypoint. They identified the plant community found on the ground and the corresponding base map class using the plant community/map class key. The evaluator assigned confidence in the base map classes using a categorical scale: exact, good (some problems), poor, or none that fit. If the evaluator's confidence was less than exact, then the reasons were

Table 9. Summary of data collected within accuracy assessment observation sites

Type of information	Items noted
Site documentation	Site identification, georeferencing, photo, elevation
Map class	Base map class of the site
Confidence in map class	The evaluators confidence in base map class assignment
Plant community	Association, alliance, or park special at site
Confidence in plant community	The evaluators confidence in plant community assignment
Vegetation description	Cover class, dominant species by strata

documented. If additional map classes or plant communities were present in the polygon, the evaluator also listed the occurrence of these base map classes. During the accuracy assessment fieldwork, the field crew and the SBSC project leaders refined the plant community/map class key and some of the plant community descriptions. Fieldwork was terminated when rain and snow made field access difficult or impossible.

4.1.3 Field Data Processing and Accuracy Assessment Statistics

Data from 806 accuracy assessment sampling locations were entered into a Microsoft Access database. The SBSC team rigorously quality-checked the data entry by comparing entered data with the original data sheet.

The SBSC team developed accuracy assessment statistics by comparing the reference map class (the map class determined in the field during accuracy assessment) to the map class in the vegetation map database (the map class assigned by the photointerpreter) at the sampled waypoint. In some cases, if the field crew could not access a sample location, they made observations from a remote location. When this occurred, the geographic coordinates of the target site, as determined during development of the sampling design, were the geographic location for the reference data. The team listed all sites where there was a difference in the sample and reference comparison (apparent error). The field data sheet for each apparent error was re-examined and the secondary base map class was accepted if it matched the reference data.

The team developed a contingency table (also known as an error matrix) to summarize the reference and sample-data comparisons for each map class. The SBSC team used methods described in the Vegetation Mapping Program guidelines (Environmental Systems Research Institute et al 1994) to calculate user and producer accuracy (see Glossary) for individual map classes, as well as overall percent accuracy and the Kappa Index, which accounts for correct classifications for the map as a whole due to chance (Foody 1992, The Nature Conservancy and Environmental Systems Research Institute 1994a). The Kappa Index was calculated only for the set of map classes that were assigned target sites. Map classes not targeted for accuracy assessment, such as land-cover classes observed as a reference observation, but also not targeted as a sample, were not included in the calculation of the Kappa Index. Statistics were derived using the JMP v5.1 statistical application. The two-tailed, 90% confidence intervals for user, producer, and overall accuracy were calculated using Score Confidence Interval Tables (Agresti and Coull 1998).

4.1.4 Group and Management Map Classes

After calculating assessment statistics for the base map classes, the SBSC team developed two aggregated map class schemas—the group and management map classes. The group map class schema is an aggregation of base map classes based on the concept of the group level of the NVCS Version 2 (FGDC 2008) (see table 2). The SBSC team used the ecological-system assignments for associations developed by NatureServe as a substitute for the assignment of group map classes, which were not available in final form at the time this project was completed.

Management map classes reflect base-map class performance and resource management needs. User and producer accuracy statistics for each base map class, as well as confusion among map classes as shown on the base map contingency table, were used to develop recommendations for aggregations of commonly confused and floristically or ecologically similar map classes. CACH resource management staff reviewed these management map-class recommendations at a meeting held at the park in May 2007. They made additional

recommendations using management goals for particular vegetation types and vegetation classes of particular interest, regardless of their assessed accuracy performance.

The SBSC team created a crosswalk between the base map classes and each aggregated map class. The crosswalks were used to add the group and management map classes to the map database. To conduct an accuracy assessment of each aggregated map class, the team also created a crosswalk between the reference data for the accuracy assessment and the group and management map classes The number of polygons and the area of each map class within the base, group and management map-class schemas were calculated using a GIS program.

4.2 Results

4.2.1 Accuracy Assessment Samples

In 2006, 806 accuracy assessment locations were sampled (figure 10). Data from 636 of these locations were used in the accuracy assessment analysis (629 for group map classes). Accuracy assessment points were eliminated from the analysis if (1) the points were sampled remotely with binoculars, (2) GPS location data were absent or had extremely large error due to poor satellite coverage, and/or (3) the GPS error exceeded the distance of the observation location to the nearest polygon edge.

4.2.2 Base Map Class Accuracy and Summary Statistics

4.2.2.1 Accuracy

The overall accuracy of the 53 base map classes was 50.8%; Kappa Index was 53.1% +/- 0.02. The Kappa Index and its standard error was calculated for map classes with both sample and corresponding reference data The contingency table for base map class accuracy is presented in Appendix H.

Three map classes—Quaking Aspen / Three-leaf Sumac Forest, Sand Dunes,

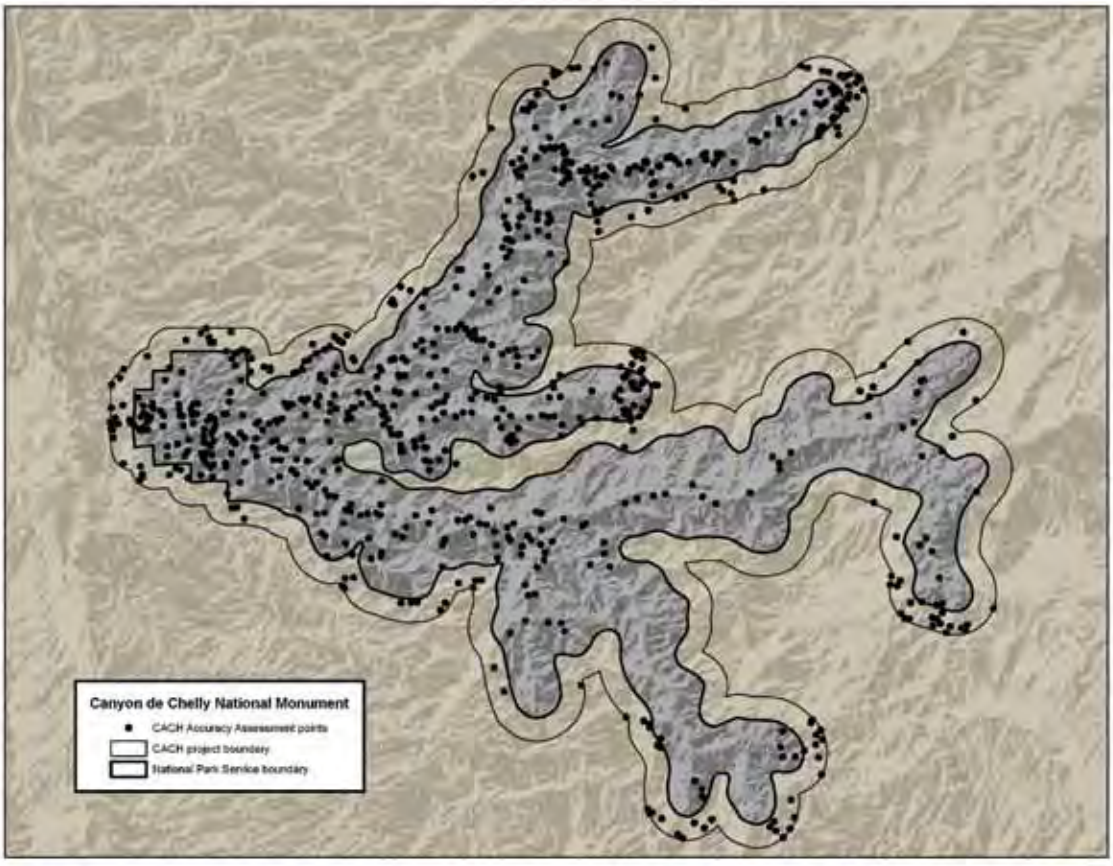


Figure 10. Location of 782 accuracy assessment sites observed from August through early December 2006.

and Major Roads—had both 100% user and producer accuracy (table 10). Another 17 map classes met the 80% accuracy standard for either the user or producer accuracy. Two vegetated map classes had no observations for either user or producer accuracy and constituted less than 0.1 % of the project area: Desert Wheatgrass Herbaceous Vegetation and Douglas-fir Scree Woodland.

Table 10. Base map class accuracy statistics

Base map class		Users' accuracy	90% CI[1] (range)	Producers' accuracy	90% CI (range)
FOREST					
B1	Douglas-fir / Gambel Oak Forest	60.0	35.2 - 80.6	85.7	54.8 - 96.7
B2	Douglas-fir / Rio Grande Cottonwood Forest	66.7	25.4 - 92.2	66.7	25.4 - 92.2
B3	Quaking Aspen / Three-leaf Sumac Forest	100.0	27.0 - 100.0	100.0	27.0 - 100.0
WOODLAND					
B4	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland	0.0	NA	NS	NS
B5	Boxelder / Disturbed Understory Woodland	NS[2]	NS	0.0	NA[3]
B6	Douglas-fir / Muttongrass Woodland	33.3	7.8 - 74.6	100.0	27.0 - 100.0
B7	Douglas-fir Scree Woodland	NS	NS	NS	NS
BB	Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland	25.0	13.5 - 41.5	46.2	26.1 - 67.5
B9	Ponderosa Pine / Blue Grama Woodland	20.0	9.3 - 37.8	57.1	28.9 - 81.4
B10	Ponderosa Pine / Gambel Oak Woodland	45.0	28.4 - 62.8	45.0	28.4 - 62.8
B11	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland	69.2	53.1 - 81.7	85.7	69.1 - 94.1
B12	Russian Olive Woodland	20.0	4.6 - 56.5	16.7	3.8 - 50.2
B13	Two-needle Pinyon - Juniper spp. / Big Sagebrush Woodland	70.8	54.1 - 83.3	34.7	24.6 - 46.4
B14	Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland	23.5	11.0 - 43.3	33.3	15.9 - 56.9
B15	Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland	35.3	19.5 - 55.1	33.3	18.3 - 52.7
B16	Two-needle Pinyon - Utah Juniper / Black Sagebrush Woodland	44.8	30.7 - 59.8	56.5	39.7 - 71.9
B17	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland	62.5	45.8 - 76.7	53.6	38.4 - 68.1
B18	Two-needle Pinyon - Utah Juniper / Cliff Fendlerbush Woodland	0.0	NA	0.0	NA
B19	Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland	25.0	57.9 - 64.4	14.3	3.3 - 45.2
B20	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland	52.6	34.7 - 69.9	33.3	21.1 - 48.3
B21	Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland	50.0	34.6 - 65.4	44.8	30.7 - 56.8
B22	Two-needle Pinyon - Utah Juniper / Stansbury Cliffrose Woodland	47.4	30.0 - 65.3	36.0	22.3 - 52.4
B23	Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland	50.0	24.9 - 75.1	26.7	12.6 - 47.9
SHRUBLAND					
B24	Big Sagebrush / Black Sagebrush Shrubland	26.9	15.3 - 42.9	77.8	50.4 - 92.4
B25	Big Sagebrush / Blue Grama Shrubland	47.6	31.0 - 64.8	76.9	54.2 - 90.4
B26	Big Sagebrush / Disturbed Understory Semi-natural Shrubland	88.9	62.3 - 97.5	21.6	12.6 - 34.5
B27	Gambel Oak / Cliff Fendlerbush Shrubland	0.0	NA	0.0	NA
B28	Gambel Oak Woodland	37.5	20.8 - 57.8	100.0	68.9 - 100.0
B29	Prickly-pear Dwarf-shrubland	50.0	33.5 - 66.5	44.0	29.1 - 60.1
B30	Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland	52.2	35.7 - 68.2	54.5	37.6 - 70.5
B31	Saltcedar Temporarily Flooded Shrubland	0.0	NA	0.0	NA
B32	Shadscale / Galleta Shrubland	54.2	37.9 - 69.6	100.0	82.7 - 100.0
B33	Utah Serviceberry - Cliff Fendlerbush Shrubland	14.3	3.3 - 45.2	33.3	7.8 - 74.6

Table 10, continued. Base map class accuracy statistics

Base map class		Users' accuracy (%)	90% CI[1] (range)	Producers' accuracy (%)	90% CI (range)
HERBACEOUS					
B34	Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation	25.0	5.8 - 64.4	50.0	12.1 - 87.9
B35	Blue Grama Herbaceous Vegetation	53.3	33.3 - 72.3	80.0	54.1 - 93.1
B36	California Brickelbush Shrubland	66.7	25.3 - 92.2	50.0	18.2 - 81.8
B37	Cheatgrass Herbaceous Vegetation	0.0	NA	0.0	NA
B38	Desert Wheatgrass Herbaceous Vegetation	NS	NS	NS	NS
B39	Indian Ricegrass Colorado Plateau Herbaceous Vegetation	25.0	57.9 - 64.4	100.0	27.0 - 100.0
B40	Mixed Riparian Herbaceous	52.6	39.7-71.9	100.0	29.6-58.1
B41	Mixed Weedy Herbaceous	66.7	34.7 - 88.3	22.2	10.4 - 41.3
B42	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation	58.3	35.6 - 78.0	87.5	58.9 - 97.2
LAND USE / LANDFORMS					
B43	Artificial Catchment	100.0	52.6 - 100.0	60.0	27.2 - 85.7
B44	Barren Wash Bottom	88.9	62.3 - 97.5	100.0	74.7 - 100.0
B45	Major Roads	100.0	27.0 - 100.0	100.0	27.0 - 100.0
B46	Mixed Urban Chinle	100.0	76.9 - 100.0	90.0	65.2 - 97.8
B47	Mixed Urban Monument	100.0	27.0 - 100.0	20.0	4.6 - 56.5
B48	Rim Agriculture	60.9	43.9 - 75.6	93.3	74.9 - 98.5
B49	Sand Dunes	100.0	52.6 - 100.0	100.0	52.6 - 100.0
B50	Sandstone Rock	75.0	46.0 - 91.3	100.0	68.9 - 100.0
B51	Traditional Community-Use Agriculture (Canyon del Chelly)	63.2	44.4 - 78.6	92.3	71.8 - 98.3
B52	Traditional Community-Use Agriculture (Canyon del Muerto)	85.2	70.8 - 93.2	95.8	83.3 - 99.1
B53	Tsaile Lake	100.0	27.0 - 100.0	25.0	5.8 - 64.4

1 CI = confidence interval

2 NS = map class not sampled

3 NA = not applicable, statistic could not be calculated

4.2.2.2 Summary statistics.
Of the 53 base map classes at CACH, 4 contributed greater than 5% to the vegetated cover of the park. Together, they constituted nearly 66% of the total park land cover (table 11). The most abundant map classes were

- Two-needle Pinyon – Juniper species / Big Sagebrush Woodland (39.4%, fig. 11)
- Big Sagebrush / Blue Grama Shrubland (12.9%, fig. 12)
- Two-needle Pinyon – Utah Juniper / Sparse Understory Woodland (7.9%, fig. 13)
- Ponderosa Pine / Gambel Oak Woodland (5.4%, fig. 14)

An additional seven map classes contributed between 2 and 5% to the land cover, together contributing 21% of the land cover. Thirteen classes contributed less than 0.05% cover each (0.0% in Table 11). One map class occurred only within the project environs: Boxelder / Disturbed Understory Woodland. Four other map classes had more than half of their mapped area outside park boundaries. Additional information on the distribution of each map class can be found in Appendix G.



Figure 11. Two-needle Pinyon – Juniper species / Big Sagebrush Woodland (base map class 13)

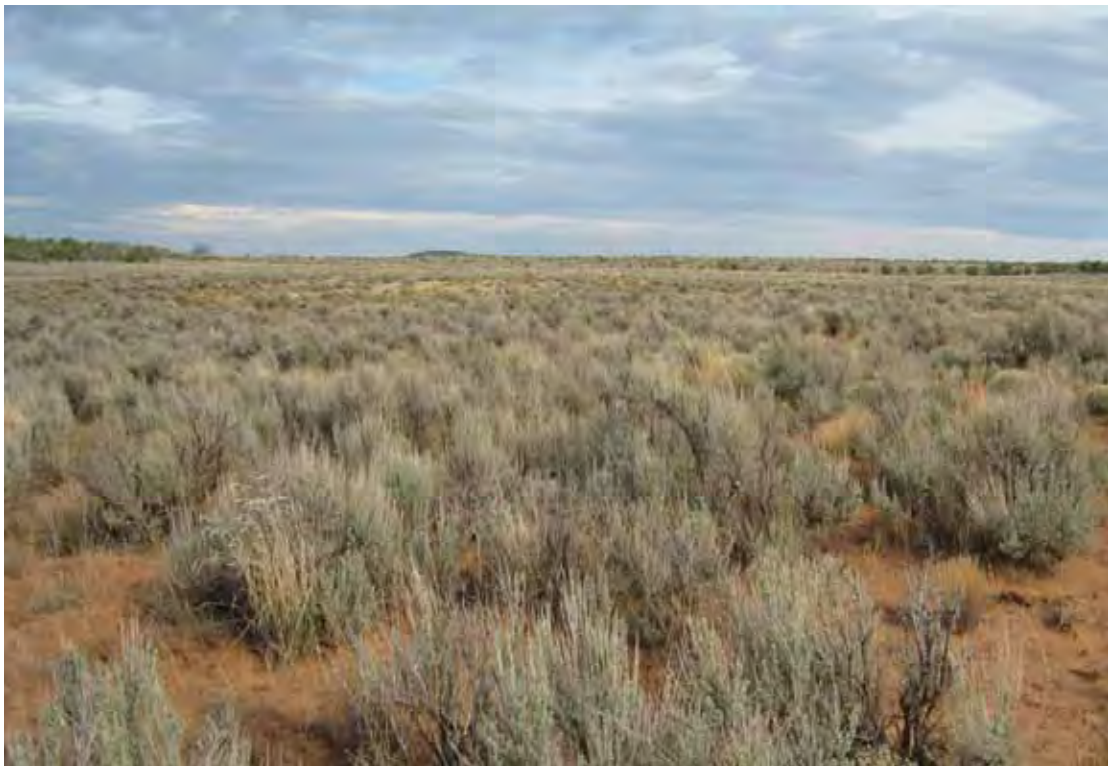


Figure 12. Big Sagebrush / Blue Grama Shrubland (base map class 25)



Figure 13. Two-needle Pinyon – Utah Juniper / Sparse Understory Woodland (base map class 21)



Figure 14. Ponderosa Pine / Gambel Oak Woodland (base map class 10)

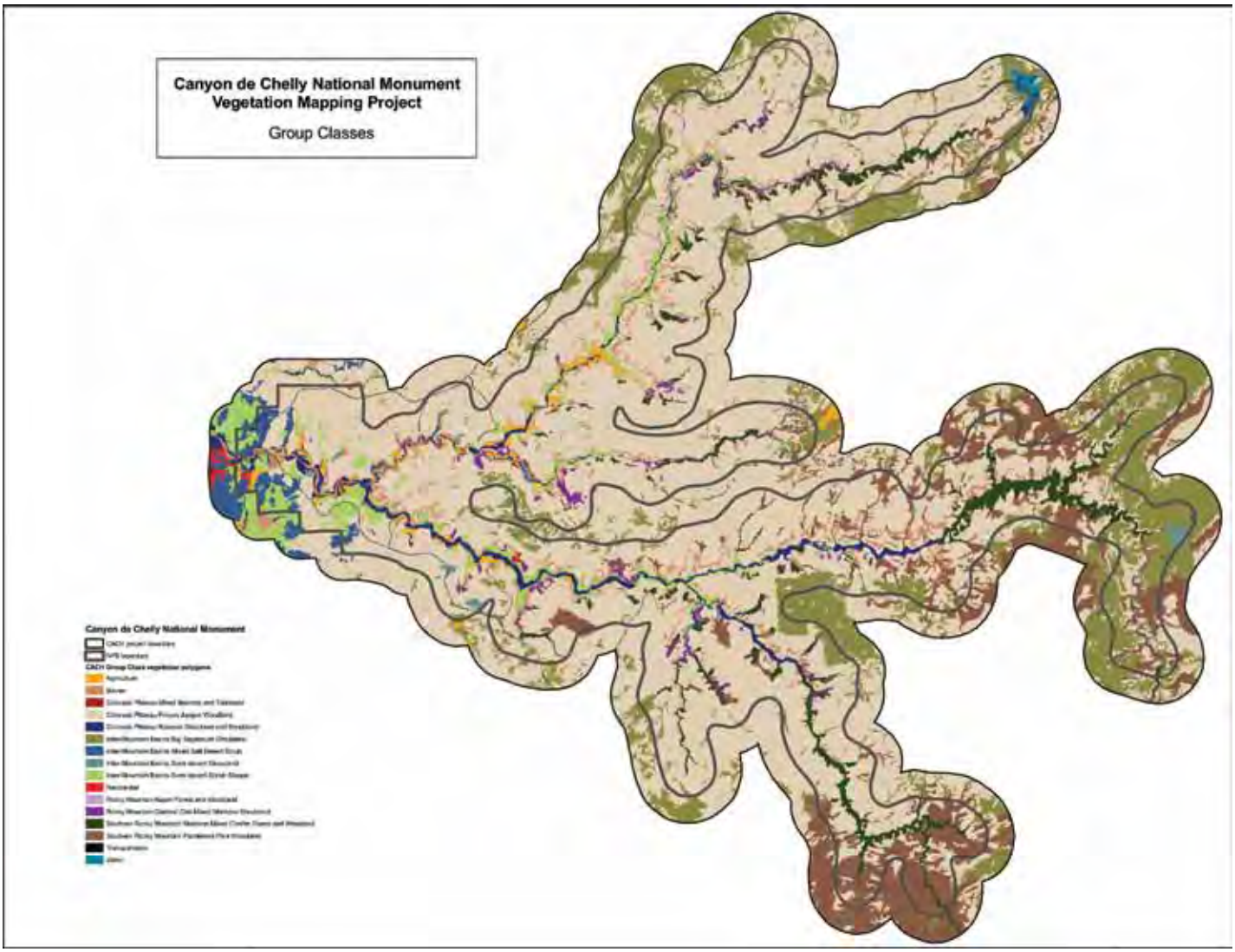


Figure 15. Group map classes at Canyon de Chelly National Monument

4.2.3 Group Map Class Accuracy and Summary Statistics

4.2.3.1 Accuracy

Sixteen group map classes (fig. 15, Appendix F) were created by aggregating the base map classes (table 12). The overall accuracy of the group map classes (table 13, Appendix H) was 79.9%; the Kappa Index was 77.1% +/- 0.02. Five of the map classes met the 80% standard for both user and producer accuracy. Nine additional map classes met the 80% standard for either users or producers accuracy. Only two map classes had both user and producer accuracy less than 80%.

4.2.3.2 Summary statistics

The group map classes consisted of 4 non-vegetated types and 12 vegetated map classes (table14). Within the park, the 3 most abundant group map classes were Colorado Plateau Pinyon Juniper Woodland (62.3%), Inter-Mountain Basins Big Sagebrush Shrubland (14.9%), and Southern Rocky Mountain Ponderosa Pine Woodland (9.1%). Together they constituted 86.3% of the park's vegetated cover.

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Table 11. Base map class summary statistics

Base map class		Project area				Park area				Occurrence outside park boundaries (%)
		# Map units	Ha	Ac	Project area land cover (%)	# Map units	Ha	Ac	Park area land cover (%)	
FOREST										
B1	Douglas-fir / Gambel Oak Forest	137	1614.0	3988.2	2.7	133	1598.3	3949.6	4.3	1.0
B2	Douglas-fir / Rio Grande Cottonwood Forest	5	3.1	7.6	<0.1	5	3.1	7.6	<0.1	<0.1
B3	Quaking Aspen / Three-leaf Sumac Forest	1	1.0	2.4	<0.1	1	1.0	2.4	<0.1	<0.1
WOODLAND										
B4	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland	11	9.2	22.7	<0.1	11	9.2	22.7	<0.1	<0.1
B5	Boxelder / Disturbed Understory Woodland	1	0.9	2.3	<0.1				<0.1	100.0
B6	Douglas-fir / Muttongrass Woodland	13	59.3	146.5	0.1	13	59.3	146.5	0.2	<0.1
B7	Douglas-fir Scree Woodland	12	48.3	119.4	0.1	12	48.3	119.4	0.1	<0.1
B8	Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland	69	682.9	1687.4	1.1	33	280.6	693.3	0.7	58.9
B9	Ponderosa Pine / Blue Grama Woodland	157	1508.8	3728.3	2.5	113	810.9	2003.7	2.2	46.3
B10	Ponderosa Pine / Gambel Oak Woodland	95	3226.2	7972.2	5.4	88	1578.9	3901.7	4.2	51.1
B11	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland	121	863.2	2133.1	1.4	104	806.7	1993.3	2.2	6.6
B12	Russian Olive Woodland	9	25.9	64.0	<0.1	4	11.2	27.6	<0.1	56.9
B13	Two-needle Pinyon - Juniper spp. / Big Sagebrush Woodland	631	23521.2	58122.2	39.4	428	13654.0	33739.9	36.5	42.0
B14	Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland	52	295.3	729.6	0.5	44	184.8	456.7	0.5	37.4
B15	Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland	88	1285.9	3177.5	2.2	87	1279.5	3161.8	3.4	0.5
B16	Two-needle Pinyon - Utah Juniper / Black Sagebrush Woodland	94	558.0	1378.7	0.9	30	149.6	369.8	0.4	73.2
B17	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland	86	2545.9	6291.2	4.3	73	1612.6	3984.9	4.3	36.7
B18	Two-needle Pinyon - Utah Juniper / Cliff Fendlerbush Woodland	3	8.9	22.0	<0.1	3	8.9	22.0	<0.1	<0.1
B19	Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland	42	99.8	246.6	0.2	42	99.8	246.6	0.3	<0.1
B20	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland	110	1446.9	3575.5	2.4	101	1307.3	3230.4	3.5	9.7
B21	Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland	301	4716.5	11654.7	7.9	246	3693.9	9127.9	9.9	21.7
B22	Two-needle Pinyon - Utah Juniper / Stansbury Cliffrose Woodland	102	907.1	2241.6	1.5	99	803.7	1986.1	2.1	11.4
B23	Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland	280	1838.0	4541.9	3.1	278	1837.7	4541.1	4.9	<0.1
SHRUBLAND										
B24	Big Sagebrush / Black Sagebrush Shrubland	112	1135.3	2805.5	1.9	61	325.9	805.3	0.9	71.3
B25	Big Sagebrush / Blue Grama Shrubland	738	7701.7	19031.2	12.9	455	2932.4	7246.2	7.8	61.9
B26	Big Sagebrush / Disturbed Understory Semi-natural Shrubland	27	60.5	149.6	0.1	22	31.9	78.9	0.1	47.3
B27	Gambel Oak / Cliff Fendlerbush Shrubland	8	33.6	83.0	0.1	8	33.6	83.0	0.1	<0.1

Table 11, continued. Base map class summary statistics

Base map class		Project area				Park area				
		# Map units	Ha	Ac	Project area land cover (%)	# Map units	Ha	Ac	Park area land cover (%)	Occurrence outside park boundaries (%)
B28	Gambel Oak Woodland	73	268.4	663.3	0.4	70	264.5	653.7	0.7	1.5
B29	Prickly-pear Dwarf-shrubland	128	749.9	1853.1	1.3	126	748.4	1849.4	2.0	0.2
B30	Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland	159	980.0	2421.7	1.6	135	511.6	1264.3	1.4	47.8
B31	Saltcedar Temporarily Flooded Shrubland	7	2.3	5.7	<0.1	4	1.1	2.8	<0.1	51.4
B32	Shadscale / Galleta Shrubland	50	671.0	1658.2	1.1	28	309.1	763.9	0.8	53.9
B33	Utah Serviceberry - Cliff Fendlerbush Shrubland	32	134.2	331.6	0.2	32	134.2	331.6	0.4	<0.1
HERBACEOUS										
B34	Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation	15	23.2	57.3	<0.1	15	23.2	57.3	0.1	<0.1
B35	Blue Grama Herbaceous Vegetation	28	102.7	253.8	0.2	25	83.4	206.0	0.2	18.8
B36	California Brickelbush Shrubland	9	11.3	27.9	<0.1	9	11.3	27.9	<0.1	<0.1
B37	Cheatgrass Herbaceous Vegetation	12	32.6	80.6	0.1	12	32.6	80.6	0.1	<0.1
B38	Desert Wheatgrass Herbaceous Vegetation	1	9.2	22.6	<0.1	1	3.8	9.4	<0.1	58.6
B39	Indian Ricegrass Colorado Plateau Herbaceous Vegetation	4	17.9	44.3	<0.1	4	17.9	44.3	<0.1	<0.1
B40	Mixed Riparian Herbaceous	59	111.0	274.3	0.2	46	83.3	205.8	0.2	24,8
B41	Mixed Weedy Herbaceous	16	48.5	120.0	0.1	11	29.3	72.4	0.1	39.7
B42	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation	14	193.0	476.8	0.3	14	187.5	463.3	0.5	2.8
LAND USE / LANDFORMS										
B43	Artificial Catchment	11	4.4	10.8	<0.1	5	2.4	5.8	<0.1	45.8
B44	Barren Wash Bottom	9	109.9	271.5	0.2	9	95.9	236.9	0.3	12.7
B45	Major Roads	4	66.9	165.2	0.1	9	41.6	102.9	0.1	37.7
B46	Mixed Urban Chinle	9	56.5	139.6	0.1	1	2.1	5.1	<0.1	96.4
B47	Mixed Urban Monument	1	10.2	25.3	<0.1	1	10.2	25.3	<0.1	<0.1
B48	Rim Agriculture	62	147.7	365.1	0.2	15	38.3	94.5	0.1	74.1
B49	Sand Dunes	5	48.5	119.9	0.1	1	6.9	17.2	<0.1	85.7
B50	Sandstone Rock	620	1390.1	3434.9	2.3	594	1348.9	3333.1	3.6	3.0
B51	Traditional Community-Use Agriculture (Canyon del Chelly)	29	91.2	225.3	0.2	29	91.2	225.3	0.2	<0.1
B52	Traditional Community-Use Agriculture (Canyon del Muerto)	50	180.3	445.6	0.3	50	180.3	445.6	0.5	<0.1
B53	Tsaile Lake	6	80.8	199.7	0.1	4	26.2	64.7	0.1	67.6
	Total	**4,718**	**59,739.3**	**14,7619.0**		**3,744**	**37,448.5**	**92,537.3**		

Table 12. Crosswalk of group map classes to base map classes

Group map class		Base map class	
G2	Agriculture	B43	Artificial catchment
		B48	Rim agriculture
		B51	Traditional Community-Use Agriculture (Canyon de Chelly)
		B52	Traditional Community-Use Agriculture (Canyon del Muerto)
G2	Barren	B44	Barren Wash Bottom
		B49	Sand Dunes
		B50	Sandstone Rock
G3	Colorado Plateau Mixed Bedrock and Tableland	B34	Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation
G4	Colorado Plateau Pinyon Juniper Woodland	B13	Two-needle Pinyon - *Juniper* spp. / Big Sagebrush Woodland
		B14	Two-needle Pinyon - *Juniper* spp. / Gambel Oak Woodland
		B15	Two-needle Pinyon - *Juniper* spp. / Mountain-mahogany Mixed Shrubs Woodland
		B16	Two-needle Pinyon - Utah Juniper / Black Sagebrush Woodland
		B17	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland
		B18	Two-needle Pinyon - Utah Juniper / Cliff Fendlerbush Woodland
		B19	Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland
		B20	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland
		B21	Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland
		B22	Two-needle Pinyon - Utah Juniper / Stansbury Cliffrose Woodland
		B23	Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland
G5	Colorado Plateau Riparian Woodland and Shrubland	B4	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland
		B5	Boxelder / Disturbed Understory Woodland
		B40	Mixed Riparian Herbaceous
		B11	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland
		B12	Russian Olive Woodland
		B31	Saltcedar Temporarily Flooded Shrubland
G6	Inter-Mountain Basins Big Sagebrush Shrubland	B24	Big Sagebrush / Black Sagebrush Shrubland
		B25	Big Sagebrush / Blue Grama Shrubland
		B26	Big Sagebrush / Disturbed Understory Semi-natural Shrubland
G7	Inter-Mountain Basins Mixed Salt Desert Scrub	B32	Shadscale / Galleta Shrubland
G8	Inter-Mountain Basins Semi-desert Grassland	B35	Blue Grama Herbaceous Vegetation
		B37	Cheatgrass Herbaceous Vegetation
		B38	Desert Wheatgrass Herbaceous Vegetation
		B39	Indian Ricegrass Colorado Plateau Herbaceous Vegetation
		B41	Mixed Weedy Herbaceous
G9	Inter-Mountain Basins Semi-desert Shrub-Steppe	B36	California Brickelbush Shrubland
		B29	Prickly-pear Dwarf-shrubland
		B30	Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland
		B42	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation

Table 12. **continued.** Crosswalk of group map classes to base map classes

Group map class		Base map class	
G10	Residential	B46	Mixed Urban Chinle
		B47	Mixed Urban Monument
G11	Rocky Mountain Aspen Forest and Woodland	B3	Quaking Aspen / Three-leaf Sumac Forest
G12	Rocky Mountain Gambel Oak-Mixed Montane Shrubland	B27	Gambel Oak / Cliff Fendlerbush Shrubland
		B28	Gambel Oak Woodland
		B33	Utah Serviceberry - Cliff Fendlerbush Shrubland
G13	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland	B1	Douglas-fir / Gambel Oak Forest
		B6	Douglas-fir / Muttongrass Woodland
		B2	Douglas-fir / Rio Grande Cottonwood Forest
		B7	Douglas-fir Scree Woodland
G14	Southern Rocky Mountain Ponderosa Pine Woodland	B8	Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland
		B9	Ponderosa Pine / Blue Grama Woodland
		B10	Ponderosa Pine / Gambel Oak Woodland
G15	Transportation	B45	Major Roads
G16	Water	B53	Tsaile Lake

Table 13. Group map class accuracy statistics

Group map class		Users' accuracy (%)	90% CI[1] (range)	Producers' accuracy (%)	90% CI (range)
G1	Agriculture	75.0	65.9 - 82.4	94.7	87.5 - 97.9
G2	Barren	85.0	67.8 - 93.8	100.0	27.0 - 100.0
G3	Colorado Plateau Mixed Bedrock and Tableland	25.0	57.9 - 64.4	100.0	27.0 - 100.0
G4	Colorado Plateau Pinyon Juniper Woodland	94.7	91.3 - 96.8	77.2	72.3 - 81.4
G5	Colorado Plateau Riparian Woodland and Shrubland	86.9	78.2 - 92.4	76.8	67.5 - 84.1
G6	Inter-Mountain Basins Big Sagebrush Shrubland	96.4	89.8 - 98.8	85.7	77.0 - 91.5
G7	Inter-Mountain Basins Mixed Salt Desert Scrub	54.2	37.9 - 69.6	100.0	82.8 - 100.0
G8	Inter-Mountain Basins Semi-desert Grassland	56.3	41.9 - 69.6	60.0	45.1 - 73.3
G9	Inter-Mountain Basins Semi-desert Shrub-Steppe	71.7	61.3 - 80.1	72.9	62.5 - 81.2
G10	Residential	100.0	78.7 - 100.0	71.4	49.4 - 86.5
G11	Rocky Mountain Aspen Forest and Woodland	100.0	27.0 - 100.0	100.0	27.0 - 100.0
G12	Rocky Mountain Gambel Oak-Mixed Montane Shrubland	36.0	22.3 - 52.4	81.8	57.3 - 93.8
G13	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland	62.5	42.2 - 79.2	90.9	67.7 - 97.9
G14	Southern Rocky Mountain Ponderosa Pine Woodland	68.8	58.6 - 77.4	89.8	80.5 - 94.9
G15	Transportation	100.0	27.0 - 100.0	100.0	27.0 - 100.0
G16	Water	100.0	27.0 - 100.0	100.0	27.0 - 100.0

[1] CI = confidence interval

Table 14. Group map class summary statistics

Group map class		Project Area				Park Area				Occurrence outside park boundaries (%)
		# Map units	Ha	Ac	Project area land cover (%)	# Map units	Ha	Ac	Park area land cover (%)	
G1	Agriculture	152	423.6	1046.7	0.7	99	312.1	771.2	0.8	26.3
G2	Barren	634	1,548.5	3,826.3	2.6	604	1,451.7	3,587.2	3.9	6.2
G3	Colorado Plateau Mixed Bedrock and Tableland	15	23.2	57.3	<0.1	15	23.2	57.3	0.1	<0.1
G4	Colorado Plateau Pinyon Juniper Woodland	1,789	37,223.6	91981.5	62.3	1431	24,632.0	60,867.1	65.8	33.8
G5	Colorado Plateau Riparian Woodland and Shrubland	208	1,012.6	2502.2	1.7	169	911.5	2,252.3	2.4	10.0
G6	Inter-Mountain Basins Big Sagebrush Shrubland	877	8,897.5	21,986.3	14.9	538	3,290.3	8130.4	8.8	63.0
G7	Inter-Mountain Basins Mixed Salt Desert Scrub	50	671.0	1658.2	1.1	28	309.1	763.9	0.8	53.9
G8	Inter-Mountain Basins Semi-desert Grassland	61	211.0	521.3	0.4	53	167.0	412.6	0.4	20.9
G9	Inter-Mountain Basins Semi-desert Shrub-Steppe	310	1934.2	4779.6	3.2	284	1458.8	3604.9	3.9	24.6
G10	Residential	10	66.7	164.9	0.1	2	12.3	30.4	<0.1	81.6
G11	Rocky Mountain Aspen Forest and Woodland	1	1.0	2.4	<0.1	1	1.0	2.4	<0.1	<0.1
G12	Rocky Mountain Gambel Oak-Mixed Montane Shrubland	113	436.2	1077.9	0.7	110	432.3	1068.3	1.2	0.9
G13	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland	167	1724.6	4261.6	2.9	163	1709.0	4223.0	4.6	0.9
G14	Southern Rocky Mountain Ponderosa Pine Woodland	321	5417.9	13387.9	9.1	234	2670.4	6598.7	7.1	50.7
G15	Transportation	4	66.9	165.2	0.1	9	41.6	102.9	0.1	37.7
G16	Water	6	80.8	199.7	0.1	4	26.2	64.7	0.1	67.6
	Total	**4,718.0**	**59,739.3**	**147,619.0**		**3,744.0**	**37,448.5**	**92,537.3**		

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4.2.4 Management Map Class Accuracy and Summary Statistics

4.2.4.1 Accuracy

Twenty-eight management map classes were created by aggregating the base map classes (fig. 16, table 15, Appendix F). The overall accuracy of the management map classes (table 16, Appendix H) was 69.0%; Kappa Index was 68.2% +/- 0.02. Eight of the management map classes met the 80% standard for both user accuracy and producer accuracy, and nine met the standard for either user or producer accuracy.

4.2.4.2 Summary statistics

The 28 management map classes consisted of five developed or agricultural map classes, three landform-based map classes, and twenty vegetated classes (table 17). The three most abundant map classes were Mixed Conifer Sagebrush Woodland (44.0%), Big Sagebrush / Natural and Semi-natural Understory Shrubland (14.9%), and Two-needle Pinyon – Utah Juniper / Shrub Live Oak Woodland (10.7%). These constituted 69.6% of the park vegetation.

4.3 Uses and Limitations of the Vegetation Map Database and Affiliated Products

The vegetation map database provides three representations of the CACH vegetation. The finest thematic resolution, represented by the base map classes, offers the most spatial detail with the lowest accuracy. Both the group and management map classes represent the vegetation at coarser thematic resolution, but with greater accuracy. While each representation provides information, and the representation chosen for any particular objective should be evaluated using the accuracy assessment and summary statistics tables provided in this report and in Appendices G and H.

The vegetation map database and ancillary products produced during the course of this project can provide both background and direct input to a number of park and SCPN activities. Other national park units have used products from vegetation classification, distribution, and mapping projects to informactivities related to resource management, environmental compliance, planning (locating new features), fire management planning, habitat modeling, education and interpretation, inventory and monitoring (placement of sample sites), research, and cooperative work with adjacent land owners.

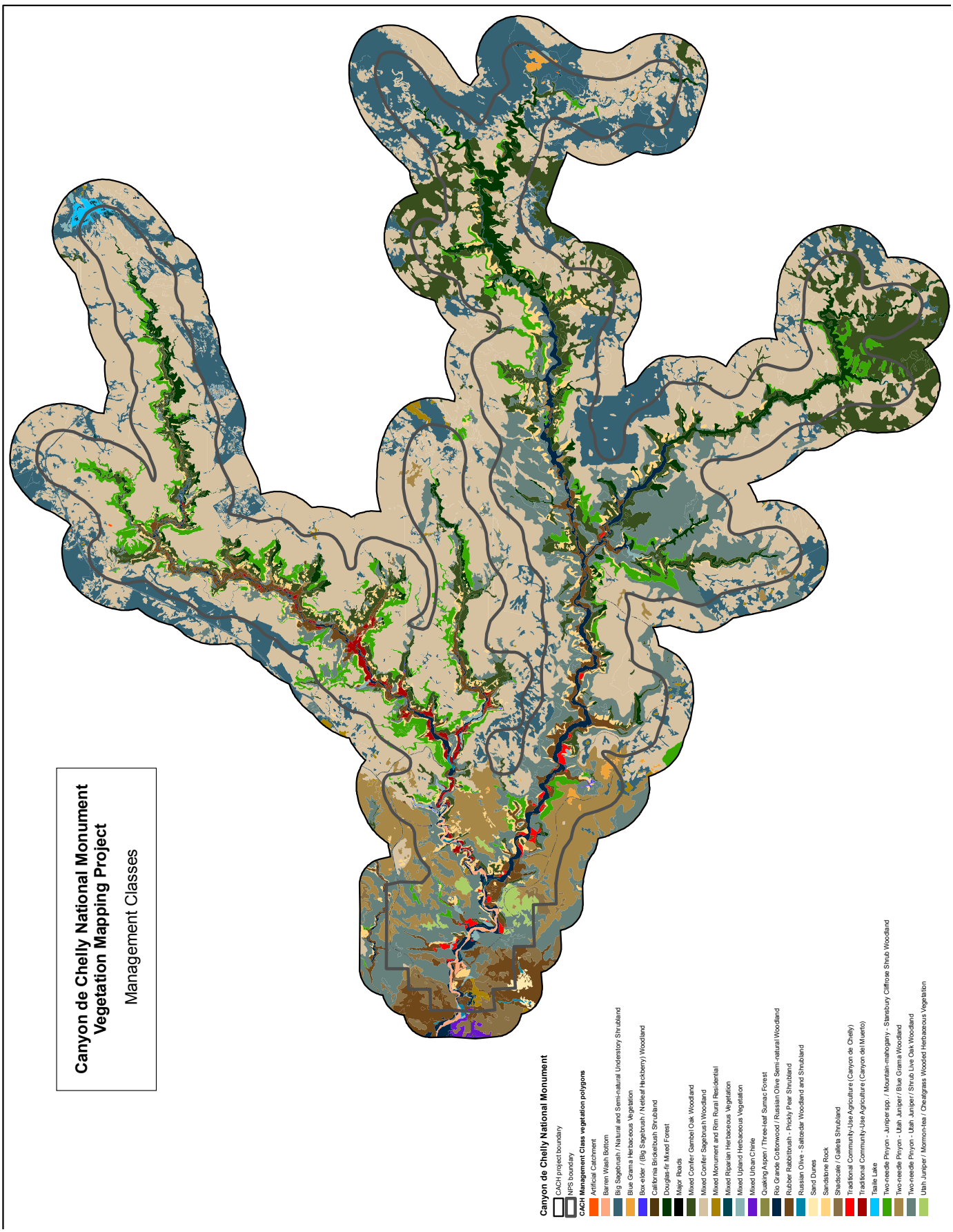


Figure 16. Management map classes at Canyon de Chelly National Monument

Table 15. Crosswalk of management map classes to base map classes

Management map class		Base map class	
M1	Artificial Catchment	B43	Artificial Catchment
M2	Barren Wash Bottom	B44	Barren Wash Bottom
M3	Big Sagebrush / Natural and Semi-natural Understory Shrubland	B24	Big Sagebrush / Black Sagebrush Shrubland
		B25	Big Sagebrush / Blue Grama Shrubland
		B26	Big Sagebrush / Disturbed Understory Semi-natural Shrubland
M4	Blue Grama Herbaceous Vegetation	B35	Blue Grama Herbaceous Vegetation
M5	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland	B4	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland
M6	California Brickelbush Shrubland	B36	California Brickelbush Shrubland
M7	Douglas-fir Mixed Forest	B1	Douglas-fir / Gambel Oak Forest
		B6	Douglas-fir / Muttongrass Woodland
		B2	Douglas-fir / Rio Grande Cottonwood Forest
		B7	Douglas-fir Scree Woodland
M8	Major Roads	B45	Major Roads
M9	Mixed Conifer Gambel Oak Woodland	B27	Gambel Oak / Cliff Fendlerbush Shrubland
		B28	Gambel Oak Woodland
		B10	Ponderosa Pine / Gambel Oak Woodland
		B14	Two-needle Pinyon - *Juniper* spp. / Gambel Oak Woodland
		B23	Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland
M10	Mixed Conifer Sagebrush Woodland	B8	Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland
		B9	Ponderosa Pine / Blue Grama Woodland
		B13	Two-needle Pinyon - Juniper spp. / Big Sagebrush Woodland
		B15	Two-needle Pinyon - Utah Juniper / Black Sagebrush Woodland
M11	Mixed Monument and Rim Rural Residential	B47	Mixed Urban Monument
		B48	Rim agriculture
M12	Mixed Riparian Herbaceous Vegetation	B40	Mixed Riparian Herbaceous
M13	Mixed Upland Herbaceous Vegetation	B37	Cheatgrass Herbaceous Vegetation
		B38	Desert Wheatgrass Herbaceous Vegetation
		B39	Indian Ricegrass Colorado Plateau Herbaceous Vegetation
		B41	Mixed Weedy Herbaceous
M14	Mixed Urban Chinle	B46	Mixed Urban Chinle
M15	Quaking Aspen / Three-leaf Sumac Forest	B3	Quaking Aspen / Three-leaf Sumac Forest
M16	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland	B11	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland
M17	Rubber Rabbitbrush - Prickly Pear Shrubland	B34	Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation
		B5	Boxelder / Disturbed Understory Woodland
		B29	Prickly-pear Dwarf-shrubland
		B30	Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland
M18	Russian Olive - Saltcedar Woodland and Shrubland	B12	Russian Olive Woodland
		B31	Saltcedar Temporarily Flooded Shrubland

Table 15. continued. Crosswalk of management map classes to base map classes

Management map class		Base map class	
M19	Sand Dunes	B49	Sand Dunes
M20	Sandstone Rock	B50	Sandstone Rock
M21	Shadscale / Galleta Shrubland	B32	Shadscale / Galleta Shrubland
M22	Traditional Community-Use Agriculture (Canyon de Chelly)	B51	Traditional Community-Use Agriculture (Canyon de Chelly)
M23	Traditional Community-Use Agriculture (Canyon del Muerto)	B52	Traditional Community-Use Agriculture (Canyon del Muerto)
M24	Tsaile Lake	B53	Tsaile Lake
M25	Two-needle Pinyon - Juniper spp. / Mountain-mahogany - Stansbury Cliffrose Shrub Woodland	B15	Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland
		B22	Two-needle Pinyon - Utah Juniper / Stansbury Cliffrose Woodland
M26	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland	B17	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland
M27	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland	B18	Two-needle Pinyon - Utah Juniper / Cliff Fendlerbush Woodland
		B19	Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland
		B20	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland
		B21	Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland
		B33	Utah Serviceberry - Cliff Fendlerbush Shrubland
M28	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation	B42	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation

Table 16. Management map class summary statistics

Management map class		Project area				Park area				Occurrence outside park boundaries (%)
		# Map units	Ha	Ac	Project area land cover (%)	# Map units	Ha	Ac	Park area land cover (%)	
M1	Artificial Catchment	11.0	4.4	10.8	<0.1	5.0	2.4	5.8	<0.1	45.8
M2	Barren Wash Bottom	9.0	109.9	271.5	<0.1	9.0	95.9	236.9	<0.1	12.7
M3	Big Sagebrush / Natural and Semi-natural Understory Shrubland	877.0	8,897.5	21,986.3	0.1	538.0	3,290.3	8,130.4	0.1	63.0
M4	Blue Grama Herbaceous Vegetation	28.0	102.7	253.8	<0.1	25.0	83.4	206.0	<0.1	18.8
M5	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland	11.0	9.2	22.7	<0.1	11.0	9.2	22.7	<0.1	<0.1
M6	California Brickelbush Shrubland	9.0	11.3	27.9	<0.1	9.0	11.3	27.9	<0.1	<0.1
M7	Douglas-fir Mixed Forest	167.0	1,724.6	4,261.6	<0.1	163.0	1,709.0	4,223.0	<0.1	0.9
M8	Major Roads	4.0	66.9	165.2	<0.1	9.0	41.6	102.9	<0.1	37.7
M9	Mixed Conifer Gambel Oak Woodland	508.0	5,661.5	13,989.9	0.1	488.0	3,899.6	9,636.2	0.1	31.1
M10	Mixed Conifer Sagebrush Woodland	951.0	26,270.9	64,916.7	0.4	604.0	14,895.1	36,806.7	0.4	43.3
M11	Mixed Monument and Rim Rural Residential	63.0	158.0	390.4	<0.1	16.0	48.5	119.8	<0.1	69.3
M12	Mixed Riparian Herbaceous Vegetation	59.0	111.0	274.3	<0.1	46.0	83.3	205.8	<0.1	24.9
M13	Mixed Upland Herbaceous Vegetation	33.0	108.2	267.5	<0.1	28.0	83.6	206.6	<0.1	22.8
M14	Mixed Urban Chinle	9.0	56.5	139.6	<0.1	1.0	2.1	5.1	<0.1	96.4
M15	Quaking Aspen / Three-leaf Sumac Forest	1.0	1.0	2.4	<0.1	1.0	1.0	2.4	<0.1	<0.1
M16	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland	121.0	863.2	2,133.1	<0.1	104.0	806.7	1,993.3	<0.1	6.6
M17	Rubber Rabbitbrush - Prickly Pear Shrubland	303.0	1,754.1	4,334.4	<0.1	276.0	1,283.2	3,170.9	<0.1	26.8
M18	Russian Olive - Saltcedar Woodland and Shrubland	16.0	28.2	69.7	<0.1	8.0	12.3	30.4	<0.1	56.4
M19	Sand Dunes	5.0	48.5	119.9	<0.1	1.0	6.9	17.2	<0.1	85.7
M20	Sandstone Rock	620.0	1,390.1	3,434.9	<0.1	594.0	1,348.9	3,333.1	<0.1	3.0
M21	Shadscale / Galleta Shrubland	50.0	671.0	1,658.2	<0.1	28.0	309.1	763.9	<0.1	53.9
M22	Traditional Community-Use Agriculture (Canyon de Chelly)	29.0	91.2	225.3	<0.1	29.0	91.2	225.3	<0.1	<0.1
M23	Traditional Community-Use Agriculture (Canyon del Muerto)	50.0	180.3	445.6	<0.1	50.0	180.3	445.6	<0.1	<0.1
M24	Tsaile Lake	6.0	80.8	199.7	<0.1	4.0	26.2	64.7	<0.1	67.6
M25	Two-needle Pinyon - Juniper spp. / Mountain-mahogany - Stansbury Cliffrose Shrub Woodland	190.0	2,193.0	5,419.1	<0.1	186.0	2,083.3	5,147.8	0.1	5.0
M27	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland	488.0	6,406.3	15,830.4	0.1	424.0	5,244.1	12,958.5	0.1	18.1
M28	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation	14.0	193.0	476.8	<0.1	14.0	187.5	463.3	<0.1	2.8
	Total	**4,718.0**	**59,739.3**	**147,619.0**		**3,744.0**	37,448.5	**92,537.3**		

Table 17. Management map class accuracy statistics

Management map class		Users' accuracy (%)	90% CI[1] (range)	Producers' accuracy (%)	90% CI (range)
M1	Artificial Catchment	100.0	52.8 - 100.0	60.0	27.2 - 85.7
M2	Barren Wash Bottom	88.9	62.3 - 97.5	100.0	74.7 - 100.0
M3	Big Sagebrush / Natural and Semi-natural Understory Shrubland	96.4	89.8 - 98.8	88.5	80.1 - 93.7
M4	Blue Grama Herbaceous Vegetation	53.3	33.3 - 72.3	80.0	54.1 - 93.1
M5	Box-elder / (Big Sagebrush / Netleaf Hackberry) Woodland	0.0	N/A	N/S[2]	N/S
M6	California Brickelbush Shrubland	66.7	25.4 - 92.2	50.0	18.2 - 81.8
M7	Douglas-fir Mixed Forest	62.5	42.2 - 79.2	90.9	67.7 - 97.9
M8	Major Roads	100.0	27.0 - 100.0	100.0	27.0 - 100.0
M9	Mixed Conifer Gambel Oak Woodland	52.4	42.1 - 62.4	62.3	51.0 - 71.4
M10	Mixed Conifer Sagebrush Woodland	75.3	67.4 - 81.7	77.7	69.9 - 83.9
M11	Mixed Monument and Rim Rural Residential	66.7	49.9 - 80.1	80.0	62.2 - 90.7
M12	Mixed Riparian Herbaceous Vegetation	69.6	52.4 - 82.6	48.5	34.8 - 62.4
M13	Mixed Upland Herbaceous Vegetation	29.4	15.1 - 49.4	26.3	13.4 - 45.1
M14	Mixed Urban Chinle	100.0	76.9 - 100.0	90.0	62.2 - 97.7
M15	Quaking Aspen / Three-leaf Sumac Forest	100.0	27.0 - 100.0	100.0	27.0 - 100.0
M16	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland	69.2	53.1 - 81.7	85.7	69.1 - 94.1
M17	Rubber Rabbitbrush - Prickly Pear Shrubland	77.6	66.5 - 85.8	74.5	63.4 - 83.1
M18	Russian Olive - Saltcedar Woodland and Shrubland	27.3	11.5 - 52.0	27.3	11.5 - 52.0
M19	Sand Dunes	100.0	52.6 - 100.0	100.0	52.6 - 100.0
M20	Sandstone Rock	75.0	46.0 - 91.3	100.0	68.9 - 100.0
M21	Shadscale / Galleta Shrubland	54.2	37.9 - 69.6	100.0	82.8 - 100.0
M22	Traditional Community-Use Agriculture (Canyon de Chelly)	63.2	44.4 - 78.6	92.3	71.8 - 98.3
M23	Traditional Community-Use Agriculture (Canyon del Muerto)	85.2	70.8 - 93.2	95.8	83.3 - 99.1
M24	Tsaile Lake	100.0	27.0 - 100.0	100.0	27.0 - 100.0
M25	Two-needle Pinyon - *Juniper* spp. / Mountain-mahogany - Stansbury Cliffrose Shrub Woodland	55.6	42.0 - 68.3	45.5	33.7 - 57.7
M26	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland	62.5	45.8 - 76.7	60.0	43.7 - 74.4
M27	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland	70.7	60.1 - 79.4	55.4	45.9 - 64.6
M28	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation	58.3	35.6 - 78.0	87.5	58.9 - 97.2

[1]CI = confidence interval

[2]N/S = not sampled

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Glossary

Glossary modified from USGS-NPS Vegetation Mapping Program: http://biology.usgs.gov/npsveg/glossary.html.

Accuracy: The closeness of results of observations, computations, or estimates to the true values or to values that are accepted as being true (Rabchevsky 1984). In the USGS-NPS Vegetation Mapping Program there are two aspects of accuracy: thematic and positional accuracy.

Accuracy assessment: The process of determining the positional and thematic accuracy of the spatial vegetation community data. This is an independent process performed after the vegetation mapping and classification is complete.

Accuracy assessment point: A location where accuracy assessment data are collected.

Aerial photography: Analog imagery taken from an airplane. The optical axis is oriented perpendicular to the earth's surface so that the film is parallel to the surface being photographed. (also Vertical Aerial Photography). A sequence of aerial photographs will overlap so the photos can be used in stereoscopic analysis (stereo pairs). The overlap is referred to as "endlap" (top-to-bottom area in common, same flightline) and "sidelap" (side-to-side area in common, different flightlines) (portions from Rabchevsky 1984). Aerial photography used in the program is 9 × 9-inch vertical, stereoscopic, color or color infrared photography.

Alliance: A physiognomically uniform group of associations sharing one or more diagnostic (dominant, differential, indicator, or character) species that, as a rule, are found in the uppermost stratum of the vegetation (FGDC 1997). This is the second-finest level in the National Vegetation Classification Standard hierarchy. See the table under USNVC.

Anderson Classification System: A land cover/land use classification system developed for use with remote sensing systems in the 1970s adopted for the USGS-NPS Vegetation Mapping Program to map cultural land cover (Anderson et al. 1976); see below.

Anderson Classification System.

Level I	Level II
Urban or Built-up Land	Residential
	Commercial and Services
	Industrial
	Transportation, Communications, and Utilities
	Industrial and Commercial Complexes
	Mixed Urban or Built-up Land
	Other Urban or Built-up Land
Agricultural Land	Cropland and Pasture
	Orchard, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
	Confined Feeding Operations
	Other Agricultural Lands
Water (non-vegetated portion)	Streams and Canals
	Lakes
	Reservoirs
	Bays and Estuaries
Barren Land	Dry Salt Flats
	Beaches
	Sandy Areas other than Beaches
	Strip Mines, Quarries, and Gravel Pits
	Transitional Areas
	Mixed Barren Lands
Perennial Snow or Ice	Perennial Snowfields
	Glaciers

Note: This is not the complete Anderson Level II Classification. Areas of natural vegetation are classified under the NVCS.

Association: The finest level of the National Vegetation Classification Standard. The association is a physiognomically uniform group of vegetation stands that share one or more diagnostic (dominant, differential, indicator, or character) overstory and

understory species. These elements occur as repeatable patterns of assemblages across the landscape, and are generally found under similar habitat conditions (FGDC 1997). See table under USNVC an example. Within the program association is the preferred term, but it is also synonymous with community, community type, plant community, type, vegetation community, and vegetation type.

Attribute: (digital data) A numeric, text, or image data field in a relational database table (such as a GIS) that describes a spatial feature (point, line, polygon, cell) (ESRI 1994).

Automate: The process of entering data into a computer. Synonymous with digitize.

Base map: The source or control from which all spatial data are developed and geo-referenced to. Photo interpreted data are transferred to a base to rectify and register the data. For this program, base maps consist of USGS DOQQs or specially made orthophotos.

Class: The level in the National Vegetation Classification Standard hierarchy based on the structure of the vegetation and determined by the relative percentage of cover and the height of the dominant, uppermost life forms (Grossman et al. 1998). See the table under USNVC.

Classification accuracy: How closely the map classes match the vegetation communities found on the landscape. This is determined by accuracy assessment protocols. See "Producing rigorous and consistent accuracy assessment procedures" at http://biology.usgs.gov/npsveg/aa/index.html for more information. Also see producer and user accuracy.

Community: An assemblage of species that co-occur in defined areas at certain times and have the potential to interact with one anther (Grossman et al. 1998). May also refer to an association in the USNVC, but this is not preferred.

Contingency table: A table that compares mapped data with ground data to determine accuracy. The "known" classes derived from accuracy assessment plots are compared to the classes derived from photo interpretation. The results are then tabulated in the form of a contingency table to determine the degree of misclassification that has occurred between classes. Also referred to as error matrix, confusion matrix, or misclassification matrix. For an example of a contingency table see http://biology.usgs.gov/npsveg/scbl/aa_matrix.html.

Cover: The area of ground covered by the vertical projection of the aerial parts of plants of one or more species.(FGDC 1997).

Cover type: A designation based upon the plant species forming a plurality of composition within a given area (e.g., Oak–Hickory) (FGDC 1977). Also refers to an alliance or group of alliances in the USNVC.

Coverage: A file format used by Arc/Info software for vector spatial data.

Crosswalk: Relationship between the elements of two classification systems. For example, there is a crosswalk between map classes and units of the NVCS. This relationship is often shown in a look up table.

Datum: A mathematical model that describes the size and shape of the ellipsoid. The earth is not a sphere, but an ellipsoid distorted by rotation about its axis, with the globe bulging at the equator and flattened at the poles. The flattening is not uniform around the Earth due to the influence of the continents location (Snyder 1982). Using the wrong datum in relation to geographic coordinates can result in errors of hundreds of meters in position. This program uses the North American Datum (NAD) of 1983 or NAD83.

Density: The relationship between the area covered by the overstory of a

vegetation community and the total area of a polygon in which the community is found. One of the physiognomic modifiers classified in the USGS-NPS Vegetation Mapping Program. Density in map units is classified as Closed/Continuous >60 %, Discontinuous 40–60%, Dispersed 25–40%, Sparse 10–25%, Rare 2–10%. Compare with pattern and height.

Dichotomous field key: A document that identifies vegetation communities on the basis of exclusive characteristics. An example of exclusive characteristics is forested versus non-forested. Also known as vegetation field key and vegetation key. This key is an important product of each vegetation-mapping project. For an example of a dichotomous field key visit http://biology.usgs.gov/npsveg/agfo/report.pdf#vegkey.

Digital Orthophoto Quarter Quadrangle (DOQQ): USGS digital product derived from high altitude aerial photography. These digital images are rectified and registered to locations on the earth and cover approximately one quarter of a 7.5-minute quadrangle. Also called 3.75-minute DOQ. DOQs are often used as base maps to register the photo interpreted data in this program.

Digitize: The process of entering data into a computer. There are several methods of entering spatial data into a computer including manual digitizing, scan digitizing, and soft copy photogrammetric methods. Synonymous with automate.

Division: The highest level in the NVCS separating Earth cover into either vegetated or non-vegetated categories (FGDC 1997). See table under USNVC.

Dominance: The extent to which a given species or life form predominates in a community because of its size, abundance or cover, and affects the fitness of associated species (FGDC 1997).

Error: The distance of results of observations, computations, or estimates from the true values or to values that are accepted as being true. Also refers to the misclassification of thematic data. Contrast with accuracy.

Error matrix: See contingency table.

Federal Geographic Data Committee (FGDC): Coordinates the development of the National Spatial Data Infrastructure (NSDI). The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. The 17 federal agencies that make up the FGDC are developing the NSDI in cooperation with organizations from state, local and tribal governments, the academic community, and the private sector. The program complies with FGDC standards for vegetation classification, metadata, spatial data transfer, and positional accuracy.

Field reconnaissance: Preliminary field visits by photo interpreters and vegetation classification experts to gain an overview of the vegetation of the project area and how it relates to the NVCS. Communication between photo interpreters and vegetation classification experts during this fieldwork is key to developing an accurate classification system. Observation point data are collected during this reconnaissance.

Field verification: Field visits by photo interpreters after photo interpretation is complete to check for correctness of photo interpretation. At this point changes may be made to the photo interpretation. This occurs prior to accuracy assessment.

Flight line: Refers to a line or strip of aerial photography. Usually designated on the film as “flightline number – photo number”. Technical: A line connecting the principal points of sequential vertical aerial photographs (portions from Rabchevsky 1984)

Floristics: The kinds and number of plant species in particular areas and their distribution.

Formation: A level in the National

Vegetation Classification Standard hierarchy below subgroup which represents vegetation types that share a definite physiognomy or structure within broadly defined environmental factors, relative landscape positions, or hydrologic regimes (Grossman et al. 1998). See table under USNVC.

Geographic Information System (GIS): An organized collection of geographically (spatially) referenced information (portions from ESRI 1994).

Georeference: The process of converting a map or image into real-world coordinates. A non-georeferenced map or image is said to be in "digitizer-inches" or "scanner-inches," that is, it has no real-world coordinates.

Global Positioning System (GPS): A system of satellites, ground receiving stations and handheld receivers that allow accurate measurement of feature coordinates on the face of the earth. GPS receivers are used to measure the location of field plots, reconnaissance points, and accuracy assessment points.

Ground truth: The process of taking aerial photographs into the field to verify the ground condition compared to how that condition appears in the photograph.

Group: The level in the National Vegetation Classification Standard hierarchy below subclass based on leaf characteristics and identified and named in conjunction with broadly defined macroclimatic types to provide a structural-geographic orientation (Grossman et al. 1998). See table under USNVC.

Habitat: The combination of environmental or site conditions and ecological processes influencing a plant community.

Habitat type: (1) a collective term for all parts of the land surface supporting, or capable of supporting, the same kind of climax plant association (Daubenmire 1978); (2) an aggregation of land areas having a narrow range of environmental variation and capable of supporting a given plant association (Gabriel and Talbot 1984).

Hectare: A metric unit of measure equal to 10,000 m^2, or approximately 2.471 acres.

Height: Height of the overstory of a vegetation community. One of the physiognomic modifiers classified in the USGS-NPS Vegetation Mapping Program. Height in map units is classified as <0.5 meters, 0.5–2 meters, 2–5 meters, 5–15 meters, 15–35 meters, 35–50 meters, or >50 meters. Compare with density and pattern.

Integrated Taxonomic Information System (ITIS): A comprehensive, standardized reference for the scientific names, and synonyms and common names, for all the plants and animals and other biological organisms of North America and the surrounding oceans developed and maintained by an international partnership among agencies, organizations, and taxonomic specialists. This database is accessible over the Internet and is used by scientists, resource managers, educators and students, museum curators, conservationists, and the interested public. The USDA PLANTS database (http://plants.usda.gov/) is an important ITIS partner providing plant taxonomic information to ITIS (http://www.itis.gov/).

Land cover classification: A classification of the cultural, physical, and vegetation features that cover the earth, commonly used with remote sensing technology. Vegetation classification is a subset of land cover classification.

Land use classification: A classification of the earth's surface that defines the use that people are making of the land, commonly used with remote sensing technology, and commonly combined with land cover classification. Natural vegetation areas may be classified as "vacant" or "forest," or "grazing".

Land use/land cover classification: A combination of a land use classification and land cover classification where the land use classification is used to classify areas that are under a definite land use, such as agriculture, residential, or mining. The land cover classification is used to classify lands that that do not have definite land use, such as areas of bare rock, snow and ice, or open water. The Anderson Classification System is a land cover and land use classification.

Look-up table: A computer file that relates the elements of one classification to another in a crosswalk. The values of a map classification are related to the associations of the NVCS in a park project.

Map accuracy: A measure of the maximum errors permitted in horizontal positions and elevations shown on maps. The National Map Accuracy Standard of the USGS at 1:24,000 scale is the map accuracy standard for the program. This standard is that 90% of well-defined objects should appear within 40 feet (12.2 meters) of their true location. See United States National Map Accuracy Standards.

Map attribute: Collectively the map class (or map unit) code, the physiognomic modifier codes, and special modifiers if they are used: map unit code is that portion of the map attribute code defining the map unit (e.g., AB) the physiognomic modifier code portion of map attribute code defining the vegetation community's structure (e.g. -1A3). The map attribute code is thus AB-1A3.

Map class: The vegetation units that can be discerned on an aerial photograph. Often associations in an alliance cannot be distinguished on an aerial photograph because the differences are found in the understory, so map classes must be developed. For example, at Devils Tower National Monument, there were five associations in the Ponderosa Pine Woodland Alliance, but it was necessary to create two ponderosa pine map classes because the associations could not be distinguished on the photography. Map classes may be complexes or mosaics of associations or map classes may also be the same as an association if that can be discerned on the photograph. Also known as map unit.

Map unit: See map class.

Map validation: The process of field checking and updating photo interpretation. This step is completed prior to accuracy assessment.

Metadata: Data about data. Metadata describes the content, quality, condition, and other characteristics of data. Its purpose is to help organize and maintain a organization's internal investment in spatial data, provide information about an organization's data holdings to data catalogues, clearinghouses, and brokerages, and provide information to process and interpret data received through a transfer from an external source (FGDC 1997). The FGDC sets standards for metadata content and structure.

Minimum Mapping Unit (MMU): The smallest area that will be consistently delineated during photo interpretation. The MMU for the USGS-NPS Vegetation Mapping Program is 0.5 hectares.

National Vegetation Classification Standard (NVCS): The Federal Geographic Data Committee's vegetation classification standard. It has been adopted to the formation level (as of June 2001); adoption of the floristic levels is pending. It is based on the Association for Biodiversity Information's United States National Vegetation Classification (USNVC) system. See table under USNVC for comparison and crosswalk.

NatureServe Explorer: A website managed by NatureServe that provides authoritative conservation information in a searchable database for more than 50,000 plants, animals, and ecological communities in the U.S. and Canada. Vegetation community data developed by the USGS-NPS Program is available

on NatureServe (URL is http://www.natureserveexplorer.org/).

North American Datum (NAD): The datum for map projections and coordinates throughout North America (see also datum). Usually associated with a version, such as 1927 or 1983. This program uses the 1983 datum (NAD83), which is consistent with satellite location systems. The 1983 datum uses the GRS 80 spheroid whereas the 1927 datum uses the Clarke 1866 spheroid (portions from ESRI 1994).

Observation point: A field location point used to support map unit and vegetation classification development. These points are collected during reconnaissance and the mappers' subsequent fieldwork.

Order: The second-highest level in the NVCS hierarchy under Division. The orders within the Vegetated Division are generally defined by dominant life form (tree, shrub, dwarf shrub, herbaceous, or non-vascular). (FGDC 1997). See table under USNVC.

Ortho image: An aerial photograph that has had the distortions due to camera lens, topographic relief, tilt of the aircraft, and other factors common to aerial photography removed and has been registered to locations on the earth. A digital ortho image can be placed in a GIS and have other layers, such as vegetation, overlain on it. Aerial photo interpretation can also be registered to an ortho image in the process of registering and automating the data into a GIS. A DOQ is a digital ortho image covering 3.75 minutes by 3.75 minutes of the earth's surface.

Pattern: Configuration of vegetation features or across a landscape. One of the physiognomic modifiers classified in the USGS-NPS Vegetation Mapping Program. Pattern in map units is classified as Evenly Dispersed, Clumped/Bunched, Gradational/Transitional, Alternating. Compare with density and height.

Photo interpretation: The art and science of identifying and delineating objects on an aerial photograph. Photo interpreters in the USGS-NPS Vegetation Mapping Program are knowledgeable about the vegetation in their project area and highly skilled in identifying vegetation map units accurately and consistently.

Photo interpretation key: A description of the distinguishing features that make up the signature of each map class. This description may include written clues, as well as graphic examples of the signatures.

Photosignature: Characteristics of an item on a photograph by which the item may be identified.

Physiognomy: The structure and life form of a plant community (FGDC 1997).

Plant community: A generic term that references any vegetation found in the mapping study and can be any level in the USNVC, association or alliance, or a unique community to the park, a park special.

Positional accuracy: The nearness of a point in a spatial database to its actual location on the earth's surface. The program standard for horizontal positional accuracy meets National Map Accuracy Standards at the 1:24,000 scale. This means that each well-defined object in the spatial database will be within 1/50 of an inch of its actual location or 40 feet (12.2 meters).

Producer accuracy: The probability that a reference sample (the ground data) has been classified correctly, also known as error of omission. This quantity is computed by dividing the number of samples that have been classified correctly by the total number of reference samples in that class (Story and Congalton 1986). Compare with user accuracy.

Projection: A map or a geospatial database is a flat representation of data located on a curved surface. A projection is a device for producing all or part of a round body on a flat sheet. This projection cannot be done without distortion, so the cartographer

must choose which characteristic (distance, direction, scale, area, or shape) that is to be emphasized at the expense of the other characteristics (Snyder, 1982). All spatial data in the program are represented in the Universal Transverse Mercator (UTM) coordinate system that is based on the transverse mercator projection applied between 84 degrees north and 80 degrees south latitude.

Quadrangle: A USGS paper map. Typically, a 7.5-minute USGS map. Informally known as quad.

Quarter quadrangle: A map or image that includes ¼ the area of a 7.5-minute quadrangle and is organized in quadrants of the original quadrangle as follows: Northeast, Northwest, Southeast, and Southwest. USGS DOQQs cover ¼ of a 7.5-minute quadrangle. Informally known as quarter quad.

Rectify: Remove distortions common to aerial photographs in the process of automating the photo-interpreted information into a digital database. Distortions on aerial photographs are due to topographic relief on the ground, radial distortion in the geometry of the aerial photography, tip and tilt of the plane, and differences in elevation of the airplane from its nominal scale. This process may be separate or included in the registration process depending on the technology used. See transfer.

Register: The process of correlating objects on an aerial photograph with locations on the surface of the Earth using a defined coordinate system. This is necessary to be able to place the vegetation community data in a GIS with other appropriate data such as transportation, topography, soils, etc. This process may be separate or included in the rectification process depending on the technology used. See transfer.

Scale: The relationship between a distance portrayed on a map and the same distance on the Earth (Dana 1999). A map scale can be defined by a representative fraction (e.g., 1 unit on map / 12,000 units on ground) or by a graphic scale bar.

Spatial Data Transfer Standard (SDTS): A comprehensive transfer standard for Earth-referenced data endorsed by the Federal Geographic Data Committee. Spatial data in SDTS format consists of a group of files each with specific content and format.

Signature: The unique combination of color, texture, pattern, height, physiognomy, and position in the landscape used by an photo interpreters to identify map classes on an aerial photograph.

Stratum: A horizontal layer of vegetation. A stratum may be defined by the life form of the vegetation (tree, shrub, herbaceous), or its actual height.

Structure (Vegetation): The spatial distribution pattern of life forms in a plant community, especially with regard to their height, abundance, or coverage within the individual layers. Synonymous with physiognomy.

Subclass: The level in the National Vegetation Classification Standard hierarchy under class based on growth form characteristics (Grossman et al. 1998). See hierarchy under USNVS.

Subgroup: The level in the National Vegetation Classification Standard hierarchy below group which divides each group into either a "natural/semi-natural" or "cultural" (planted/cultivated) subgroup (Grossman et al. 1998). See hierarchy under USNVS.

Transfer: The process of moving photo interpreted data from an aerial photo overlay to an ortho image to register and rectify the data. This process varies depending on the type of technology used.

Transform(ation): The process of converting coordinates (map or image) from one coordinate system to another. This involves scaling, rotation, translation, and warping (images) (ESRI 1994).

Transition zone: An area where the vegetation composition and structure is intermediate between two associations. The transition zone may be small as the associations abruptly change due to a large shift in the landscape, such as a cliff, or it may be large as the physical environment changes gradually. Transition zones often are challenges to properly classify and/or map vegetation.

United States National Map Accuracy Standards (NMAS): USGS accuracy standards for published maps, including horizontal and vertical accuracy, accuracy testing method, accuracy labeling on published maps, labeling when a map is an enlargement of another map, and basic information for map construction as to latitude and longitude boundaries. The table below shows the standard for some common map scales. To meet NMAS maps must have less than 10 percent of the points tested (well-defined points) exceed the standard. Note that the conversion of paper maps into digital data usually creates additional error.

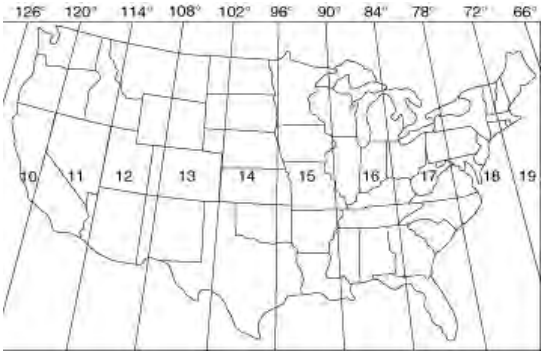
Horizontal accuracy examples.

Scale	Engineering Scale	National Map Accuracy Standard
1:1,200	1″= 100′	+/- 3.33 feet
1:2,400	1″= 200′	+/- 6.67 feet
1:4,800	1″= 400′	+/- 13.33 feet
1:9,600	1″= 800′	+/- 26.67 feet
1:10,000		+/- 27.78 feet
1:12,000	1″ = 1000′	+/- 33.33 feet
1:24,000	1″ = 2000′	+/- 40.00 feet
1:63,360	1″ = one mile	+/- 105.60 feet
1:100,000		+/- 166.67 feet

United States National Vegetation Classification (USNVC): The Association for Biodiversity's vegetation classification system. It is the basis for the FGDC National Vegetation Classification Standard.

User accuracy: The probability that a sample from the mapped data actually represents that category on the ground, also known as error of commission. This quantity is computed by dividing the number of correctly classified samples by the total number of samples that were classified as belonging to that category (Story and Congalton 1986). Compare with producer accuracy.

Universal Transverse Mercator (UTM): Map coordinate system (not a map projection) that is defined by the Transverse Mercator projection, which has a set of zones defined by a central meridian as shown in the figure below for the United States (Portions from ESRI 1994). All spatial data products developed by the program (vegetation spatial data, plot and accuracy assessment plot data locations are in this coordinate system.



Universal Transverse Mercator projections for the U.S.

Vegetation: The collective plant cover over an area (FGDC 1997).

Vegetation characterization: The detailed portrayal of a vegetation association using diagnostic and dominant species, structure, and ecological processes. The program has a formal structure for association description based on the ABI model. Also known as vegetation description. An example of an association characterization can be found at http://biology.usgs.gov/npsveg/agfo/mapclass/scbc.pdf.

Vegetation classification: The process of categorizing vegetation into repeatable

and consistent elements. Also a document the lists and organizes the vegetation communities in an area. An example of a vegetation classification can be found at http://biology.usgs.gov/npsveg/agfo/report.pdf#classification.

Vegetation community: See plant community.

Vegetation description: See vegetation characterization.

Vegetation field key: See dichotomous field key

Vegetation key: See dichotomous field key

Vegetation mapping: The process of identifying, labeling, and placing in real world coordinates vegetation communities.

Vegetation structure: See structure (vegetation).

Vertical aerial photography: See Aerial Photography.

Wetland: A location on the landscape that is characterized by either hydric soils or hydrophytic plants or both. A wetland may be vegetated or non-vegetated. The vegetation description for each association includes it wetland status.

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Appendix A: List of Project Products

This appendix lists the products developed for the Canyon de Chelly National Monument project. The report and appendices are available in hard copy and on the project DVD. The vegetation map database, field data locations and plant data, graphics, images, and metadata are also available on the DVD. This appendix lists each product, its file name on the DVD, and the format in which the product is available. The DVD is available with the hard copy report and through the Southern Colorado Plateau Network. These products are also available on the USGS-NPS Vegetation Mapping Program product pages (http://biology.usgs.gov/npsveg/products/cach.html).

Product/File Names	Description
Report	
cachrpt.pdf	Full report
cachquantclass.doc	Graphics of quantitative classification
cachveg.pdf	Low resolution map graphic
cachveg_large.pdf	High resolution map graphic
cachplotsclass.pdf	
cachplotsaa.pdf	
cachplotspi.pdf	Map graphics of classification, accuracy assessment, and photointerpretation plots
Aerial Photography	
cachcirmosaic.exe	Aerial photo mosaic
metacachcirmosaic.txt	Metadata for aerial photo mosaic in text format
cachdoqq.exe	All DOQQs
metacachphotosdoqq.txt	Metadata for DOQQs in text format
Field Data	
cachdata.mdb	Access database that includes all classification and accuracy assessment field data
metacachdata.txt	Metadata for classification and accuracy assessment field data in text format
cachfieldphotos.exe	Field photos: Classification and accuracy assessment
cachplotfieldform.pdf	Classification plots field form
cachaafieldform.pdf	Accuracy assessment plots field form
Classification Spatial Data	
cachplot.exe	Classification plots shapefile and metadata
metacachplots.txt	Metadata for classification plots
Thematic AA Points Spatial Data	
cachaa.exe	Accuracy assessment plots shapefile and metadata
metacachaa.txt	Metadata for accuracy assessment shapefile in text format
Park Boundary Spatial Data	
cachbdy.exe	Park boundary shapefile and metadata
metacachbdy.txt	Metadata for park boundary in text format
Project Boundary Spatial Data	
cachprjbdy.exe	Project boundary shapefile and metadata
metacachprjbdy.txt	Metadata for project boundary in text format
Vegetation Map Spatial Data	
cach.exe	Vegetation map shapefile and metadata
metacachspatial.txt	Metadata for vegetation maps in text format
Photointerpretation Sites Spatial Data	
cachphotoplots.exe	Photointerpretation observation locations shapefile and metadata
metacachphotoplots.txt	Photointerpretation sites shapefile metadata in text format

Appendix B: Plot Numbers Documenting Plant Communities at Canyon De Chelly National Monument

This appendix (see table, next page) lists the relevé numbers of ground-based observations for each plant community in this project. The data for the 145 classification relevés and the 738 accuracy assessment observations made in the field are available as an Access database (cachdata.exe) and mapped as GIS shapefiles (cachplot.exe and cachaa.exe). Images of the 2004 classification relevés and 2006 accuracy assessment observations are also available. The 2004 classification relevé codes are listed in the "PlotCode" field in the table and in "tblPlotDetails" within cachdata.exe. It is crosswalked to the "Plot_ID" field, which is used to reference the relevé in all other classification tables in the database. The relevé assignements are listed in tblVegetation, field Association. The 2006 accuracy assessment observation code refers to the "PlotCode"field, found in all three accuracy assessment tables in cachdata.exe. The photointerpreter's observation locations are also mapped as a shapefile. Appendix A lists the locations of these products and their metadata on the DVD. The 2001/03 Rink database is not available through this project.

	Plant community	2004 Classification releve code	2001/03 Glenn Rink survey code	2006 Accuracy assessment observation code
FOREST				
1	*Populus tremuloides / Rhus trilobata* Forest	CACH-0241		
2	*Pseudotsuga menziesii / Populus deltoides* Forest	CACH-0020		C1, C3, H8
3	*Pseudotsuga menziesii / Quercus gambelii* Forest	CACH-0097, CACH-0100, CACH-0166, CACH-0177, CACH-0218, CACH-0222, CACH-0240, CACH-0242	CACH-11182	A4, A18, A25, A28, A31, C2, C4, D7
WOODLAND				
4	*Acer negundo / Artemisia tridentata* Woodland	CACH-0021		D3, D4
5	*Acer negundo* / Disturbed Understory Woodland	CACH-0056		LL4
6	*Elaeagnus angustifolia* Semi-natural Woodland	CACH-0101	CACH-11937	JJ2, OO3, W1, W24, WW3, WW22, X4
7	*Juniperus scopulorum - Quercus gambelii* Woodland [Provisional]	CACH-0192		
8	*Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland	CACH-0016, CACH-0043, CACH-0060, CACH-0073, CACH-0076, CACH-0095, CACH-0111, CACH-0134, CACH-0138, CACH-0209	CACH-5179, CACH-8691, CACH-12031, CACH-17078, CACH-17078, CACH-17614, CACH-18537, CACH-18944,	CC11, CC21, H9, JJ4, M3, M7, M8, M9, M13, M14, O23, O26, O28, O29, O39, QQ3, QQ5, QQ7, QQ8, QQ9, QQ10, QQ11, V2
9	*Pinus edulis - Juniperus osteosperma / Amelanchier utahensis* Woodland	CACH-0058		A1, A3, A6, A7, A10, A19, AAA27, CC26, DD15, DD18, F2, G3, H2, H3, H7, I18, I22, J31, L4, P14, R16, S16, S17, T4, T7, T14, T19, T26, V9, V13, V26, V28, W22
10	*Pinus edulis - Juniperus osteosperma / Artemisia nova* Woodland	CACH-0078, CACH-0088, CACH-0194, CACH-0205, CACH-0221		DD16, DD21, FF6, I25, J27, K22, K25, O10, O12, O13, O15, O17, O19, O20, O25, O27, O30, Q17, QQ14 S30, S34, S6, U20
11	*Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus* Woodland	CACH-0063, CACH-0154, CACH-0064,		A36, AAA38, CC10, DD5, DD11, P5, P17, P21, P24, P27, Q5, R1, S4, T3
12	*Pinus edulis - Juniperus osteosperma / Chrysothamnus greenei* Woodland	CACH-0032		BB12, HH10, M1, M17, VV3
13	*Pinus edulis - Juniperus osteosperma / Ephedra viridis* Woodland		CACH-5750	
14	*Pinus edulis - Juniperus osteosperma / Fendlera rupicola* Woodland	CACH-0012, CACH-0102, CACH-0202		F3, H11, PP5, Q18, R15, V4, V14

	Plant community	2004 Classification releve code	2001/03 Glenn Rink survey code	2006 Accuracy assessment observation code
15	*Pinus edulis - Juniperus osteosperma / Purshia stansburiana* Woodland	CACH-0004, CACH-0006, CACH-0014, CACH-0035, CACH-0079, CACH-0081, CACH-0090, CACH-0094, CACH-0104, CACH-0105, CACH-0 112, CACH-0152, CACH-0198, CACH-0210, CACH-0211, CACH-0214, CACH-0216, CACH-0225	CACH-5343, CACH-5615, CACH-8447, CACH-9383, CACH-11861, CACH-11861B, CACH-19382	DD13, F5, I12, I28, I29, I30, J3, M2, M23, M33, Q29, Q30, R2, S14, S15, S22, S23, S25, S26, T11, U1, U4, U32, V7, V11, V17, V24
16	*Pinus edulis - Juniperus osteosperma / Quercus turbinella* Woodland	CACH-0128, CACH-0084, CACH-0174, CACH-0124, CACH-0144, CACH-0131, CACH-0063, CACH-0042, CACH-0045, CACH-0163	CACH-2097, CACH-2363, CACH-3305, CACH-5860, CACH-13422	BB11, DD12, DD14, DD19, DD20, FF7, I1, I2, I3, I4, I5, I16, I19, II3, M22, M25, N2, N3, P1, P4, P31, Q2, Q3, Q11, Q15, Q20, Q21, Q23, QQ1, QQ6, S1, S7, T6, T13, T17, T21, T22
17	*Pinus edulis - Juniperus osteosperma /* Sparse Understory Woodland	CACH-0030, CACH-0033, CACH-0038, CACH-0049, CACH-0067, CACH-0141, CACH-0147, CACH-0173, CACH-0217	CACH-5071, CACH-9545, CACH-11179	A27, AAA35, CC16, CC24, CC28, DD27, DD31, HH13, I10, I38, J4, M6, M16, M27, M28, M29, Q4, Q28, Q31, R11, R14, R17, R19, R21, R23, R37, S3, S9, S11, T10, T28, T36, U2, V10, VV19
18	*Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland	CACH-0001, CACH-0005, CACH-0013, CACH-0039, CACH-0048, CACH-0052, CACH-0066, CACH-0181, CACH-0185, CACH-0186, CACH-0187, CACH-0196, CACH-0203, CACH-0204, CACH-0236	CACH-1551, CACH-7897, CACH-8300, CACH-8749, CACH-9093, CACH-9337, CACH-9891, CACH-9922, CACH-1106, CACH-18404, CACH-18558, CACH-18682, CACH-18694, CACH-18820, CACH-18957	AA18, AA19, BB26, F4 , HH11, I14, I24, J8, K3, K4, K5, K6, K8, K10, K11, K13, K27, K40, L5, L30, M21, O1, O2, O16, O18, O21, O22, O24, O31, O40, R5, R7, R9, R26, R29, S13, U3, U5, U7, U10, U11, U12, U13, U14, U15, U21, U22, U25, U28, U29, U34, U38, V30, Y3, Y9, Y28, Y34, Z16, Z23, Z35, Z39
19	*Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* Mixed Shrub Woodland	CACH-0002, CACH-0050, CACH-0059, CACH-0082, CACH-0110, CACH-0130, CACH-0140, CACH-0207	CACH-5725, CACH-5881, CACH-7244, CACH-9400, CACH-10039, CACH-12880, CACH-12964	A11, A13, A14, A33, AAA21, CC30, DD26, FF2, G2, H5, I7, I9, I11, I15, I33, N1, P8, Q7, Q8, Q14, Q16, R10, R12, S5, S8, S10, S12, S18, S32, V6, V8, V12, V15
20	*Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland	CACH-0213		
21	*Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland	CACH-0132, CACH-0146, CACH-0148, CACH-0193, CACH-0230		H6, H10, H13, H16, J2, L9, L25, O9, V21, V23, V25, W26
22	*Pinus ponderosa / Artemisia nova* Woodland	CACH-0183, CACH-0223,	CACH-19246	B1, J24, J25, J26, J28, J39, K23, K24, K31, L21, L31, L40
23	*Pinus ponderosa / Artemisia tridentata* ssp. *vaseyana* Woodland	CACH-0068, CACH-0093		
24	*Pinus ponderosa / Bouteloua gracilis* Woodland		CACH-14326, CACH-17082	L22, L38, O6
25	*Pinus ponderosa / Quercus gambelii* Woodland	CACH-0109, CACH-0212, CACH-0220, CACH-0224, CACH-0226,	CACH-13422, CACH-17477	A9, A26, A30, J5, J12, J30, K16, K17, K18, L11, L16, L26, O4, O5

	Plant community	2004 Classification releve code	2001/03 Glenn Rink survey code	2006 Accuracy assessment observation code
26	*Populus deltoides* ssp. *wislizeni* / Disturbed Understory Woodland	CACH-0135	CACH-1955	BB10, E1, OO4, W3, W4, W5, W7, W8, W9, W10, W11, W12, W14, W15, W16, W18, W19, W20, W25, W27, W28, W29, W39, X5, X9, YY5, YY6, YY7
27	*Pseudotsuga menziesii* / *Poa fendleriana* Woodland	CACH-0208	CACH-17618	A24, F7
28	*Pseudotsuga menziesii* Scree Woodland	CACH-0143	CACH-14181	A8, DD24, G1, G4
SHRUBLAND				
29	*Amelanchier utahensis* Shrubland	CACH-0121		A2, DD6, II1, PP3, PP10
30	*Artemisia tridentata* / *Artemisia nova* Shrubland			Q6, Y29, Z1, Z20, Z30
31	*Artemisia tridentata* ssp. *wyomingensis* / *Bouteloua gracilis* Shrubland	CACH-0054, CACH-0069, CACH-0077, CACH-0153, CACH-0156	CACH-5189, CACH-13955, CACH-18161, CACH-18162, CACH-18163, CACH-18281, CACH-18422, CACH-18432, CACH-18550, CACH-18817, CACH-18821, CACH-18826, CACH-18842, CACH-18961, CACH-19089, CACH-19092, CACH-19094, CACH-19252, CACH-19365, CACH-19385, CACH-19637	Y5, Y21, Y22, Y24, Y27, Z10, Z12, Z22, Z26, Z27
32	*Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-Natural Shrubland	CACH-0007, CACH-0025, CACH-0061, CACH-0127, CACH-0133	CACH-610, CACH-11588, CACH-11817, CACH-19089, CACH-19365	AA8, AA10, AA14, AA15, AA16, AA17, AA24, BB29, GG6, GG7, K12, K15, K34, VV15, VV23, VV25, VV27, VV28, Y6, Y7, Y8, Y11, Y12, Y13, Y14, Y15, Y16, Y18, Y35, Z2, Z3, Z4, Z6, Z7, Z8, Z9, Z17, Z19, Z21, Z24, Z28, Z32, Z38
33	*Atriplex confertifolia* / *Pleuraphis jamesii* Shrubland	CACH-0057, CACH-0118	CACH-1010	BB5, CC1, CC2, CC3, CC4, CC6, CC7, CC8, CC14, CC15, CC17, CC19, CC31, PP2
34	*Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland	CACH-0019, CACH-0023	CACH-474, CACH-3980, CACH-4264, CACH-9701	AA3, AA11, AA13, BB1, BB2, BB3, BB6, BB7, EE19, EE20, EE25, EE30, GG4, HH1, JJ11, M4, PP1, V1, VV7
35	*Fendlera rupicola* Talus Shrubland	CACH-0099, CACH-0150		DD17, H1, P16, Q9
36	*Opuntia* (*fragilis*, *polyacantha*, *phaeacantha*) Shrubland	CACH-0119, CACH-0125, CACH-0136, CACH-0139	CACH-9159, CACH-10102	BB13, BB14, BB15, BB17, BB18, BB21, BB22, BB24, CC29, D2, EE3, EE6, EE9, EE10, EE12, EE15, EE16, EE22, JJ5, LL2, M26, NN1, PP11, WW16, XX26
37	*Quercus gambelii* / *Fendlera rupicola* Shrubland [Provisional]	CACH-0189		EE28, H12, T15, V19
38	*Quercus gambelii* Shrubland	CACH-0024		H15, H19, H25, H26, H27, H28, H29, H30

	Plant community	2004 Classification releve code	2001/03 Glenn Rink survey code	2006 Accuracy assessment observation code
39	*Tamarix* spp. Temporarily Flooded Semi-natural Shrubland			MM1, OO2, W2, W23, X2, X3
HERBACEOUS				
40	*Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation	CACH-0080		
41	*Agropyron desertorum* Semi-natural Herbaceous Vegetation		CACH-19362	WW9
42	*Artemisia bigelovii / Bouteloua gracilis* Dwarf-shrub Herbaceous Vegetation	CACH-0106		EE5
43	*Bouteloua gracilis* Herbaceous Vegetation		CACH-18817, CACH-18818, CACH-18822	BB9, EE1, HH12, HH5, HH7, HH8, HH9, HH12, JJ6, M10, M11, M19, M35, QQ12, QQ13, Y1
44	*Brickellia californica* Shrubland	CACH-0051, CACH-0070, CACH-0075		AA6, D5, II4, II5, LL3, PP15
45	*Bromus tectorum* Semi-natural Herbaceous Vegetation			AA5, KK1, W34
46	*Juniperus osteosperma / Ephedra viridis / Bromus tectorum* Wooded Herbaceous Vegetation	CACH-0238		CC23
47	Mixed Riparian Herbaceous Vegetation	CACH-00044	CACH-474, CACH-2631, CACH-9968	NN15, NN16, NN17, NN14, NN2, NN13, NN12, BB28, NN3 , NN5 , BB23, NN8, NN9, OO1, WW11, XX3, QQ2, YY8, BB19, GG3, GG1,WW10, NN4, WW5, GG5, EE31, EE27, GG2, JJ1, EE23, EE2, EE13, MM5, W6, EE17, EE14, EE18
48	Mixed Weedy Herbaceous Vegetation			HH14, HH6, BBB2, EE4, EE26, NN7, EE24, LL1, NN31, NN20, NN19, MM15, MM3, MM4, BB16, W6, XX16, XX15, XX25, XX14, XX13, XX12, XX11, WW12, XX18, WW14, W5, W40, XX7, XX8, XX9, WW20, Y17, XX6, W14, WW13, WW19, W30

Appendix C: Global and Local Plant Community Descriptions

C.1 Introduction

The plant community descriptions present information on each association, alliance, and park special as it occurs in Canyon de Chelly National Monument (local) and as it has been found elsewhere (global). The plant communities are organized by life form—forest, woodland, shrubland, herbaceous, and finally, sparse.

Following is a summary of the information provided by each description, in the order in which it occurs within each description:

- Scientific name for plant community
- Translated name for plant community assigned by NatureServe
- NatureServe Code: Community Element Global code (CEGL) assigned by NatureServe
- Global concept of plant community
- Classification Confidence: The level of confidence in the classification, based on the quality and type of data used in the analysis, as well as the extent to which the entire (or potential) range of the element was considered. Values include: 1 = Strong, 2= Moderate, and 3 = Weak.
- Classification comments: Globally and locally
- Vegetation hierarchy
- Physiognomic Class: NVCS Version 1 class
- Physiognomic Subclass: NVCS Version 1 subclass
- Physiognomic Group: NVCS Version 1 group
- Physiognomic Subgroup: NVCS Version 1 subgroup
- Formation name: NVCS Version 1 formation name
- Alliance name: NVCS Version 1 alliance name
- Ecological Systems Place: Nature Serve-assigned ecological system
- NatureServe Conservation Status: NatureServe-assigned conservation status rank (G5 Secure/ G4 Apparently secure/G3 Vulnerable/G2 Imperiled/ GNR Not yet ranked)
- Distribution: Global and local distribution
- Environmental setting
- USFWS Wetland System (Cowardin et al. 1979)
- Vegetation global and local descriptions
- Most abundant species: Global and local
- Other noteworthy species: Global and local
- Element sources: Authors of global and local descriptions
- References

C.2 Forest

1. Populus tremuloides / Rhus trilobata Forest [Park Special]

NatureServe common name	Quaking Aspen / Skunkbush Forest [Park Special]
NatureServe code	Park Special

Summary:

This *Populus tremuloides* dominated forest association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 - Weak.

Classification comments:

Canyon de Chelly National Monument. This vegetation type has not been identified in other locations outside of Canyon de Chelly National Monument. Since this vegetation type is only known from one relevé location in the monument, it is not currently included as a new vegetation association in the National Vegetation Classification (NVC) and is listed as a "park special." Park specials are vegetation communities that represent a unique vegetation assemblage that has not been described elsewhere. If additional data are collected on this vegetation type, then this community may be re-classified as an NVCS association.

Small stands of *Populus tremuloides* likely occur throughout the monument. Our sampling effort was limited to a single stand. Additional data should be collected on this vegetation type to understand the complexity of the understory community.

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.813	Rocky Mountain Aspen Forest and Woodland

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. *Populus tremuloides* / *Rhus trilobata* Forest [Park Special] was only sampled from one relevé location in a small canyon within Canyon de Chelly National Monument. This particular relevé is located in the floodplain of Coyote Wash.

Environmental summary:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This relevé occurs on silt loam soil at an elevation of 2157 m (7077 feet). It has a slope of 22% and occurs on a northeastern aspect. The relevé is located near the bank of a wash and is subject to seasonal flooding.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. One relevé is classified as *Populus tremuloides* / *Rhus trilobata* Forest [Park Special]. The total vegetation cover class for this vegetation type is 75-100%. The tree stratum is characterized by a total cover class range of 50-75%, the shrub stratum covers 50-75%, and the herbaceous stratum covers 5-10%. The species richness is 20 species. The tree stratum is dominated by *Populus tremuloides*, which has 50-75% cover with a dbh ranging from 5.0-16.5 cm (9.5 cm average dbh). *Juniperus scopulorum* is also present in the tree stratum with low cover (1-5%) and dbh ranging between 8.7 and 12.1 cm (9.2 cm average dbh). This relevé has a dense canopy (50-75% cover) with a height of 10-20 m. The subcanopy is 5-10 m high and has low cover (5-10% cover). Low cover of tree seedlings is also present (1-5% cover). The shrub stratum is dominated by *Rhus trilobata* (10-25% cover) and also has low cover (1-5%) of *Mahonia repens* and *Rosa woodsii*. The shrub stratum has two distinct layers. The tall-shrub layer is the main layer and covers 50-75% with a height of 2-5 m. A short-shrub layer covers 1-5% at a height of 0.5-1 m. The herbaceous stratum has low cover (5-10%) and a high diversity of species, including *Bromus porteri* (= *Bromus anomalus*) and *Valeriana acutiloba* (each with 1-5% cover).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*N/A*	*Populus tremuloides*
Tall/short shrub/ sapling	*N/A*	*Rhus trilobata*

Other noteworthy species:

Global species	Canyon de Chelly species
N/A	*Bromus porteri (= Bromus anomalus), Juniperus scopulorum, Mahonia repens, Ribes pinetorum, Rosa woodsii, Valeriana acutiloba*

Authors:

Global descriptions. Not applicable.

Local descriptions. M. Hansen

References:

None available.

2. *Pseudotsuga menziesii / Populus deltoides* Forest [Park Special]

NatureServe common name	Douglas-fir / Quaking Aspen Forest [Park Special]
NatureServe code	Park Special

Summary:

This *Pseudotsuga menziesii* dominated forest association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 - Weak.

Classification comments:

Canyon de Chelly National Monument. This vegetation type has not been identified in other sampling efforts outside of Canyon de Chelly National Monument. Since this vegetation type is only known from one relevé location in the monument, it is not currently included as a new vegetation association in the National Vegetation Classification (NVC) and is listed as a "park special." Park specials are vegetation communities that represent a unique vegetation assemblage that has not been described elsewhere. If additional data are collected on this vegetation type, then this community may be re-classified as an NVCS association.

Although we only have information about this vegetation type from one location, we were able to map this vegetation type in several different areas within the project boundary. This vegetation type tends to occur between the transition zone of cool side canyon *Pseudotsuga menziesii* / *Quercus gambelii* Forest and low-level riparian *Populus deltoides* (ssp. *wislizeni*, ssp. *monilifera*) / *Elaeagnus angustifolia* Woodland.

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.823	Southern Rocky Mountain Dry Mesic Montane Mixed Conifer Forest and Woodland

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. *Pseudotsuga menziesii* / *Populus deltoides* Forest [Park Special] was only sampled from one relevé location in Canyon del Muerto within Canyon de Chelly National Monument.

Environmental summary:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This vegetation type occurs on sandy loam soil at an elevation of 1927 m (6322 feet). At this relevé there was no slope and it occurred on the floodplain terraces. This particular relevé occurs at the base of a cliff and contains dead and downed trees.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. One relevé is classified as *Pseudotsuga menziesii* / *Populus deltoides* Forest [Park Special]. The total vegetation cover class for this association is 50-75%. The tree stratum is characterized by a total cover class range of 25-50%, the shrub stratum covers 5-10%, and the herbaceous stratum also covers 5-10%. The species richness is 34 species. The tree stratum is dominated by *Pinus edulis*, which has 5-10% cover and a dbh range from 7.0-10.1 cm (8.4 cm average dbh). *Pseudotsuga menziesii* and *Populus deltoides* each cover 1-5% of the relevé. *Pseudotsuga menziesii* has dbh measurements of 12.2 and 37.2 cm. Also present in the tree stratum are *Pinus ponderosa*, which has 1-5% cover, and a dbh ranging from 9.7-39.2 cm (28.2 cm average dbh), and *Juniperus scopulorum*, which covers 1-5% of the relevé and has dbh measurements of 27.8 and 40.4 cm. This relevé has a main canopy height of 10-20 m with a cover class of 25-50%, and an emergent layer that is 20-30 m tall and covers 1-5% of the relevé. There is also a small subcanopy (5-10% cover) that is 5-10 m in height and trace seedling layer (<1% cover) that is 0.5-1 m tall.

The shrub stratum is sparse and is dominated by *Ericameria nauseosa* and *Rhus trilobata*, both with a low cover class of 1-5%. The shrub stratum has two distinct layers, each covering 1-5% of the relevé. The tall-shrub layer has a height of 2-5 m and the short-shrub layer has a height of 1-2 m. The herbaceous stratum has low cover (5-10%) with a high diversity of species; no one species has a cover class greater than 1%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*N/A*	*Pseudotsuga menziesii, Populus deltoides, Pinus edulis*

Other noteworthy species:

Global species	Canyon de Chelly species
N/A	*Ericameria nauseosa, Rhus trilobata*

Authors:

Global descriptions. Not applicable.

Local descriptions. M. Hansen

References: None available.

3. Pseudotsuga menziesii / Populus deltoides Forest [Park Special]

NatureServe common name	Douglas fir / Gambel Oak Forest
NatureServe code	CEGL000452

Summary:

This forest association occurs on mountains and plateaus from Colorado to Trans Pecos Texas, west into Arizona and Utah. Elevation ranges from 1370-2870 m (4500-9400 feet). Stands are found along drainages, lower and middle slopes, steep upper slopes and ridgetops. Aspects are variable. This forest occurs as both a non obligate riparian community on the outer margins of riparian areas in desert canyons and steep draws, and as an upland forest forming extensive stands on typically north-facing hillslopes (southern aspects at higher elevations). Soils vary, but are often shallow and rocky, ranging from sandy loams to clay. The vegetation is characterized by a relatively sparse to moderately dense evergreen tree canopy, dominated by *Pseudotsuga menziesii,* sometimes with scattered large *Pinus ponderosa*, *Pinus strobiformis*, *Pinus edulis*, or *Juniperus* spp. (especially on drier sites). *Abies concolor* is typically not present. *Quercus gambelii* dominates both the sub-canopy (tree form, if present) and the moderately dense tall shrub layer that consists of dense clumps of oak. *Quercus gambelii* must have at least 5% cover, but is frequently over 25%. At higher elevations, the *Quercus gambelii* are more tree-like and *Symphoricarpos oreophilus* will be present with significant cover in the short shrub layer. At lower elevations, scattered *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus deppeana* are often present. The herbaceous layer is generally sparse and composed of mostly graminoids with scattered forbs, but can be moderately dense and diverse. Many other species are associated, such as *Amelanchier* spp., *Holodiscus dumosus*, *Mahonia repens*, *Paxistima myrsinites*, *Robinia neomexicana*, *Rosa woodsii*, *Carex* spp., *Festuca arizonica*, *Muhlenbergia virescens*, *Poa fendleriana*, *Lathyrus lanszwertii* var. *leucanthus*, *Thalictrum fendleri*, and *Vicia americana*. The shrub layer has equal or greater cover than graminoids.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Within the Habitat Type literature, four phases are mentioned: *Festuca arizonica* phase, *Holodiscus dumosus* phase, *Muhlenbergia virescens* phase (all defined by having at least 5% cover of both *Quercus gambelii* and the nominal species), and *Quercus gambelii* (typic) phase defined by an undeveloped herbaceous layer (Alexander et al. 1984b, Alexander et al. 1987, DeVelice et al. 1986, Fitzhugh et al. 1987, Johnston 1987, Larson and Moir 1987, Muldavin et al. 1996, Stuever and Hayden 1997b). There are 3 similar USNVC *Pseudotsuga menziesii* associations that use these phase species as the nominal species. These phases represent "intermediate" vegetation. Review of these associations is needed to clarify relationships between associations.

Canyon de Chelly National Monument. Four *Pseudotsuga menziesii* dominated or codominated associations/vegetation types were classified in this effort. This association was most commonly sampled and mapped during this effort.

Vegetation hierarchy:

Physiognomic class	I	Forest
Physiognomic subclass	I.A.	Evergreen forest
Physiognomic group	I.A.8.	Temperate or subpolar needle leaved evergreen forest
Physiognomic subgroup	I.A.8.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen forest
Formation name	I.A.8.N.c.	Conical crowned temperate or subpolar needle leaved evergreen forest

Alliance name	*Pseudotsuga menziesii* Forest Alliance (A.157), Douglas fir Forest Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.823	Southern Rocky Mountain Dry Mesic Montane Mixed Conifer Forest and Woodland

NatureServe conservation status:

Global rank. G5 (23 Feb 1994).

Distribution:

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

Canyon de Chelly National Monument. *Pseudotsuga menziesii* / *Quercus gambelii* Forest was sampled from eight relevés in canyons and on canyon walls within Canyon de Chelly National Monument. The relevés were found throughout the monument, including in Black Rock Canyon, Monument Canyon, Wild Cherry Canyon, and in tributary drainages of Canyon de Chelly.

Environmental summary:

Globally. This forest association occurs on mountains and plateaus at elevation ranges from 1370-2870 m (4500-9400 feet). Stands are found along drainages, gentle to moderate lower and middle slopes, steep upper slopes and ridgetops. Aspects are variable. This forest occurs as both a non obligate riparian community on the outer margins of riparian areas in desert canyons and steep draws, and as an upland forest forming extensive stands on typically north facing hillslopes (southern aspects at higher elevations). Soils vary but are often shallow and rocky, ranging from sandy loams to clay. The surface is generally largely covered with a thin layer of litter. Parent materials include fractured limestone, sandstone, granite, basalt, andesite and even slickrock.

Canyon de Chelly National Monument. This association occurs on sandy loam, silt loam, and silt clay loam soils between the elevations of 1823 and 2256 m (5981-7402 feet) (average 2018 m [6621 feet]). The slope ranges from 10-34% (average 21%) at a northeastern to northwestern aspect. The litter cover range is variable, 1-5% to 50-75%, with most relevés having a dense litter layer (average cover range 30-51%). Most relevés contain a notable amount of stones and boulders, and one relevé was unique, occurring on steep slickrock within a narrow canyon.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by a relatively sparse to moderately dense evergreen tree canopy dominated by *Pseudotsuga menziesii*, sometimes with scattered large *Pinus ponderosa*, *Pinus strobiformis*, *Pinus edulis*, or *Juniperus* spp. (especially on drier sites). *Abies concolor* is typically not present. *Quercus gambelii* dominates both the subcanopy (tree form, if present) and the moderately dense tall shrub layer that often consists of dense clumps of oak. *Quercus gambelii* must have at least 5% cover, but is frequently over 25%. At higher elevations, the *Quercus gambelii* are more tree-like, and *Symphoricarpos oreophilus* will be present with significant cover in the short shrub layer. At lower elevations, scattered *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus deppeana* are often present. Other common shrub species, depending on geographic location, may include *Acer glabrum*, *Arctostaphylos patula*, *Amel-*

anchier spp., *Cercocarpus montanus*, *Holodiscus dumosus*, *Mahonia repens*, *Paxistima myrsinites*, *Prunus virginiana*, *Ribes cereum*, *Robinia neomexicana*, and *Rosa woodsii*. The generally sparse herbaceous layer is composed of mostly graminoids with scattered forbs, but ranges to moderately dense and diverse. Associated graminoids may include *Bromus* spp., *Carex rossii*, *Festuca arizonica*, *Koeleria macrantha*, *Muhlenbergia montana*, *Muhlenbergia virescens*, and *Poa fendleriana*. Common forbs include *Achillea millefolium*, *Lathyrus lanszwertii* var. *leucanthus*, *Thalictrum fendleri*, and *Vicia americana*. The shrub layer has equal or greater cover than graminoids. This open conifer forest transitions to *Quercus gambelii* woodlands in drier sites and at lower elevations.

Canyon de Chelly National Monument. Eight relevés are classified as *Pseudotsuga menziesii* / *Quercus gambelii* Forest. The total vegetation cover class for this association ranges from 25-50% to 75-100% (average cover class 56-81%). The tree stratum is generally dense and ranges in cover class between 10-25% and 75-100% (average cover class 48-72%). The shrub stratum is sparse and ranges from cover class of trace-1% to 5-10% (average cover class 2-6%), and the herbaceous stratum is also sparse, with cover ranging between 1-5% to 5-10% (average cover class 4-9%). The species richness ranges from 13-31 species (average of 24 species). The tree stratum consists of a main canopy (cover ranging between 5-10% and 50-75%), an emergent layer (five relevés with cover ranging between 1-5% and 5-10%), a subcanopy (cover ranging between 1-5% and 10-25%), and a seedling layer (cover ranging between trace-1% and 5-10%). The main canopy layer varies between heights of 10-20 m and 20-30 m, the emergent layer, where present, is >30 m tall, and the subcanopy ranges between 2-5 m and 10-20 m tall. The tree stratum is dominated by *Pseudotsuga menziesii*, ranging between 1-5% and 50-75% cover (average cover class 18-33%), and with dbh ranging between 5.0-101.8 cm (average dbh 22.7 cm). *Quercus gambelii* often codominates the canopy layer with cover ranging between 5-10% and 50-75% (average cover class 19-35%) and a dbh ranging from 5.0-26.5 cm (average dbh 10.2 cm). Other trees with significant cover (>5% in at least one relevé) are *Pinus edulis* with a dbh of 6.2-31.4 cm (average dbh 14.5 cm) and *Juniperus osteosperma* with a dbh of 9.1-20.4 cm (average dbh 14.8 cm) or a drc range of 13.8-88.7 cm (average drc 33.3 cm).

The shrub stratum has two distinct layers. A tall shrub layer ranges in height between 1-2 and 5-10 m and a short shrub layer with a height of 0.5-1 to 1-2 m. The tall shrub layer is present in all relevés, and ranges in cover from trace-1% to 5-10% (average cover class 2-6%). The short shrub layer is present in only half of the relevés and, ranges between trace 1% and 1-5% where present. The shrub stratum is dominated by *Fendlera rupicola* and *Rhus trilobata*. Each of these species covers 5-10% in one relevé. The herbaceous layer is dominated by *Poa fendleriana*, which covers 5-10% in three relevés. Also present are several species with low cover (<5%) that are almost always present in the relevés, including *Arabis fendleri*, *Penstemon barbatus*, and *Packera neomexicana* (= *Senecio neomexicanus*).

The shrub stratum is sparse and is dominated by *Ericameria nauseosa* and *Rhus trilobata*, both with a low cover class of 1-5%. The shrub stratum has two distinct layers, each covering 1-5% of the relevé. The tall-shrub layer has a height of 2-5 m and the short-shrub layer has a height of 1-2 m. The herbaceous stratum has low cover (5-10%) with a high diversity of species; no one species has a cover class greater than 1%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Pinus ponderosa, Pinus strobiformis, Pseudotsuga menziesii*	*Juniperus osteosperma, Pinus edulis, Pseudotsuga menziesii, Quercus gambelii*
Tall/short shrub/ sapling	*Quercus gambelii*	*Rhus trilobata, Fendlera rupicola*
Herbaceous		*Poa fendleriana*

Other noteworthy species:

Global species	Canyon de Chelly species
N/A	*Ericameria nauseosa, Rhus trilobata*

Authors:

Global descriptions. K.A. Schulz, mod. J. Drake.

Local descriptions. M. Hansen, J. Donald, and K. Thomas

References:

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

C.3 Woodland

4. *Acer negundo / Artemisia tridentata* Woodland [Park Special]

NatureServe common name	Boxelder / Big Sagebrush Woodland [Park Special]
NatureServe code	Park Special

Summary:

This *Acer negundo* dominated woodland association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 - Weak.

Classification comments:

Globally. Not applicable.

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.821	Rocky Mountain Lower Montane Foothill Riparian Woodland and Shrubland

NatureServe conservation status:

Global rank. Not applicable.

Distribution:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. *Acer negundo* / *Artemisia tridentata* Woodland [Park Special] was only sampled from one relevé location in the bottom of Canyon del Muerto within Canyon de Chelly National Monument.

Environmental summary:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 1896 m (6220 feet). The relevé occurs in an intermittent streambed with a slope of 12% at a generally northern aspect. This particular relevé represents a combination of riparian and canyon bottom terrace habitats.

USFWS wetland system: Palustrine.

Vegetation description:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. One relevé is classified as *Acer negundo* / *Artemisia tridentata* Woodland [Park Special]. The total vegetation cover class for this association is 75-100%. The tree stratum is characterized by a total cover class range of 10-25%, the shrub stratum covers 50-75%, and the herbaceous stratum covers 5-10%. The species richness is 55 species. The tree stratum is dominated by *Acer negundo*, which has a cover class of 5-10%. Also present in the tree stratum are *Elaeagnus angustifolia*, *Pinus edulis*, and *Juniperus osteosperma*, each with 1-5% cover. This relevé has a main canopy height of 10-20 m with a cover class of 10-25%, a subcanopy layer that covers 1-5% and is 5-10 m in height, and a trace seedling layer (<1% cover) that is 0.5-1 m tall. The shrub stratum has two distinct layers. The tall-shrub layer covers 10-25% and is 2-5 m in height, and the short-shrub layer covers 25-50% and is 1-2 m tall. The tall-shrub layer is dominated by *Artemisia tridentata* with 10-25% cover and *Philadelphus microphyllus*, which covers 1-5%. The short-shrub layer is dominated by *Rosa woodsii*, which has 10-25% cover and is accompanied by *Gutierrezia microcephala* with 1-5% cover and *Yucca angustissima*, which covers trace-1%. The herbaceous stratum is dense and has a diversity of species, with the most common being *Artemisia ludoviciana*, *Bromus tectorum*, *Cynodon dactylon*, and *Xanthium strumarium* var. *canadense*, which each cover 1-5%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*N/A*	*Acer negundo*
Tall/short shrub/ sapling	*N/A*	*Artemisia tridentata*

Other noteworthy species:

Global species	Canyon de Chelly species
N/A	*Artemisia ludoviciana, Bromus tectorum, Cynodon dactylon, Elaeagnus angustifolia, Gutierrezia microcephala, Juniperus osteosperma, Philadelphus microphyllus, Pinus edulis, Xanthium strumarium* var. *canadense*

Authors:

Global descriptions. Not applicable.

Local descriptions. M. Hansen.

References:

None available.

5. *Acer negundo* / Disturbed Understory Woodland

NatureServe common name	Boxelder / Disturbed Understory Woodland
NatureServe code	CEGL002693

Summary:

This riparian association is found in the Colorado Plateau and other areas of the southwestern U.S. on upper alluvial terraces below 2015 m (6600 feet) elevation. Sites are on gentle slopes or flat areas near permanent or temporary streams but are rarely flooded because of their location on high, abandoned stream terraces. Soils are usually sandy. The tree canopy of this association is open to moderately closed and 5-15 m tall. The dominant tree species is *Acer negundo* with scattered *Acer glabrum*, *Juniperus osteosperma*, or *Juniperus scopulorum*. There is a sparse shrub layer up to 2 m tall with *Artemisia tridentata*, *Ericameria nauseosa*, *Fraxinus anomala*, *Rhus trilobata*, *Ribes cereum*, *Tamarix ramosissima*, and (in the south) *Quercus gambelii*. Herbaceous cover and species composition are variable. The herbaceous stratum may be sparse, or dominated by native and introduced species typically found in disturbed areas. *Bromus tectorum* is common. Other typical species are *Heterotheca villosa*, *Poa pratensis*, *Sisymbrium altissimum*, *Lepidium latifolium*, *Taraxacum officinale*, and *Verbascum thapsus*.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. *Acer negundo* generally occurs in Canyon de Chelly National Monument in moist, cool areas. It often occurs in narrow strips in side canyons or as small patches in the deeper soils on the canyon walls. The disturbed understory community often occurs adjacent to areas that have been modified through various land use activities, including agriculture, residences, and transportation corridors.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.B.	Deciduous woodland
Physiognomic group	II.B.2.	Cold deciduous woodland
Physiognomic subgroup	II.B.2.N.	Natural/Semi natural cold deciduous woodland
Formation name	II.B.2.N.b	Temporarily flooded cold deciduous woodland
Alliance name		*Acer negundo* temporarily flooded woodland alliance (A.642) Boxelder temporarily flooded woodland alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.821	Rocky Mountain Lower Montane Foothill Riparian Woodland and Shrubland

NatureServe conservation status:

Global rank. GNR (14 Aug 2001).

Distribution:

Globally. This association has been sampled in the Colorado Plateau from northwestern Colorado to southwestern Utah and northeastern Arizona; it is likely widespread elsewhere in the southwestern U.S.

Canyon de Chelly National Monument. *Acer negundo* Disturbed Understory Woodland was only sampled from one relevé location in the Many Cherry Canyon tributary of Canyon del Muerto within Canyon de Chelly National Monument.

Environmental summary:

Globally. This association is found on flat to gently sloping riparian sites near permanent or temporary streams below 2015 m (6600 feet) elevation. Sites are usually found on terraces several meters above the active floodplain and below the steeper upland slopes on any aspect. They rarely flood. Soils are usually sandy alluvium and can range from well drained to poorly drained. The ground surface is largely covered by large rocks, litter, downed wood, or bare soil.

Canyon de Chelly National Monument. This association occurs on sandy soil at an elevation of 1799 m (5902 feet). The slope of this relevé is small (1%) with a western aspect. The area sampled consists of a rocky canyon bottom that experiences intermittent flooding.

USFWS wetland system: Palustrine.

Vegetation description:

Globally. This woodland association has an open to moderately closed (10-80%) tree canopy, and moderate to dense total vegetation cover. The tree canopy is between 5 and 15 m tall and dominated by *Acer negundo*. *Acer negundo* is also present as seedlings and saplings. Other trees that can be present are *Acer glabrum*, *Juniperus osteosperma*, and *Juniperus scopulorum*. Shrub cover is sparse, though it can be more prominent when the tree canopy is open. The shrub stratum is usually less than 2 m tall and contains species such as *Artemisia tridentata* ssp. *tridentata*, *Ericameria nauseosa*, *Fraxinus anomala*, *Rhus trilobata*, *Ribes cereum*, *Tamarix ramosissima*, and (in the south) *Quercus gambelii*. Herbaceous cover and species composition are variable. The herbaceous stratum is dominated by native and introduced species typically found in disturbed areas. *Bromus tectorum* is common. Other typical components of the herbaceous stratum are *Heterotheca villosa*, *Poa pratensis*, *Lepidium latifolium*, *Sisymbrium altissimum*, *Taraxacum officinale*, and *Verbascum thapsus*.

Canyon de Chelly National Monument. One relevé is classified as *Acer negundo* Disturbed Understory Woodland. The total vegetation cover class for this association is 25-50%. The tree stratum is characterized by a total cover class range of 10-25%, the shrub stratum covers 1-5%, and the herbaceous stratum covers 10-25%. The species richness is 26 species. The tree stratum contains only *Acer negundo*, which covers 10-25% of the relevé. The main canopy has a height of 10-20 m and a cover class of 10-25%. There is also a trace seedling layer (<1% cover) that is 0.5-1 m tall. The shrub stratum is sparse and dominated by *Amelanchier utahensis*, which has a low cover class of 1-5%. *Cercocarpus montanus* is also present with trace-1% cover. The shrub stratum has only one distinct layer that is 5-10 m in height. The herbaceous stratum has a moderate cover class of 10-25% and is dominated by *Artemisia ludoviciana*, which covers 5-10%. Other herbaceous species with at least 1-5% cover include *Brickellia californica*, *Bromus tectorum*, *Solidago velutina*, and *Stephanomeria minor* var. *minor*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Acer negundo*	*Acer negundo*
Herbaceous	*N/A*	*Artemisia ludoviciana*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum, Poa pratensis	*Data are not available.*

Authors:

Global descriptions. J. Drake, mod. J. Coles and K. A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Cogan et al. 2004 .

6. *Elaeagnus angustifolia* Semi-natural Woodland

NatureServe common name	Russian olive Semi-natural Woodland
NatureServe code	CEGL005269

Summary:

This widespread Russian olive woodland type is found in the northern Great Plains, Colorado Plateau, and probably throughout much of the western United States and adjacent Canada. It is a naturalized species that has been widely planted in hedgerows for windbreaks. It has since spread to a variety of native habitats, particularly more mesic ones, such as near streams and rivers, although small upland stands are also known. The vegetation is dominated by *Elaeagnus angustifolia*, sometimes accompanied by *Tamarix* spp. Remnant *Populus fremontii* trees may remain as canopy emergents. Stands may be small and linear. The vegetation is dominated by the tree *Elaeagnus angustifolia* with a variety of native and introduced species in the shrub and herbaceous layers. Associated species have not been characterized. Canopy closure is between 40 and 50%. Shrub cover is provided by *Salix exigua* and *Amorpha fruticosa*. *Pascopyrum smithii*, *Sporobolus airoides*, *Distichlis spicata*, and *Hordeum jubatum* comprise the herbaceous layer in some stands; in others, the understory is dominated by introduced species, such as *Lepidium latifolium*, *Descurainia sophia*, and *Bassia scoparia* (= *Kochia scoparia*).

Classification confidence: 2 - Moderate.

Classification comments:

Globally. *Populus deltoides*- and *Populus fremontii*-dominated associations may have significant cover of *Elaeagnus angustifolia* in the tree canopy, but are generally considered native woodlands until *Elaeagnus angustifolia* comprises more than 80-90% of the tree cover. Some stands have a nearly closed tree canopy (80% cover) or may have significant gaps in the tree canopy.

Canyon de Chelly National Monument. *Elaeagnus angustifolia*, a nonnative invasive shrub, is commonly found along the riparian corridors of Canyon de Chelly and Canyon del Muerto. Although this species may occur in high cover within native communities, this association concept is restricted to communities with a monoculture of *Elaeagnus angustifolia*.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.B.	Deciduous woodland
Physiognomic group	II.B.2.	Cold deciduous woodland
Physiognomic subgroup	II.B.2.N.	Natural/Semi natural cold deciduous woodland
Formation name	II.B.2.N.a.	Cold deciduous woodland
Alliance name		*Elaeagnus angustifolia* Semi-natural Woodland Alliance (A.3566) Russian olive Semi natural Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.821	Rocky Mountain Lower Montane Foothill Riparian Woodland and Shrubland

NatureServe conservation status:

Global rank. GNA (invasive) (5 Nov 1999).

Distribution:

Globally. This widespread Russian olive woodland type is reported from the northern Great Plains, Colorado Plateau, and probably occurs throughout much of the western United States and adjacent Canada along rivers and streams, where it replaces native *Populus* spp. and *Acer negundo* dominated forests and woodlands.

Canyon de Chelly National Monument. *Elaeagnus angustifolia* Semi-natural Woodland was only sampled from one relevé location in Black Rock Canyon below Tsegi Point within Canyon de Chelly National Monument.

Environmental summary:

Globally. This woodland type is naturalized throughout the interior West and Great Plains, probably spreading as a result of *Elaeagnus angustifolia* being widely planted in hedgerows for windbreaks. It has spread to a variety of native habitats, particularly more mesic ones, such as riverbanks, stream terraces and shorelines. Stands also occur in upland basins and drainages. Stands may be small and linear, but many extend for great distances along streams. Adjacent vegetation includes other riparian shrublands and wetlands dominated by *Salix exigua* or *Scirpus* and/or *Schoenoplectus* spp. Upland vegetation is variable.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 1707 m (5600 feet). The relevé was located on a level floodplain of Black Rock Canyon. The litter cover is high (50-75% cover) with large *Populus deltoides* ssp. *wislizeni* trees located outside the relevé.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation is dominated by the tree *Elaeagnus angustifolia,* with a variety of native and introduced species in the shrub and herbaceous layers. Canopy closure is open to moderately dense (25-50% cover). On the Colorado Plateau, *Tamarix ramosissima* may be present in the tree canopy with less cover than *Elaeagnus angustifolia*; or relict *Populus deltoides* or *Populus fremontii* trees may remain as canopy emergents. Shrubs in the understory include *Salix exigua*, *Rhus trilobata*, *Artemisia tridentata* ssp. *tridentata*, *Chrysothamnus linifolius*, and *Amorpha fruticosa*. The herbaceous understory is variable in composition and abundance, depending on location. Some species known to occur include *Atriplex patula*, *Distichlis spicata*, *Eleocharis palustris*, *Euthamia occidentalis*, *Glycyrrhiza lepidota*, *Grindelia* sp., *Hordeum jubatum*, *Muhlenbergia asperifolia*, *Pascopyrum smithii*, *Spartina pectinata*, and *Sporobolus airoides*. Exotic herbaceous species may be common to abundant, including *Bassia scoparia*, *Bromus tectorum*, *Descurainia sophia*, *Lepidium latifolium*, and *Xanthium strumarium*.

Canyon de Chelly National Monument. One relevé is classified as *Elaeagnus angustifolia* Semi-natural Woodland. The total vegetation cover class for this association is 75-100%. The tree stratum is characterized by a cover class range of 50-75%, the shrub stratum covers trace-1%, and the herbaceous stratum covers 25-50%. The species richness is 31 species. The tree stratum is dominated by *Elaeagnus angustifolia*, which has 50-75% cover and a dbh that ranges from 5.0-11.2 cm (7.6 cm average dbh). Also present in the tree stratum are *Populus deltoides* ssp. *wislizeni*, which has 1-5% cover and a dbh that ranges from 5.1-8.2 cm (6.4 cm average dbh), and *Tamarix* sp. which covers 1-5%. This relevé has a main canopy height of 10-20 m with a cover class of 50-75%, a subcanopy layer that is 2-5 m in height with a cover class of 25-50%, and a trace seedling layer (<1% cover) that is 0.5-1 m tall. The shrub stratum is sparse (trace-1%) and is dominated by *Salix exigua*. The shrub stratum has only one distinct layer that has a height of 1-2 m. The herbaceous stratum has moderate cover (25-50%) and is dominated by *Hordeum murinum* ssp. *glaucum*, which covers 10-25% and *Bromus rigidus*, which covers 5-10%. Other herbaceous species with at least 1-5% cover include *Heterotheca villosa* and *Pascopyrum smithii*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Elaeagnus angustifolia*	*Elaeagnus angustifolia*
Tall/short shrub/sapling	*Amorpha fruticosa*	*N/A*
Tall shrub/sapling	*Salix exigua, Tamarix ramosissima*	*N/A*
Herbaceous	*Distichlis spicata, Pascopyrum smithii, Sporobolus airoides*	*Bromus rigidus, Hordeum murinum* ssp. *glaucum*

Other noteworthy species:

Global species	Canyon de Chelly species
Lepidium latifolium	*Data are not available.*

Authors:

Global descriptions. D. Faber Langendoen, mod. J. Coles and K. A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Great Plains Flora Association 1986, Von Loh et al. 1999.

7. *Juniperus scopulorum - Quercus gambelii* Woodland [Provisional]

NatureServe common name	Rocky Mountain Juniper - Gambel Oak Woodland
NatureServe code	CEGL002967

Summary:

This woodland association is known from the southern Colorado Plateau in northeastern Arizona and southwestern Utah at elevations ranging from 1647-2238 m (5400-7343 feet). Stands occur in gently sloping drainage bottomlands and swales, and occasionally hillsides. Soils include sandy loams, and ground litter ranges from 15-50% cover. The vegetation is characterized by an open to relatively dense tree canopy (20-80% cover) codominated by *Juniperus scopulorum* and *Quercus gambelii*. *Juniperus osteosperma* may also be present to common in the tree canopy of some stands, and occasional emergent *Pinus ponderosa* trees may be present with <5% cover. *Pinus edulis* and *Pinus monophylla* are typically absent but may occur with low cover (<5%). In some stands the oaks may form more of a tall shrub layer than a tree canopy. Otherwise, the shrub layer is typically sparse with scattered *Artemisia tridentata*, *Cercocarpus montanus*, *Chrysothamnus depressus*, *Fendlera rupicola*, *Gutierrezia microcephala*, *Purshia tridentata*, and *Yucca angustissima*. The herbaceous layer is variable with sparse to moderate cover (5-50%) and low to high diversity of species. Common species may include *Antennaria parvifolia* and *Pascopyrum smithii*.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. *Juniperus scopulorum* / *Quercus gambelii* Woodland [Provisional] is provisionally accepted as a NVCS association. It is under review to determine if this community should be retained in the NVCS as an association. At Canyon de Chelly National Monument, this vegetation community was considered a small outcropping of unique vegetation within either the *Pinus ponderosa* or *Pinus edulis* overstory with *Quercus gambelii* understory. This community was not mappable or easily identifiable on the aerial photography.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Juniperus scopulorum* woodland alliance (A.506) Rocky Mountain Juniper Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.818	Rocky Mountain Gambel Oak Mixed Montane Shrubland
CES306.821	Rocky Mountain Lower Montane Foothill Riparian Woodland and Shrubland

NatureServe conservation status:

Global rank. GNR (22 Jan 2002).

Distribution:

Globally. This association has currently only been described from Canyon de Chelly National Monument in northeastern Arizona, Zion National Park in southwestern Utah, and in Curecanti National Recreation Area in western Colorado. It will likely be found elsewhere in the southern Colorado Plateau.

Canyon de Chelly National Monument. *Juniperus scopulorum* / *Quercus gambelii* Woodland [Provisional] was only sampled from one relevé location near the confluence of Coyote Wash and Crystal Creek within Canyon de Chelly National Monument.

Environmental summary:

Globally. This woodland association is known from the southern Colorado Plateau in northeastern Arizona and southwestern Utah, at elevations ranging from 1647-2238 m (5400-7343 feet). Stands occur in gently sloping drainage bottomlands and swales, and occasionally hillsides. Soils include sandy loams, and ground litter ranges from 15-50% cover.

Canyon de Chelly National Monument. This association occurs on sandy clay loam soil at an elevation of 2238 m (7343 feet). The relevé occurs on a swale with a slope of 2% at a northern aspect. This particular relevé shows evidence of logging and chaining activity and has a moderate amount of litter (10-25% cover class).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by an open to relatively dense tree canopy (20-80% cover), codominated by *Juniperus scopulorum* and *Quercus gambelii*. *Juniperus osteosperma* may also be present to common in the tree canopy of some stands, and occasional emergent *Pinus ponderosa* trees may be present with <5% cover. *Pinus edulis* and *Pinus monophylla* (western stands) are typically absent but may occur with low cover (<5%). In some stands, the oaks may form more of a tall shrub layer than a tree canopy. Otherwise, the shrub layer is typically sparse with scattered *Artemisia tridentata*, *Cercocarpus montanus*, *Chrysothamnus depressus*, *Fendlera rupicola*, *Gutierrezia microcephala*, *Purshia tridentata*, and *Yucca angustissima*. The herbaceous layer is variable with sparse to moderate cover (5-50%) and low to high diversity of species. Common species may include *Antennaria parvifolia* and *Pascopyrum smithii*.

Canyon de Chelly National Monument. One relevé is classified as *Juniperus scopulorum* / *Quercus gambelii* Woodland [Provisional]. The total vegetation cover class for this association is 50-75%. The tree stratum is characterized by a cover class range of 25-50%, the shrub stratum covers 1-5%, and the herbaceous stratum covers 25-50%. The species richness is 36 species. The tree stratum is codominated by *Juniperus scopulorum* and *Quercus gambelii*, each having a cover class of 25-50%. *Juniperus scopulorum* has a dbh range of 12.8-32.9 cm (19.2 cm average dbh). Also present in the tree stratum is *Pinus ponderosa*, which covers 1-5% of the relevé (one dbh measurement of 45.4 cm). This relevé has a main canopy height of 5-10 m with a cover class of 25-50%, and an emergent layer that is 20-30 m tall that covers 1-5%. There is also a subcanopy layer that covers 10-25% and is 2-5 m in height, and a trace seedling layer (<1% cover) that is 0.5-1 m tall. The shrub stratum is sparse (1-5% cover class) and is composed of trace 1% cover of *Cercocarpus montanus*, *Chrysothamnus depressus*, *Fendlera rupicola*, *Gutierrezia microcephala*, and *Yucca angustissima*. The herbaceous stratum has moderate cover (25-50%) and has a diversity of species, all with a cover class <1% except for *Antennaria parvifolia* and *Pascopyrum smithii* that have a 1-5% cover class.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus scopulorum, Quercus gambelii*	*Juniperus scopulorum, Quercus gambelii*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K. A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

CONHP unpubl. data 2003, Cogan et al. 2004.

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

NatureServe common name	Two needle Pinyon - (Utah Juniper) / Blue Grama Woodland
NatureServe code	CEGL000778

Summary:

This woodland association is known from mountains and mesas in the southern Colorado Plateau, Mogollon Rim and extending north into southern Utah and probably western Colorado. Elevations normally range from 1700-2400 m (5575-7875 feet). Sites are variable but generally are relatively dry and rocky. Stands occur on flat to moderate slopes along drainages and on mesa-tops, on gentle to moderate (10-40%) rocky slopes of foothills, and at the base of cinder cones. The substrates are variable and range from deep, coarse textured soils derived from cinder to finer textured soils derived from sandstone, shale and limestone. The vegetation is characterized by an open to moderately dense tree canopy (10-65% cover) codominated by *Pinus edulis* and *Juniperus osteosperma* trees that are between 1 and 5 m tall. *Pinus edulis* may be present with relatively small cover in some stands. *Juniperus deppeana* may replace *Juniperus osteosperma* in southern stands. Other species of *Juniperus*, such as *Juniperus scopulorum*, may be present in higher elevation stands. Shrub cover is sparse (<10% cover). If *Quercus gambelii* is present, it has less than 5% cover. Other associated shrubs may be present in low cover, such as *Cercocarpus montanus*, *Chrysothamnus viscidiflorus*, *Ephedra viridis*, *Ericameria nauseosa*, *Eriogonum microthecum*, *Rhus trilobata*, or *Yucca* spp. The herbaceous layer is typically moderately dense and is dominated by the warm season, perennial short grass *Bouteloua gracilis*. Associated graminoids include *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua curtipendula*, *Elymus elymoides*, *Koeleria macrantha*, *Hesperostipa comata* (= *Stipa comata*), *Hesperostipa neomexicana* (= *Stipa neomexicana*), and *Pleuraphis jamesii* (= *Hilaria jamesii*). *Muhlenbergia montana* is absent or scarce (<1% cover). Forb cover is typically low but may be moderately diverse.

Classification confidence: 2 - Moderate.

Classification comments:

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

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. G5 (23 Feb 1994).

Distribution:

Globally. This woodland association is known from mountains and mesas in the southern Colorado Plateau and Mogollon Rim of northern Arizona and extends into southern Utah and probably into western Colorado and possibly into western New Mexico.

Canyon de Chelly National Monument. *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland occurs on ten relevés on canyon terraces, mesas, plateaus, and canyon rims within Canyon de Chelly National Monument. The relevés for this association were sampled throughout the monument, including near the vicinity of Canyon del Muerto, Canyon de Chelly, White House Canyon, Monument Canyon and Black Rock Canyon.

Environmental summary:

Globally. This woodland association is known from mountains and mesas in the southern Colorado Plateau, Mogollon Rim and extending north into southern Utah and probably western Colorado. Elevations normally range from 1700-2400 m (5575-7875 feet). Sites are variable but generally are relatively dry and rocky. Stands occur on flat to moderate slopes along drainages and on mesatops, on gentle to moderate (10-40%) rocky slopes of foothills, and at the base of cinder cones. The substrates are variable and range from to deep, coarse textured soils derived from cinder, to sandy loams derived from sandstone or fine textured soils derived from limestone or shale.

Canyon de Chelly National Monument. This association occurs on sandy clay loam soil at an elevation of 2238 m (7343 feet). The relevé occurs on a swale with a slope of 2% at a northern aspect. This particular relevé shows evidence of logging and chaining activity and has a moderate amount of litter (10-25% cover class).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This plant association is characterized by an open to moderately dense tree canopy (10-65% cover) codominated by *Pinus edulis* and *Juniperus osteosperma* trees that are between 1 and 5 m tall. *Pinus edulis* may be present with relatively small cover in some stands. *Juniperus deppeana* may replace *Juniperus osteosperma* in southern stands. Other species of *Juniperus*, such as *Juniperus scopulorum*, may be present in higher elevation stands. Shrub cover is sparse (<10% cover). If *Quercus gambelii* is present, it has less than 5% cover. Other associated shrubs may be present, such as scattered *Artemisia tridentata*, *Brickellia californica*, *Cercocarpus montanus*, *Chrysothamnus viscidiflorus*, *Ephedra viridis*, *Ericameria nauseosa*, *Eriogonum* corymbosum, *Eriogonum microthecum*, *Fallugia paradoxa*, *Gutierrezia sarothrae*, *Opuntia* spp., *Purshia stansburiana*, *Rhus trilobata*, *Ribes cereum*, or *Yucca* spp. The herbaceous layer is typically moderately dense and is dominated by the warm season, perennial short grass *Bouteloua gracilis*. Associated graminoids include *Aristida* spp., *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua curtipendula*, *Elymus elymoides*, *Koeleria macrantha*, *Hesperostipa comata* (= *Stipa comata*), *Hesperostipa neomexicana* (= *Stipa neomexicana*), and *Pleuraphis jamesii* (= *Hilaria jamesii*). *Muhlenbergia montana* is absent or scarce (<1% cover). Forb cover is typically low but may be moderately diverse. Species such as *Artemisia dracunculus*, *Eriogonum* spp., *Hymenoxys richardsonii*, and *Oxytropis lambertii* are common.

Canyon de Chelly National Monument. Ten relevés are classified as *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland. The total vegetation cover class for this

association ranges from 25-50% to 75-100% (average cover class 43-68%). The tree stratum is moderate to dense and ranges in cover class between 1-5% and 75-100% (average cover class 36-57%). The shrub stratum is generally sparse and ranges from trace-1% to 10-25% (average cover class 2-6%). The herbaceous stratum is also fairly sparse, with cover ranging between 1-5% and 10-25% (average cover class 6-14%). The species richness ranges from 16-30 species (average of 23 species). The tree stratum consists of a main canopy (cover ranging between 1-5% and 50-75%), an emergent layer (one relevé with an emergent cover class of 5-10%), a subcanopy (eight relevés with cover ranging from trace-1% to 5-10%) and a seedling layer that covers trace-1% of all relevés. The main canopy layer varies between 2-5 m and 20-30 m in height, the emergent layer (present in one relevé only) is 10-20 m, the subcanopy ranges from 2-5 m to 5-10 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Pinus edulis*, which ranges between trace-1% and 50-75% cover (average cover class 21-37%), and with a dbh ranging from 5.3-39.7 cm (average dbh 17.2 cm). *Juniperus osteosperma* is always present and is occasionally the dominant tree or is codominant with *Pinus edulis*. It ranges between trace-1% and 25-50% cover (average cover class 8-18%) and has a dbh that ranges from 10.5-67.3 cm (average dbh 30.4 cm) or has a drc that ranges from 9.5-64.2 cm (average drc 34.2 cm). Three of the relevés in this association also contain *Pinus ponderosa*, which covers 1-5% or 5-10% where present. These trees have a dbh of 7.9-29.2 cm (average dbh 17.6 cm).

The shrub stratum has a tall shrub layer that ranges in height between 0.5-1 m and 5-10 m and a short shrub layer of 0.5-1 m to 1-2 m. The tall shrub layer is present in all but two of the relevés and has low cover that ranges from trace-1% to 1-5%. The short shrub layer is present in only half of the relevés and has low cover that ranges between trace-1% and 1-5% where present. The shrub stratum is not consistent and is most commonly dominated by *Gutierrezia sarothrae*, which covers 5-10% of one relevé and is present in four others. *Gutierrezia microcephala* and *Artemisia tridentata* are also fairly common and occasionally cover as much as 1-5% in some relevés. The herbaceous layer is dominated by *Bouteloua gracilis*, which ranges in cover from 1-5% to 5-10% (average cover class 3-7%). There are a diversity of other herbaceous species which all have <1% cover, except for *Bromus tectorum* and *Hymenoxys richardsonii*, which occasionally cover as much as 1-5% in some relevés.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus deppeana, Juniperus osteosperma, Juniperus scopulorum, Pinus edulis*	*Juniperus osteosperma, Pinus edulis, Pinus ponderosa*
Herbaceous	*Bouteloua gracilis*	*Gutierrezia sarothrae, Bouteloua gracilis*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum.	*Bromus tectorum.*

Authors:

Global descriptions. K.A. Schulz, mod. J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Bourgeron and Engelking 1994, Dick Peddie 1986, Driscoll et al. 1984, Dwyer and Pieper 1967, Hansen et al. 2004b, Jameson 1962, Kennedy 1983, Ladyman and Muldavin 1996, Larson and Moir 1987, Little 1987, Moir and Carleton 1987, Muldavin et al. 1998, Powell 1988, Stuever and Hayden 1997a, USFS 1982, Wright et al. 1973, Wright et al. 1979.

9. *Pinus edulis - Juniperus osteosperma / Amelanchier utahensis* Woodland

NatureServe common name	Two needle Pinyon - Utah Juniper / Utah Serviceberry Woodland
NatureServe code	CEGL002329

Summary:

This association is characteristic of rocky slopes in the Colorado Plateau and extends into the southern Rocky Mountains in western Colorado and northeastern Arizona. Elevations and aspects are variable. Stands occurring at lower elevations (1406-2006 m) on the Colorado Plateau and northwestern Colorado tend to occur on northerly aspects, whereas stands occurring in west central and southwestern Colorado occur at higher elevations (2481-2510 m) and have southerly aspects. Stands throughout the range may be on gentle to steep slopes (7-160%). Soils are rapidly drained, but texture and parent materials vary from clay to sandy loam and from marine shale to sandstone and granite. The unvegetated ground surface is composed primarily of exposed bedrock, rocks, gravel and bare ground. This woodland association has an open to relatively closed tree canopy and sparse to dense total vegetation cover. *Juniperus osteosperma* and *Pinus edulis* comprise the tree canopy, but individually do not exceed 25% cover. There is a tall shrub stratum with up to 25% cover dominated by *Amelanchier utahensis*. Other shrubs that may be present with low cover include *Artemisia tridentata*, *Cercocarpus montanus*, *Fraxinus anomala*, *Ephedra viridis*, *Fendlera rupicola*, *Quercus gambelii*, *Rhus trilobata*, and *Symphoricarpos oreophilus*. Dwarf shrubs may include *Yucca harrimaniae*, *Gutierrezia sarothrae*, and *Chrysothamnus viscidiflorus*. The herbaceous layer has sparse to low cover and contains graminoids, such as *Achnatherum hymenoides*, *Carex geyeri*, *Leymus salinus*, and *Poa fendleriana*, and forbs, such as *Antennaria parvifolia*, *Erigeron peregrinus*, *Eriogonum ovalifolium*, *Heterotheca villosa*, *Lathyrus lanszwertii*, *Lepidium montanum*, *Phlox austromontana*, and *Streptanthella longirostris*. Disturbed stands may contain *Bromus tectorum*.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. *Amelanchier utahensis* is a common constituent of plant communities on rocky slopes in the Colorado Plateau. There is some overlap with *Pinus edulis - Juniperus osteosperma* / (*Shepherdia rotundifolia*, *Amelanchier utahensis*) Wooded Shrubland (CEGL002334), and as more information becomes available, woodlands with *Amelanchier utahensis* as a significant component should be re analyzed.

Canyon de Chelly National Monument. Although only one relevé was defined as *Pinus edulis - Juniperus* spp. / *Amelanchier utahensis* Woodland, this association was mapped frequently throughout the monument. This is likely due to the steep slopes that this association typically grows on and the lack of accessibility to sample these areas.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. GNR (11 Jan 2005).

Distribution:

Globally. This association is found in the Colorado Plateau in northeastern Arizona and southeastern Utah and extends east into the southern Rocky Mountains of western Colorado.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus* spp. / *Amelanchier utahensis* Woodland was only sampled from one relevé location in a canyon west of Coyote Wash within Canyon de Chelly National Monument.

Environmental summary:

Globally. This association is characteristic of rocky slopes in western Colorado. Stands in northwestern Colorado are at lower elevations (1528-1950 m) and tend to occur on northerly aspects. Stands in central and southern Colorado occur at higher elevations (2481-2510 m) and have southerly aspects. Stands throughout the range may be on gentle to steep slopes (7-160%). Soils are rapidly drained, but texture and parent materials vary from clay to sandy loam and from marine shale to sandstone and granite. The unvegetated ground is composed primarily of exposed bedrock, rocks, gravel and bare ground.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 2006 m (6581 feet). The relevé occurs on a step in slope with an incline of 32% and a western aspect. This particular relevé has a fairly high cover of stones and boulders (each having a cover class of 10-25%) that are in the form of rock slabs.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This woodland association has an open to relatively closed tree canopy and sparse to dense total vegetation cover. The dominant tree species, *Juniperus osteosperma* and *Pinus edulis*, are typically between 2 and 10 m tall and individually do not exceed 25% cover. There is a tall shrub stratum with up to 25% cover dominated by *Amelanchier utahensis*. Other shrubs that may be present with low cover include *Artemisia tridentata*, *Cercocarpus montanus*, *Fraxinus anomala*, *Ephedra viridis*, *Fendlera rupicola*, *Quercus gambelii*, *Rhus trilobata*, and *Symphoricarpos oreophilus*. Dwarf shrubs may include *Yucca harrimaniae*, *Gutierrezia sarothrae*, and *Chrysothamnus viscidiflorus*. The herbaceous layer has sparse to low cover and contains graminoids, such as *Achnatherum hymenoides*, *Carex geyeri*, *Leymus salinus*, and *Poa fendleriana*, and forbs, such as *Antennaria parvifolia*, *Artemisia ludoviciana*, *Collinsia parviflora*, *Erigeron peregrinus*, *Eriogonum ovalifolium*, *Heterotheca villosa*, *Lathyrus lanszwertii*, *Lepidium montanum*, *Phlox austromontana*, and *Streptanthella longirostris*. Disturbed stands may contain *Bromus tectorum*.

Canyon de Chelly National Monument. One relevé is classified as *Pinus edulis - Juniperus* spp. / *Amelanchier utahensis* Woodland. The total vegetation cover class for this association is 25-50%. The tree stratum is characterized by a total cover class range of 10-25%, the shrub stratum covers 5-10%, and the herbaceous stratum also covers 5-10%. The species richness is 17 species. The tree stratum is codominated by *Juniperus osteosperma* and *Pinus edulis*, each having a cover class of 5-10%. *Juniperus osteosperma* has a drc range from 12.0 59.0 cm (33.2 cm average drc). Two trees of *Pinus edulis* were measured for dbh at 7.2 cm and 11.2 cm. This relevé has a main canopy height of 5-10 m with a cover class of 10-25%, a subcanopy layer that covers 1-5% and is 2-5 m tall, and a trace seedling layer (<1% cover)

that is 0.5-1 m tall. The shrub stratum has two distinct layers. The tall shrub layer covers 1-5% and is 2-5 m in height, and the short shrub layer covers 5-10% and is 1-2 m tall. The dominant shrub species is *Amelanchier utahensis*, which has a 1-5% cover class. Also present in the shrub stratum are *Artemisia nova*, *Ephedra viridis*, and *Gutierrezia microcephala*. The herbaceous stratum has a diversity of species, all having a cover class <1%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus osteosperma, Pinus edulis*	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis*	*Amelanchier utahensis*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum	*Data are not available.*

Authors:

Global descriptions. J. Drake and J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

10. *Pinus edulis - Juniperus osteosperma / Artemisia nova* Woodland

NatureServe common name	Two needle Pinyon - Utah Juniper / Black Sagebrush Woodland
NatureServe code	CEGL002331

Summary:

This Colorado Plateau association occurs in western and northern Colorado, eastern Utah and northeastern Arizona on the higher areas of local topographical features such as canyon rims, mesas, hills, ridgetops, and upper slopes. Sites are nearly level to moderately steep and tend toward northern aspects, although other directions are possible. Elevation ranges from 1772 to 2518 m (5800-8260 feet). The soils are variable and range from sandy loam to silt clay loam and sandy clay soil textures. Soils are typically shallow and rapidly drained. Parent materials are often sandstones or limestones but can also be eolian deposits or shale. The unvegetated surface is composed of litter, bare soil, bedrock, and large and small rocks. Cryptogams often have moderate to high cover. This woodland association ranges from a moderately dense to a more typically open tree canopy (10-60% cover) dominated by short evergreen trees 2-10 m tall. *Pinus edulis* and *Juniperus osteosperma* dominate the tree canopy and may form a sparse subcanopy 2-5 m tall where the upper canopy is taller. In most stands, *Pinus edulis* and *Juniperus osteosperma* each have between 3 and 35% canopy cover, although in some sparsely vegetated stands, they may have less. Scattered *Pseudotsuga menziesii* may be present at higher elevations. Shrubs provide low to moderate cover. The dwarf shrub *Artemisia nova* is the most abundant shrub, usually with less than 20% cover (rarely up to 50%). Other shrubs include *Amelanchier utahensis*, *Artemisia tridentata*, *Cercocarpus montanus*, *Ephedra viridis*, *Gutierrezia microcephala*, *Purshia stansburiana*, *Purshia tridentata*, and *Opuntia* spp. A number of herbaceous species can be found across the range of this association, but any one stand usually has low to moderate diversity and less than 10% cover in aggregate. Common herbaceous species include the graminoids *Achnatherum hymenoides*, *Bouteloua gracilis*, *Carex* spp., *Elymus elymoides*, *Koeleria macrantha*, and *Poa fendleriana* and forbs *Antennaria parvifolia*, *Arabis* spp., *Hymenoxys richardsonii*, *Petradoria pumila*, *Phlox* spp., and many others.

Classification confidence: 2 - Moderate**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. GNR (11 Jan 2005).

Distribution:

Globally. This association is found on the Colorado Plateau and western slope of the southern Rocky Mountains in western and northern Colorado, eastern Utah and northeastern Arizona.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus osteosperma* / *Artemisia nova* Woodland occurs on five relevés on hills and canyon rims within Canyon de Chelly National Monument. The relevés for this association were sampled throughout the monument, including suitable landforms in Monument Canyon, Black Rock Canyon, Canyon de Chelly proper, and in Cattail Wash near Yellowhair Spring.

Environmental summary:

Globally. This Colorado Plateau association occurs on the higher areas of local topographical features such as canyon rims, mesas, hills, ridgetops, and upper slopes. Sites are nearly level to moderately steep and tend toward northern aspects, although other directions are possible. Elevation ranges from 1772 to 2518 m (5800-8260 feet). The soils are variable and include sandy loam, sandy clay loam, silt loam, and silt clay loam soil textures. They tend to be shallow and rapidly drained. Parent materials are often sandstones but can also be eolian deposits, limestone, or shale. The unvegetated surface is composed of litter, bare soil, bedrock, and large and small rocks. Cryptogams often have moderate to high cover.

Canyon de Chelly National Monument. This association occurs on sandy loam, sandy clay loam, silt loam and silt clay loam soils between the elevations of 2000 and 2253 m (6562-7392 feet) (average 2181 m [7156 feet]). The slope ranges from 0-10% (average 4%) at various aspects. The litter cover is moderate, ranging from 1-5% to 25-50%, with an average cover range of 9-20%. Cryptogamic soil crust is present in four of the five relevés and has fairly high cover in two relevés with 10-25% and 25-50% cover, respectively.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This woodland association ranges from a moderately dense to a more typically open tree canopy (10-60% cover) dominated by short evergreen trees 2-10 m tall. *Pinus edulis* and *Juniperus osteosperma* dominate the tree canopy and may form a sparse subcanopy 2-5 m tall where the upper canopy is taller. In most stands, *Pinus edulis* and *Juniperus osteosperma* each have between 3 and 35% canopy cover, although in some sparsely vegetated stands, they may have less. Shrubs are present but provide low to moderate cover. The dwarf shrub *Artemisia nova* is the most abundant shrub, usually with less than 20% cover, but stands with up to 50% cover have been observed. Other shrubs that are typically found include *Amelanchier utahensis*, *Artemisia tridentata*, *Cercocarpus montanus*, *Ephedra viridis*, *Gutierrezia microcephala*, *Purshia stansburiana*, *Purshia tridentata*, and *Opuntia* spp. Herbaceous species can be relatively diverse between stands, but any one stand usually has low to moderate diversity and less than 10% cover in aggregate. Common species include *Achnatherum hymenoides*, *Bouteloua gracilis*, *Carex* spp., *Elymus elymoides*, *Koeleria macrantha*, and *Poa fendleriana*. Forbs can include *Antennaria parvifolia*, *Arabis* spp., *Hymenoxys richardsonii*, *Petradoria pumila*, *Phlox* spp., and many others.

Canyon de Chelly National Monument. Five relevés are classified as *Pinus edulis - Juniperus osteosperma* / *Artemisia nova* Woodland. The total vegetation cover class for this association ranges from 25-50% to 50-75% (average cover class 40-65%). The tree stratum varies from low to dense, ranging in cover class between 1-5% and 50-75% (average cover class 28-47%). The shrub stratum has a fairly low cover class which ranges from 1-5% to 10-25% (average cover 5-14%). The herbaceous stratum also has fairly low cover, ranging between 1-5% and 10-25% (average cover class 6-17%). The species richness ranges from 15-23

species (average of 20 species). The tree stratum consists of a main canopy (cover ranging between 5-10% and 25-50%), a subcanopy which covers trace-1% to 25-50%, and a seedling layer that covers trace-1% or 1-5%. The main canopy layer varies between 5-10 m and 20-30 m in height, the subcanopy ranges from 1-2 m to 5-10 m, and the seedling layer is 0.5-1 m or 1-2 m tall. The tree stratum is dominated by *Pinus edulis*, ranging between 5-10% and 50-75% cover (average cover class 19-34%), and with a dbh ranging from 5.3-58.3 cm (average dbh 17.9 cm). *Pinus edulis* is usually accompanied by *Juniperus scopulorum*, which ranges in cover from 0% to 5-10% (2-5% average cover class) and has a drc that varies from 5.0-57.1 cm (average drc 20.1 cm). Two trees were measured for dbh at 6.2 cm and 15.2 cm. Two of the relevés also have 5-10% cover of *Juniperus osteosperma*, which range in drc from 32.1-99.4 cm (average drc 59.4 cm), and one of the relevés has 5-10% cover of *Pseudotsuga menziesii*, which ranges in dbh from 8.9-15.7 cm (average dbh 11.7 cm).

The shrub stratum has a tall shrub layer that ranges in height between 1-2 m and 2-5 m and a short shrub layer of 0.5-1 m. The tall shrub layer covers 1-5% of all relevés, and the short shrub layer covers between 1-5% and 10-25%. The shrub stratum is dominated by *Artemisia nova*, which ranges in cover from 1-5% to 10-25% (average cover class 4-11%). Other species frequently present in the shrub stratum are *Artemisia tridentata*, *Ephedra viridis*, *Gutierrezia microcephala*, and *Purshia stansburiana*. The herbaceous stratum is dominated by *Bouteloua gracilis*, which covers 0% to 10-25% (average cover class 3-8%) and *Poa fendleriana*, which covers 0% to 5-10% (average cover class 1-2%). Other frequently encountered herbaceous species are *Antennaria parvifolia*, *Elymus elymoides*, and *Hymenoxys richardsonii*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus osteosperma, Pinus edulis*	*Juniperus osteosperma, Juniperus scopulorum, Pinus edulis, Pseudotsuga menziesii*
Tall/short shrub/ sapling	*Amelanchier utahensis*	*Artemisia nova*
Herbaceous	*Artemisia nova*	*Bouteloua gracilis, Poa fendleriana*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. J. Drake, mod. J. Coles and K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas, mod. K.A. Schulz.

References:

None available.

11. *Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus* Woodland

NatureServe common name	Two needle Pinyon - Utah Juniper / Littleleaf Mountain mahogany Woodland
NatureServe code	CEGL000779

Summary:

This woodland association occurs on dry sandstone ridgetops, mesa edges, outcrops, colluvial slopes, slickrock hills, benches and knolls at moderate elevations of 1525 to 2470 m (5000-8100 feet) on the Colorado Plateau and in extreme northwestern Colorado, adjacent Utah, and possibly Wyoming. South and southwest aspects are common, and slopes can be variable in steepness. Exposed bedrock and large rock may cover over 50% of the stand, with vegetation growing in the cracks. These sandstone derived soils are generally poorly developed, coarse textured and skeletal. Bare soil is common. The vegetation is characterized by a short (2-10 m), open tree canopy (10-25% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*, and by the dominance of *Cercocarpus intricatus* in the relatively sparse short shrub layer (5-25% cover). *Pinus edulis* and *Juniperus osteosperma* vary in cover between 1 and 15%, though higher covers are possible. The shrubs *Amelanchier utahensis*, *Arctostaphylos patula*, *Gutierrezia sarothrae*, *Mahonia fremontii*, *Quercus gambelii*, or *Yucca* spp. are often present in many stands. Herbaceous cover is sparse (<5% cover) and is composed of scattered forbs and grasses such as species of *Cryptantha*, *Penstemon*, and *Opuntia*, *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua gracilis*, *Elymus elymoides*, *Pleuraphis jamesii*, and *Poa fendleriana*.

Classification confidence: 2 - Moderate**.**

Classification comments:

Globally. Compare this association with *Juniperus osteosperma* / *Cercocarpus intricatus* Woodland (CEGL000733) which is very similar, but lacks *Pinus edulis*. On dry, rocky or slickrock sites on the Colorado Plateau, this pinyon juniper woodland association may include stands with very open tree canopies (5-10% cover) in cases where the total vegetation cover is less than 15%. These stands may be similar to open *Cercocarpus intricatus* shrublands with scattered pinyon and juniper trees but is considered a variation of the woodland type because of the ecological values of the trees.

Canyon de Chelly National Monument. The few number of relevés sampled in this association is likely due to the inaccessibility of the sites. This association tends to occur on bedrock outcrops in areas with steep slopes and on top of isolated buttes.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.765	Colorado Plateau Mixed Bedrock Canyon and Tableland
CES304.766	Colorado Plateau Pinyon Juniper Shrubland
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. G3 (30 Dec 2000). The plant association is limited to a small geographic area and is documented from a narrow elevational band on sandstone substrates in extreme northwestern Colorado and possibly adjacent Utah. There are 11 documented stands in Colorado with size ranging from 4-450 acres. Although most occurrences are considered in good to excellent condition, those in excellent condition tend to be small. Grazing and woodcutting are the primary threats where stands are accessible.

Distribution:

Globally. This plant association is found on the Colorado Plateau and in extreme northwestern Colorado, adjacent Utah, and possibly Wyoming.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus osteosperma* / *Cercocarpus intricatus* Woodland was only sampled from two relevé locations within Canyon de Chelly National Monument. One is located in a side canyon of Canyon del Muerto and the other is in Monument Canyon near the confluence with Bat Canyon.

Environmental summary:

Globally. This woodland association occurs on dry, sandstone ridgetops, mesa edges, outcrops, colluvial slopes, slickrock hills, benches, and knolls at moderate elevations (1525-2470 m) on the Colorado Plateau and in extreme northwestern Colorado, adjacent Utah, and possibly Wyoming. South and southwest aspects are common, and slopes can vary from gentle to steep. Exposed bedrock and large rock may cover over 50% of the stand, with vegetation growing in soil that has collected in joints and cracks. These sandstone derived soils are generally poorly developed, coarse textured and skeletal. Bare soil is common.

Canyon de Chelly National Monument. This association occurs on sandy loam soils at the elevations of 1854 and 1866 m (6083 and 6122 feet). One relevé is found on a north facing canyon wall at a slope of 24%, and the other occurs on a south facing canyon rim bench with a slope of 6%. Both relevés have a large portion of exposed bedrock (25-50% and 50-75% cover classes, respectively).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The association is characterized by an open tree canopy (10-25% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*, and by the dominance of *Cercocarpus intricatus* in the relatively sparse short shrub layer (5-25% cover). The tree canopy may be between 2 and 10 m tall, and *Pinus edulis* and *Juniperus osteosperma* vary in cover between 1 and 15%, with some stands having up to 25% cover of *Pinus edulis*. Some sparse (<10% total cover), tree dominated stands from extremely dry, rocky sites in the Colorado Plateau are included in this woodland association as a best fit. The shrub layer represents the mesic end of the pinyon juniper / mixed shrub understory communities found on slickrock exposures. *Amelanchier utahensis*, *Arctostaphylos patula*, *Gutierrezia sarothrae*, *Mahonia fremontii*, *Quercus gambelii*, or *Yucca* spp. are often present in many stands. Herbaceous cover is sparse (<5% cover) and is composed of scattered forbs and grasses such as species of *Cryptantha*, *Penstemon*, and *Opuntia*, *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua gracilis*, *Elymus elymoides*, *Pleuraphis jamesii*, and *Poa fendleriana*.

Canyon de Chelly National Monument. Two relevés are classified as *Pinus edulis - Juniperus osteosperma* / *Cercocarpus intricatus* Woodland. The total vegetation cover class for this association is low in both relevés (5-10% and 10-25%). The tree stratum is sparse, with a cover class of 1-5%. The shrub stratum ranges from trace-1% cover in one relevé to 5-10% in the other. The herbaceous stratum is also sparse in both relevés, with cover classes of 1-5% and 5-10%. The species richness is 15 and 27 species, respectively. The tree stratum is dominated by *Juniperus osteosperma* in one relevé and by *Pinus edulis* in the other. Both species have a cover class of 1-5% where dominant and are present in both relevés. *Juniperus osteosperma* has a drc range from 12.1-45.9 cm (24.1 cm average drc). The tree stratum is primarily composed of a main canopy layer that covers 1-5% and is 5-10 m in height. One relevé also has a trace subcanopy (<1% cover) that is 1-2 m tall, and both have a trace seedling layer (<1% cover) that is 0.5-1 m tall.

The shrub stratum has two distinct layers. The tall shrub layer covers trace-1% in one relevé where it has a height class of 1-2 m and covers 5-10% in the other relevé where it is 2-5 m tall. The short shrub layer has a cover class of trace-1% and is 0.5-1 m tall in both relevés. The shrub stratum is dominated by *Cercocarpus intricatus*, which covers 5-10% in one relevé and has trace-1% cover in the other. Also present in the shrub stratum are *Amelanchier utahensis*, *Artemisia bigelovii*, *Brickellia californica*, *Chrysothamnus viridis*, *Gutierrezia microcephala*, and *Quercus turbinella*. The herbaceous stratum has low cover (1-5% and 5-10%) and has a diversity of species. All have a cover class of <1%, except for *Muhlenbergia pauciflora* and *Pleuraphis jamesii*, which each have a 1-5% cover class in one relevé.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus osteosperma, Pinus edulis*	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Amelanchier utahensis, Cercocarpus intricatus*	*N/A*
Short shrub/ sapling	*N/A*	*Cercocarpus intricatus*
Herbaceous	*Achnatherum hymenoides, Elymus elymoides, Poa fendleriana*	

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. A.E. Black, mod. K.A. Schulz, J. Drake, J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Baker 1983a, Baker 1983b, Baker 1984, Baker and Kennedy 1985, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Cogan et al. 2004, Driscoll et al. 1984, Zimmerman 1978.

12. *Pinus edulis - Juniperus osteosperma / Chrysothamnus greenei* Woodland [Park Special]

NatureServe common name	Two-needle Pinyon – Utah Juniper / Greene's Rabbitbrush Woodland [Park Special]
NatureServe code	Park Special

Summary:

This *Pinus edulis - Juniperus osteosperma* woodland association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. Not applicable.

Distribution:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus osteosperma* / *Chrysothamnus greenei* Woodland [Park Special] was only sampled from one relevé location northeast of Canyon del Muerto (in the vicinity of Standing Rock) within Canyon de Chelly National Monument.

Environmental summary:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 2000 m (6562 feet). The relevé occurs on a mesatop that has a slope of 3%. There is a 25-50% cover of gravel, and cobble covers 10-25% of the relevé. Also present is a moderately dense layer of litter, which has a cover class of 25-50%.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. One relevé is classified as *Pinus edulis - Juniperus osteosperma* / *Chrysothamnus greenei* Woodland [Park Special]. The total vegetation cover class for this association is 25-50%. The tree stratum is characterized by a total cover class of 25-50%, the shrub stratum covers 5-10%, and the herbaceous stratum covers 1-5%. The species richness is 22 species. The tree stratum is dominated by *Pinus edulis*, which has a cover class of 10-25% and two dbh measurements at 15.5 cm and 18.5 cm. Also present in the tree stratum is *Juniperus osteosperma*, which covers 5-10% and has a drc that ranges from 4.8-37.0 cm (20.9 cm average drc). This relevé has a main canopy height of 5-10 m with a cover class of 25-50%, a subcanopy layer that covers 5-10% and is 2-5 m in height, and a trace seedling layer (<1% cover) that is 0.5-1 m tall. The shrub stratum has two distinct layers. The tall-shrub layer covers 1-5% and is 1-2 m in height, and the short-shrub layer also covers 1-5% and is 0.5-1 m tall. The shrub stratum is dominated by *Chrysothamnus greenei*, which covers 1-5% and is accompanied by *Artemisia bigelovii* and *Purshia stansburiana*. The herbaceous stratum has a diversity of species, all having a cover class <1%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*N/A*	*Juniperus osteosperma, Pinus edulis*
Shrub/sapling	*N/A*	*Chrysothamnus greenei*

Other noteworthy species:

Global species	Canyon de Chelly species
N/A	*Artemisia bigelovii, Purshia stansburiana*

Authors:

Global descriptions. Not applicable.

Local descriptions. M. Hansen.

References:

None available.

13. *Pinus edulis - Juniperus osteosperma / Ephedra viridis* Woodland

NatureServe common name	Two needle Pinyon - Utah Juniper / Mormon tea Woodland
NatureServe code	CEGL002370

Summary:

This woodland association occurs on dry middle and upper slopes of ridges and canyons, as well as on colluvial slopes and benches in eastern Utah and northwestern Colorado. Sites are moderate to steep (25-65% slope), mostly on south or west facing slopes between 1558 and 2204 m elevation. Soils are coarse, rocky and generally are derived from sedimentary rocks. The tree canopy is characterized by the codominance of *Juniperus osteosperma* and *Pinus edulis* trees that are 2-5 m tall with up to 40% cover. The shrub layer is generally sparse and is dominated by *Ephedra viridis*, which contributes approximately 10% cover. Few other shrubs are present, and because of the low diagnostic value of *Ephedra viridis*, these associated shrubs have very low cover: *Amelanchier utahensis*, *Artemisia tridentata*, *Cercocarpus intricatus*, *Glossopetalon spinescens* var. *meionandrum*, *Shepherdia rotundifolia*, *Artemisia bigelovii*, and *Mahonia fremontii* may be present. Associated graminoids provide low cover and include *Poa secunda*, *Pseudoroegneria spicata*, and *Pleuraphis jamesii*. Forbs are diverse but inconsistent among stands and contribute little cover.

Classification confidence: 2 - Moderate**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. G3 (5 Jun 2006). Although this association appears to be rare, it is likely to be somewhat common but overlooked, because of its lack of attention grabbing diagnostic species.

Distribution:

Globally. This association has been documented only from scattered sites in the southern part of Capitol Reef National Park in southeastern Utah and the canyons of the Yampa and Green rivers in Dinosaur National Monument in northeastern Utah and northwestern Colorado. It is likely to occur in xeric, rocky sites throughout the pinyon juniper zone of the Colorado Plateau.

Canyon de Chelly National Monument. This association has been observed at Canyon de Chelly National Monument in the Rink 2001-03 survey. No survey plots were obtained for this association in this project. It was included within adjacent vegetation polygons in the photointerpretation.

Environmental summary:

Globally. This association is known from dry, rocky colluvial slopes and canyons in southern Utah and northwestern Colorado. It occupies steep colluvial and other xeric slopes in canyons and hogbacks. Slopes are moderate to steep (15 to 32 degrees), are generally oriented to the south or west, and lie between 1558 and 2204 m (5100-7230 feet) elevation. Soils are rocky and are derived mainly from sedimentary rocks.

Canyon de Chelly National Monument. Data are not available.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This xeric woodland is characterized by a canopy of mixed *Pinus edulis* and *Juniperus osteosperma* with between 10 and 40% cover. Some stands on extremely steep slopes may have less than 10% tree cover but are so sparsely vegetated that they can still be considered a wooded vegetation type. The understory is clearly dominated by *Ephedra viridis* (5-15% cover); if other shrubs such as *Fraxinus anomala*, *Atriplex* spp., *Glossopetalon spinescens* var. *meionandrum*, *Purshia stansburiana*, or *Cercocarpus intricatus* are present, they have 1% or less cover. The herbaceous layer is generally sparse and poorly developed because of the moving substrate, but a few stable stands have as much as 10% cover by grasses. Species present vary from stand to stand but may include *Hesperostipa comata*, *Pleuraphis jamesii*, *Phlox hoodii*, *Tetraneuris acaulis*, *Koeleria macrantha*, *Achnatherum hymenoides*, *Phlox austromontana*, *Artemisia dracunculus*, *Pseudoroegneria spicata*, and *Poa secunda*.

Canyon de Chelly National Monument. Data are not available.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus osteosperma, Pinus edulis*	*Data are not available.*
Short shrub/ sapling	*Ephedra viridis*	*Data are not available.*
Herbaceous	*Poa secunda*	*Data are not available.*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. J. Coles.

References:

None available.

14. *Pinus edulis - Juniperus osteosperma / Fendlera rupicola* Woodland

NatureServe common name	Two needle Pinyon	Utah Juniper / Fendlerbush Woodland
NatureServe code	CEGL004005	

Summary:

This woodland association is known only from Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau. It occurs in canyons, ridges and talus slopes from 1909-2146 m (6263-7041 feet) elevation. Stands occur on gentle to moderately steep slopes (8-25%) on all aspects. The soils are generally shallow and rocky, and loamy sand to sandy loam in texture. The vegetation is characterized by an open to moderately dense tree canopy (10-50% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*. *Juniperus monosperma* may be present in some stands. *Fendlera rupicola* dominates or codominates the open to moderately dense tall shrub layer. Other shrubs may be present, including *Artemisia ludoviciana*, *Artemisia tridentata*, *Gutierrezia microcephala*, *Gutierrezia sarothrae*, *Opuntia phaeacantha*, *Opuntia polyacantha* var. *polyacantha*, *Opuntia whipplei*, and *Purshia stansburiana*. *Quercus gambelii* may be present with <5% cover. Herbaceous cover is variable, ranging from sparse to moderately dense, but is generally dominated the perennial graminoid *Bouteloua gracilis* (<5% cover) with scattered perennial forbs.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. GNR (19 Jul 2006).

Distribution:

Globally. This woodland association is known only from Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus osteosperma* / *Fendlera rupicola* Woodland occurs on three relevés in canyons and on ridges within Canyon de Chelly National Monument. The relevés for this association were sampled from Middle Trail Canyon, Bat Canyon and Canyon de Chelly proper.

Environmental summary:

Globally. This woodland association is known only from Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau. It occurs in canyons, ridges and talus slopes from 1909-2146 m (6263-7041 feet) elevation. Stands occur on gentle to moderately steep slopes (8-25%) on all aspects. The soils are generally shallow and rocky, and loamy sand to sandy loam in texture.

Canyon de Chelly National Monument. This association occurs on sandy loam soils between the elevations of 1909 and 2146 m (6263-7041 feet) (average 2012 m [6601 feet]). The slope ranges from 8-25% (average 17%) at various aspects. The litter cover is moderately low and ranges from 5-10% to 10-25%, with an average cover class of 8-20%. Two relevés have 5-10% cover of boulders while the third has 5-10% cover of bedrock.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This woodland association is characterized by an open to moderately dense tree canopy (10-50% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*. *Juniperus monosperma* may be present in some stands. *Fendlera rupicola* dominates or codominates the open to moderately dense tall shrub layer. Other shrubs may be present, including *Artemisia ludoviciana*, *Artemisia tridentata*, *Gutierrezia microcephala*, *Gutierrezia sarothrae*, *Opuntia phaeacantha*, *Opuntia polyacantha* var. *polyacantha*, *Opuntia whipplei*, and *Purshia stansburiana*. *Quercus gambelii* may be present with <5% cover. Herbaceous cover is variable, ranging from sparse to moderately dense, but is generally dominated by the perennial graminoid *Bouteloua gracilis* (<5% cover) with scattered perennial forbs. Other species that are frequently found in the herbaceous layer include *Achnatherum hymenoides*, *Arabis fendleri*, *Artemisia ludoviciana*, *Cryptantha cinerea*, *Elymus elymoides*, *Hesperostipa comata* ssp. *comata*, *Heterotheca villosa*, *Lappula occidentalis*, *Penstemon barbatus*, *Poa fendleriana*, *Packera neomexicana* (= *Senecio neomexicanus*), and *Streptanthus cordatus*. The exotic annual grass *Bromus tectorum* is often present with low to moderate cover (1 25%).

Canyon de Chelly National Monument. Three relevés are classified as *Pinus edulis - Juniperus osteosperma* / *Fendlera rupicola* Woodland. The total vegetation cover class for this association ranges from 10-25% to 50-75% (average cover class 28-50%). The tree stratum is moderate, ranging in cover class between 10-25% and 25-50% (average cover class 15-33%). The shrub stratum has generally low cover, which ranges from 1-5% to 10-25% (average cover 5-13%). The herbaceous stratum is low in one relevé (1-5% cover) and moderate in the other two (25-50%), giving an average cover class of 17-35%. The species richness is high and ranges from 25-43 species (average of 33 species). The tree stratum consists of a main canopy (cover ranging between 10-25% and 25-50%), an emergent layer (only one relevé has an emergent layer at cover of 1-5%), a subcanopy which covers 1-5% of all relevés, and a seedling layer that ranges in cover from trace-1% to 1-5%. The main canopy layer varies between 5-10 m and 10-20 m in height, the emergent layer (where present) is 10-20 m, the subcanopy ranges from 0.5-1 m to 5-10 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Juniperus osteosperma*, ranging between 5-10% and 25-50% cover (average cover class 13-28%), and with a drc ranging from 21.1-59.7 cm (average drc 42.7 cm) (one tree was measured for dbh at 76.5 cm). *Pinus edulis* is the second most abundant tree and is codominant with *Juniperus osteosperma* in one of the relevés. It covers 1-5% to 5-10% and has a dbh that ranges from 5.7-20.4 cm. One relevé contains *Juniperus monosperma* (<1% cover) that has the drc measurements of 15.5 cm and 17.8 cm, or the dbh measurements of 11.2 cm and 37.7 cm. Two relevés also contain trace-1% and 1-5% cover of *Quercus gambelii*.

The shrub stratum has a tall shrub layer that ranges in height between 2-5 m and 5-10 m and a short shrub layer of 0.5-1 or 1-2 m. The tall shrub layer covers between 1-5% and 10- 25%, and the short shrub layer covers trace-1% to 5-10%. The shrub stratum is dominated by *Fendlera rupicola*, which ranges in cover from 1-5% to 5-10% (average cover class 2-7%). Other species frequently present in the shrub stratum are *Artemisia ludoviciana*,

Artemisia tridentata, *Gutierrezia microcephala*, *Gutierrezia sarothrae*, *Opuntia phaeacantha*, *Opuntia polyacantha* var. *polyacantha*, *Opuntia whipplei*, and *Purshia stansburiana*. The herbaceous stratum is dominated by *Bouteloua gracilis*, which ranges in cover from 0% to 10- 25% (average cover class 4- 10%). *Bromus tectorum* has 10-25% cover in one relevé and trace-1% cover in the other two. Other species that are frequently found in the herbaceous layer include *Achnatherum hymenoides*, *Arabis fendleri*, *Artemisia ludoviciana*, *Cryptantha cinerea*, *Elymus elymoides*, *Hesperostipa comata* ssp. *comata*, *Heterotheca villosa*, *Lappula occidentalis*, *Penstemon barbatus*, *Poa fendleriana*, *Packera neomexicana* (= *Senecio neomexicanus*), and *Streptanthus cordatus*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus osteosperma, Pinus edulis*	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*Fendlera rupicola*	*Fendlera rupicola*
Short shrub/ sapling	*Opuntia phaeacantha*	*Opuntia phaeacantha*
Herbaceous	*Bouteloua gracilis*	*Bouteloua gracilis*

Other noteworthy species:

Global species	Canyon de Chelly species
N/A	*Bromus tectorum*

Authors:

Global descriptions. K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

15. *Pinus edulis - Juniperus osteosperma / Purshia stansburiana* Woodland

NatureServe common name	Two needle Pinyon - Utah Juniper / Stansbury's Cliffrose Woodland
NatureServe code	CEGL000782

Summary:

This woodland association is known from the Colorado Plateau of southern Utah and Colorado south to central Arizona. It occurs on dry sites on canyon rims, ridges and slopes. Elevation ranges from 1400 to 2165 m. Stands occur on gentle to moderately steep slopes on all aspects. The soils are generally shallow and rocky, ranging from sand to clay loam in texture. Rock outcrop and bare soil are common. Parent materials include sandstone and shale. The vegetation is characterized by an open to moderately dense tree canopy (10-60% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*. *Purshia stansburiana* dominates or codominates the sparse to moderately dense short shrub layer, often with *Artemisia tridentata* in the northern part of its range. *Cercocarpus montanus* and *Purshia tridentata* are scarce or absent. Other shrubs may be present, including *Amelanchier utahensis*, *Arctostaphylos patula*, *Chamaebatiaria millefolium*, *Ephedra viridis*, *Gutierrezia sarothrae*, *Quercus gambelii* (<5% cover), or species of *Yucca* and *Opuntia*. Herbaceous cover is variable, ranging from sparse to moderately dense, but generally dominated by graminoids (<5% cover) with scattered perennial forbs.

Classification confidence: 1 - Strong.

Classification comments:

Globally. The global name of this association was changed on 2001 09 04 because of a taxonomic change of the nominal species. *Purshia mexicana* var. *stansburiana* (Torr) Welsh is now recognized as *Purshia stansburiana* (Torr.) Henrickson (Kartesz 1999). *Purshia mexicana* (D. Don) Henrickson, a closely related species, occurs in Chihuahua, Durango and Zacateca, Mexico, and possibly extreme southern Arizona, and is not known to be present in this association (Cronquist et al. 1997).

This association appears to be part of a continuum of Colorado Plateau woodland communities growing on fractured sandstone. Stands where *Purshia stansburiana* is the dominant understory shrub are less common than those in which it is a component of a mixed shrub understory that includes *Cercocarpus montanus*, *Amelanchier utahensis*, and *Cercocarpus intricatus* in mesic stands, or *Coleogyne ramosissima* and *Yucca* spp. in xeric stands. An analysis of the woodland data from four parks (Colorado, Arches, Natural Bridges, Canyonlands) confirmed that *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland (CEGL000782) is a valid association but not always easy to distinguish from more mixed shrub woodlands in the field.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland has a consistent understory of *Poa fendleriana*. The NVCS association concept describes *Poa fendleriana* as the main herbaceous species in the understory of *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland, although it is not included in the association nomenclature. We would suggest that *Poa fendleriana* be included in the nomenclature to recognize its significance to the association concept. We also described a *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland that had low cover of *Purshia stansburiana* in the shrub layer and high cover of *Poa fendleriana* in the herbaceous layer. We were not able to distinguish *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland from *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland on the aerial photography and combined these two associations into one map class. It is possible that *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland could be just an ecotonal variation of *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.766	Colorado Plateau Pinyon Juniper Shrubland
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. G4? (1 Feb 1996).

Distribution:

Globally. This woodland association occurs in the Colorado Plateau region of central Arizona, western New Mexico, southwestern Colorado, and southern Utah.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus osteosperma / Purshia stansburiana* Woodland occurs on 18 relevés on mesas, plateaus, hills, washes, talus slopes, ridges, and canyon rims within Canyon de Chelly National Monument. The relevés for this association were sampled throughout the monument, including suitable landforms in the vicinity of Canyon de Chelly proper, Canyon del Muerto, Monument Canyon, Middle Trail Canyon, Wild Cherry Canyon, and Coyote Wash.

Environmental summary:

Globally. This woodland association is known only from Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau. It occurs in canyons, ridges and talus slopes from 1909-2146 m (6263-7041 feet) elevation. Stands occur on gentle to moderately steep slopes (8-25%) on all aspects. The soils are generally shallow and rocky, and loamy sand to sandy loam in texture.

Canyon de Chelly National Monument. This association occurs on sandy loam soils between the elevations of 1909 and 2146 m (6263-7041 feet) (average 2012 m [6601 feet]). The slope ranges from 8-25% (average 17%) at various aspects. The litter cover is moderately low and ranges from 5-10% to 10-25%, with an average cover class of 8-20%. Two relevés have 5-10% cover of boulders while the third has 5-10% cover of bedrock.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This woodland occurs on the Colorado Plateau of southern Utah and Colorado south to central Arizona, on dry canyon rims, ridges, hills, benches, mesas and occasionally in intermittent drainages. Elevations range from 1400 to 2165 m (4600-7100 feet). Stands occur on gentle to moderately steep slopes on all aspects. Soils are generally shallow and rocky, ranging in texture from sand in most stands to clay loam or sandy clay. Exposed sandstone or limestone bedrock and bare soil have high cover, and woody plants are generally rooted in cracks and joints in bedrock. A minority of stands may also occur on shale slopes covered by

sandstone colluvium.

Canyon de Chelly National Monument. This association occurs on silt loam, sandy loam, silt clay, silt clay loam, and clay soils between the elevations of 1982 and 2266 m (6503-7434 feet) (average 2186 m [7172 feet]). The slope ranges from 4-33% (average 13%) at a south-eastern to southwestern aspect. The litter cover range is often moderate and ranges from 1-5% to 25-50%, with an average cover range of 10-23%. Three of the relevés have exposed bedrock with 10-25% cover.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus osteosperma, Pinus edulis*	*Juniperus osteosperma, Pinus edulis, Pinus ponderosa*
Tall shrub/sapling	*Amelanchier utahensis, Purshia stansburiana*	*Purshia stansburiana*
Herbaceous	*N/A*	*Poa fendleriana*

Other noteworthy species:

Global species	Canyon de Chelly species
N/A	*Bromus tectorum*

Authors:

Global descriptions. K.A. Schulz, mod. J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

BIA 1979, Baker 1980, Baker 1984, Bourgeron and Engelking 1994, Britton and Wright 1983, CONHP unpubl. data 2003, Cogan et al. 2004, Cronquist et al. 1997, Driscoll et al. 1984, Isaacson 1967, Kartesz 1999, Larson and Moir 1987, Moir and Carleton 1987, Northcutt 1978, Stuever and Hayden 1997a, USFS 1982, USFS 1985b.

16. *Pinus edulis - Juniperus osteosperma / Quercus turbinella* Woodland

NatureServe common name	Two needle Pinyon - Utah Juniper / Turbinella Live Oak Woodland
NatureServe code	CEGL004007

Summary:

This woodland association is known only from Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau. It occurs on canyon slopes and rims from 1793 to 2104 m (5883-6903 feet) elevation. Stands occur on gentle to steep slopes (2-35%) on warmer southern and western aspects. The substrates are generally shallow, rocky sandy loam to silt loam soils. The surface typically has moderate to high cover of boulders or rock outcrops. Cover by lichens is moderate to high in some stands. The vegetation is characterized by an open to moderately dense tree canopy (10-50% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*. Very open stands may have tree cover between 5-10% cover. *Quercus turbinella* dominates or codominates the open to moderately dense shrub layer. Other shrubs may be present, including *Artemisia bigelovii*, *Chrysothamnus greenei*, *Ephedra viridis*, *Fendlera rupicola*, *Opuntia phaeacantha*, *Opuntia polyacantha* var. *polyacantha*, and *Opuntia whipplei*. Herbaceous cover is variable, ranging from sparse to moderately dense, but is often dominated by the perennial graminoid *Bouteloua gracilis* with scattered perennial forbs. Exotic annual grass *Bromus tectorum* is present in some stands.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. GNR (19 Jul 2006).

Distribution:

Globally. This woodland association is known only from Canyon de Chelly National Monument in the southern Colorado Plateau of northeastern Arizona.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus osteosperma* / *Quercus turbinella* Woodland occurs on ten relevés in canyons and on canyon rims within Canyon de Chelly National Monument. The relevés for this association were sampled throughout

the monument, including suitable landforms near Twin Trail Canyon, Canyon del Muerto, Monument Canyon, Wild Cherry Canyon, and Canyon de Chelly proper.

Environmental summary:

Globally. This woodland association is known only from Canyon de Chelly National Monument in the southern Colorado Plateau of northeastern Arizona. It occurs on canyon slopes and rims from 1793 to 2104 m (5883-6903 feet) elevation. Stands occur on gentle to steep slopes (2-35%) on warmer southern and western aspects. The substrates are generally shallow, rocky sandy loam to silt loam soils. The surface typically has moderate to high cover of boulders or rock outcrops. Cover by lichens is moderate to high in some stands.

Canyon de Chelly National Monument. This association occurs on sandy loam and silt loam soils between the elevations of 1793 and 2104 m (5883-6903 feet) (average 1890 m [6201 feet]). The slope ranges from 2-35% (average 19%) mostly at southern and western aspects. Bedrock covers 0% to 75-100% (average cover class of 30-47%) and boulders cover 0% to 25-50% (average cover class of 7-16%). The coverage of lichens is moderate to fairly high and varies between 1-5% and 25-50% (average cover class of 11-25%).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This woodland association is characterized by an open to moderately dense tree canopy (10-50% cover) codominated by *Pinus edulis* and *Juniperus osteosperma*. Very open stands may have tree cover between 5 and 10%. *Quercus turbinella* dominates or codominates the open to moderately dense shrub layer. Other shrubs may be present, including *Artemisia bigelovii*, *Chrysothamnus greenei*, *Ephedra viridis*, *Fendlera rupicola*, *Opuntia phaeacantha*, *Opuntia polyacantha* var. *polyacantha*, and *Opuntia whipplei*. Herbaceous cover is variable, ranging from sparse to moderate, but is often dominated by the perennial graminoid *Bouteloua gracilis* with scattered perennial forbs. Other common species include grasses *Achnatherum hymenoides*, *Bouteloua barbata*, *Bouteloua curtipendula*, *Pleuraphis jamesii*, *Poa fendleriana*, and forbs such as *Brickellia microphylla* var. *scabra*, *Gutierrezia microcephala*, *Heterotheca villosa*, *Lesquerella fendleri*, and *Stephanomeria minor* var. *minor*. Exotic annual grass *Bromus tectorum* is present in some stands.

Canyon de Chelly National Monument. Ten relevés are classified as *Pinus edulis - Juniperus osteosperma* / *Quercus turbinella* Woodland. The total vegetation cover class for this association ranges from 5-10% to 25-50% (average cover class 20-41%). The tree stratum is moderate, ranging in cover class between 1-5% and 25-50% (average cover class 11-24%). The shrub stratum has a low cover class, which ranges from trace-1% to 10-25% (average cover 4-10%). The herbaceous stratum also has low cover, ranging between trace-1% and 10-25% (average cover class 3-8%). The species richness ranges from 15-31 species (average of 23 species). The tree stratum consists of a main canopy (cover ranging between 1-5% and 25-50%), a subcanopy which covers trace-1% to 10-25%, and a seedling layer that covers trace-1% of all relevés. The main canopy layer varies between 2-5 m and 5-10 m in height, the subcanopy ranges from 1-2 m to 2-5 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Pinus edulis*, ranging between trace-1% and 10-25% cover (average cover class 4-9%), and with a dbh ranging from 6.5-14.7 cm (average dbh 9.9 cm). *Pinus edulis* is sometimes codominated by *Juniperus osteosperma*, which ranges in cover from 0% to 5-10% (1-5% average cover class) and has a drc that varies from 12.1-47.4 cm (average drc 28.8 cm). *Juniperus monosperma* is occasionally present, with drc measurements of 17.3 cm and 36.6 cm, and one dbh measurement at 10.8 cm.

The shrub stratum has a tall shrub layer that ranges in height between 1-2 m and 2-5 m and a short shrub layer of 0.5-1 m or 1-2 m. The tall shrub layer covers between trace-1% and 10-25%, and the short shrub layer covers trace-1% to 1-5%. The shrub stratum is dominated by *Quercus turbinella*, which ranges in cover from trace-1% to 10-25% (average cover class 3-8%). Other species frequently present in the shrub stratum are *Artemisia bigelovii*, *Chrysothamnus greenei*, *Gutierrezia microcephala*, *Opuntia phaeacantha*, and *Opuntia*

polyacantha var. *polyacantha*. The herbaceous stratum is dominated by *Bouteloua gracilis*, which covers 0% to 5-10% (average cover class 1-3%) and *Poa fendleriana*, which covers 0% to 5-10% (average cover class 1-2%). *Bouteloua barbata* covers 5-10% of one relevé but is lacking from all of the others. Other frequently encountered herbaceous species are *Achnatherum hymenoides*, *Bouteloua curtipendula*, *Brickellia microphylla* var. *scabra*, *Heterotheca villosa*, *Lesquerella fendleri*, *Pleuraphis jamesii*, and *Stephanomeria minor* var. *minor*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Data are not available.*	*Juniperus osteosperma, Pinus edulis*
Tall/short shrub/ sapling	*Data are not available.*	*Quercus turbinella*
Herbaceous	*Data are not available.*	*Bouteloua barbata, Bouteloua gracilis, Poa fendleriana*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

17. *Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland

NatureServe common name	Two needle Pinyon - Utah Juniper / Sparse Understory Woodland
NatureServe code	CEGL002148

Summary:

This variable woodland association is widespread in parts of western Colorado and eastern Utah. It is found most commonly on mid to upper slopes, though other topographic positions are possible. It has been sampled at elevations between 1580 and 2389 m and on all aspects. At higher elevations, it tends toward southwestern aspects. Sites range from flat to moderately steep. The ground has variable amounts of litter and often has moderate to high amounts of gravel, rocks, and exposed bedrock. Cryptogamic cover is usually low to moderate, but some sites have up to 55-65% cover. Soils are always rapidly drained to moderately well drained. Parent materials are also highly variable and can be sandstones, shales, or limestones. The lack of an understory may be due to high rock cover, low soil moisture, or a closed evergreen canopy of pinyon and juniper. This widespread association occurs as relatively sparse to moderately vegetated stands with total vegetation cover ranging from 10-75%. Sparsely vegetated stands (<10% total vegetation cover) composed of only trees are included as a best fit in this woodland association in extremely dry, rocky portions of the Colorado Plateau. The tree canopy is dominated by *Pinus edulis* and *Juniperus osteosperma*. Both typically range from 1-35% cover with some stands having canopy cover by one species up to 50%. The tree canopy is short, usually 2-10 m tall, and open to moderately closed. *Fraxinus anomala* has been observed in the canopy of some stands but always at no more than 5% cover. Several shrub species are commonly found in this association, but they occur as widely scattered individuals or an open shrub stratum. Scattered small *Pinus edulis* and *Juniperus osteosperma* are found along with shrubs such as *Amelanchier utahensis*, *Artemisia tridentata* ssp. *wyomingensis*, *Cercocarpus montanus*, *Ephedra viridis*, *Eriogonum microthecum*, *Shepherdia rotundifolia*, and *Opuntia* spp. The herbaceous layer is low in cover (<5%) and usually low in diversity. *Achnatherum hymenoides*, *Bouteloua gracilis*, *Bromus tectorum*, *Poa fendleriana*, and *Pleuraphis jamesii* are common graminoids. Forbs are not abundant, but typical species include *Descurainia pinnata*, *Cryptantha* spp., and *Tetraneuris acaulis*.

Classification confidence: 1 - Strong.

Classification comments:

Globally. Environmental and physiognomic variability within this association is high. There are few consistent understory species across all parks, but that is part of the concept of this type. The general sparseness of the understory is one of the main diagnostic features. Because of the wide range of circumstances that result in a sparse understory, a lot of variability in the floristic components of the understory is allowed. It is possible that this type will be split into several associations based on environmental factors, since floristic factors are not diagnostic. On dry, rocky or slickrock sites on the Colorado Plateau, this pinyon juniper woodland association may include stands with very open tree canopies (5-10% cover) in cases where the total vegetation cover is less than 15%, and they are considered a variation of the woodland type because of the ecological values of the trees.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland typically occurs in areas that are prone to human and natural disturbance, limiting the establishment of understory species.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland

Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. G5 (15 Dec 2004).

Distribution:

Globally. This association is known to occur in western Colorado and eastern Utah.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland occurs on nine relevés on mesas, hills, ridges, canyon rims and valley sides within Canyon de Chelly National Monument. The relevés for this association were sampled from the vicinity of Canyon de Chelly proper, Canyon del Muerto, Twin Trail Canyon, and Middle Mesa near Black Rock Butte.

Environmental summary:

Globally. This woodland association is found most commonly on mid to upper slopes, though other topographic positions are possible. It has been sampled at elevations between 1580 and 2389 m and on all aspects. At higher elevations, such as in Black Canyon of the Gunnison National Park it tends toward southwestern aspects. Sites range from flat to moderately steep (0-25 degrees). The ground has variable amounts of litter and often has moderate to high amounts of gravel, rocks, and exposed bedrock. Cryptogamic cover is usually low to moderate, but some sites have up to 55-65% cover. Soils vary in texture and can be loamy sand, silts, loams or silty clay but are always rapidly drained to moderately well drained. Parent materials are also highly variable and can be sandstones, shales, limestones, among others.

Canyon de Chelly National Monument. This association occurs on silt loam, sandy loam, silt clay loam and sand clay loam soils between the elevations of 1823 and 2268 m (5981-7441 feet) (average 2067 m [6782 feet]). The slope ranges from 0-31% (average 10%) at an eastern to northeastern aspect. The litter cover is often moderate to fairly high and ranges from trace-1% to 50-75%, with an average cover range of 17-29%. About half of the relevés show signs of wood cutting, and one had been chained 20-30 years ago.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This widespread association occurs as relatively sparse to moderately vegetated stands with total vegetation cover ranging from 10-75%. Sparsely vegetated stands (<10% total vegetation cover) composed of only trees are included as a best fit in this woodland association in extremely dry, rocky portions of the Colorado Plateau. The tree canopy is dominated by *Pinus edulis* and *Juniperus osteosperma*. Both typically range from 1-35% cover with some stands having canopy cover by one species up to 50%. The tree canopy is short, usually 2-10 m tall, and open to moderately closed. *Fraxinus anomala* has been observed in the canopy of some stands at Colorado National Monument but always at no more than 5% cover. Several shrub species are commonly found in this association, but they occur as widely scattered individuals or an open shrub stratum. Scattered small *Pinus edulis* and *Juniperus osteosperma* are found along with shrubs such as *Amelanchier utahensis*, *Artemisia tridentata* ssp. *wyomingen-*

sis, *Cercocarpus montanus*, *Ephedra viridis*, *Eriogonum microthecum*, *Shepherdia rotundifolia*, and *Opuntia* spp., usually *Opuntia fragilis* or *Opuntia polyacantha*. The herbaceous layer is low in cover (<5%) and usually low in diversity. *Achnatherum hymenoides*, *Bouteloua gracilis*, *Bromus tectorum*, *Poa fendleriana*, and *Pleuraphis jamesii* are common graminoids. Forbs are not abundant, but typical species include *Descurainia pinnata*, *Cryptantha* spp., and *Tetraneuris acaulis*.

Canyon de Chelly National Monument. Nine relevés are classified as *Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland. The total vegetation cover class for this association ranges from 10-25% to 75-100% (average cover class 32-56%). The tree stratum is usually moderate and ranges in cover class between 5-10% and 50-75% (average cover class 27-48%). The shrub stratum has a low cover class which ranges from trace-1% to 5-10% (average cover 1-5%). The herbaceous stratum also has low cover, ranging between trace-1% and 5-10% (average cover class 1-5%). The species richness ranges from 10-31 species (average of 21 species). The tree stratum consists of a main canopy (cover ranging between 5-10% and 50-75%), an emergent layer (two relevés with an emergent layer having cover classes of 1-5% and 10-25%), a subcanopy which ranges in cover from 1-5% to 10-25%, and a seedling layer that covers trace-1% of all relevés. The main canopy layer varies between 5-10 m and 10-20 m in height, the emergent layer (where present) is 10-20 m or >30 m, the subcanopy ranges from 2-5 m to 5-10 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Pinus edulis*, ranging between trace-1% and 50-75% cover (average cover class 19-34%), and with a dbh ranging from 6.0-42.6 cm (average dbh 16.3 cm). *Juniperus osteosperma* is always present and occasionally is the dominant tree or is codominant with *Pinus edulis*. It ranges between 1-5% and 10-25% cover (average cover class 5-11%) and has a dbh that ranges from 11.7-78.6 cm (average dbh 40.1 cm) or has a drc that ranges from 6.8-92.9 cm (average drc 30.7 cm). Two of the relevés also contain *Pinus ponderosa*, which covers 1-5% and 10-25% where present. Only one tree was measured with a dbh of 57.5 cm.

The shrub stratum has a tall shrub layer that ranges in height between 0.5-1 m and 2-5 m and a short shrub layer of 0.5-1 m to 1-2 m. The tall shrub layer is present in all but two of the relevés and covers 1-5% where present. The short shrub layer is present in five of the relevés and ranges between trace-1% and 5-10% where present. The shrub stratum is dominated by *Artemisia tridentata*, *Ephedra viridis*, and *Gutierrezia microcephala*; these shrubs are present in most relevés and cover as much as 1-5%. *Opuntia phaeacantha* and *Yucca baccata* are also frequent but always have <1% cover. The herbaceous layer is dominated by *Poa fendleriana*, which is present in all but two of the relevés and covers as much as 1-5%. There are a diversity of other herbaceous species with the most common being *Arabis fendleri*, *Bouteloua gracilis*, *Bromus tectorum*, *Elymus elymoides*, *Hymenoxys richardsonii*, *Lesquerella fendleri*, and *Packera neomexicana* (= *Senecio neomexicanus*).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus osteosperma, Pinus edulis*	*Juniperus osteosperma, Pinus edulis, Pinus ponderosa*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum	*Bromus tectorum*

Authors:

Global descriptions. J. Drake, mod. J. Coles and K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References: None available.

18. *Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland

NatureServe common name	Two needle Pinyon - Juniper species / (Wyoming Big Sagebrush, Mountain Big Sagebrush) Woodland
NatureServe code	CEGL000776

Summary:

This broadly defined woodland association is common in the Colorado Plateau but also occurs on dry foothills and mesas from north central New Mexico and southern Colorado west to the eastern Mojave Desert, in extreme northwestern Colorado and adjacent Utah. Elevations range from 1465 to 2500 m (4800-8200 feet). Stands occur most often on flat to gentle slopes on all aspects. The soils are generally poorly developed, moderately deep to deep, well drained to rapidly drained loams and sands. Ground cover is variable; bare soil is common, but bedrock, litter, and large or small rocks can also be abundant on some sites. Parent material includes sandstone and shale. The vegetation is characterized by a typically open tree canopy (10-30% cover but ranges up to 50% cover) that is codominated by *Pinus edulis* and *Juniperus* spp. The species of *Juniperus* varies with geography and elevation. *Juniperus monosperma* is common in north central New Mexico and southern Colorado. *Juniperus osteosperma* is common from northwestern New Mexico west and north into Arizona and Utah. *Juniperus scopulorum* is more common in higher elevation stands. *Artemisia tridentata* (either ssp. *vaseyana* or ssp. *wyomingensis* depending on location) strongly dominates the sparse to moderately dense short shrub layer (10-35% cover). *Purshia stansburiana* is typically absent or scarce. Other shrubs present may include *Amelanchier utahensis*, *Arctostaphylos patula*, *Cercocarpus montanus*, *Ephedra viridis*, *Gutierrezia sarothrae*, *Quercus gambelii* (typically <5% cover), or species of *Yucca* and *Opuntia*. Herbaceous cover is variable but generally sparse and dominated by graminoids (<5% cover) with scattered forbs.

Classification confidence: 1 - Strong.

Classification comments:

Globally. On dry, rocky or slickrock sites on the Colorado Plateau, this pinyon juniper woodland association may include stands with very open tree canopies (5-10% cover) in cases where the total vegetation cover is less than 15%. These stands may be similar to open *Artemisia tridentata* shrublands with scattered pinyon and juniper trees but is considered to be a variation of the woodland type because of the ecological values of the trees.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. G5 (1 Feb 1996).

Distribution:

Globally. This woodland association is common on the Colorado Plateau, occurring from north central New Mexico and southern Colorado west to the Mogollon Rim of Arizona and the eastern Mojave Desert, and in extreme northwestern Colorado and adjacent Utah.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland was sampled from 15 relevés on hills, ridges, plateaus, canyon rims, alluvial flats, and valley floors within Canyon de Chelly National Monument. The relevés occur throughout the monument, including Canyon de Chelly proper, Canyon del Muerto, Twin Trail Canyon, Monument Canyon, Middle Trail Canyon, Black Rock Canyon, Bat Canyon, Agua Sal, Sheep Point, and Crystal Creek near the confluence with Cattail Wash.

Environmental summary:

Globally. This broadly defined woodland association occurs on dry foothills and mesas across much of the Colorado Plateau and adjacent areas. Elevations range from 1459 to 2502 m. Stands occur most often on flat to gentle slopes but can be found on moderate to moderately steep slopes on all aspects. The soils are often deep, generally poorly developed, moderately well drained to rapidly drained loams and sands, and skeletal. Ground cover is variable; bare soil is common, but bedrock, litter, and large or small rocks can also be abundant on some sites. Parent material includes sandstone and shale.

Canyon de Chelly National Monument. This association occurs on sand, sandy loam, sandy clay loam, silt loam, clay loam, and silt clay loam soils between the elevations of 2067 and 2238 m (6782-7343 feet) (average 2145 m [7037 feet]). The slope ranges from 0-19% (average 6%) at various aspects. The litter cover is often moderate to fairly high and ranges from 5-10% to 50-75% (average cover class of 18-34%). Six of the relevés show signs of wood cutting, and one had been chained many years ago.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This broadly defined woodland association occurs on dry foothills and mesas across much of the Colorado Plateau and adjacent areas. Elevations range from 1459 to 2502 m. Stands occur most often on flat to gentle slopes but can be found on moderate to moderately steep slopes on all aspects. The soils are often deep, generally poorly developed, moderately well drained to rapidly drained loams and sands, and skeletal. Ground cover is variable; bare soil is common, but bedrock, litter, and large or small rocks can also be abundant on some sites. Parent material includes sandstone and shale.

Canyon de Chelly National Monument. Fifteen relevés are classified as *Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland. The total vegetation cover class for this association ranges from 25-50% to 75-100% (average cover class 48-73%). The tree stratum is usually moderate to dense and ranges in cover class between 5-10% and 50-75% (average cover class 30-50%). The shrub stratum has a moderate cover class, which ranges from 1-5% to 50-75% (average cover 12-23%). The herbaceous stratum has somewhat low cover, ranging between trace-1% and 25-50% (average cover class 6-14%). The species richness ranges from 12-26 species (average of 18 species). The tree stratum consists of a main canopy (cover ranging between 5-10% and 25-50%), an emergent layer (one relevé has an emergent layer with 1-5% cover and two others have an emergent layer with 5-10% cover), a subcanopy which ranges in cover from trace-1% to 10-25%, and a seedling layer that covers trace-1% in all relevés. The main canopy layer varies between 5-10 m and 20-30 m in height, the emergent layer (where present) is 10-20 m or 20-30 m, the subcanopy ranges from 1-2 m to 5-10 m, and the seedling layer is 0.5-1 m tall.

The tree stratum is dominated by *Pinus edulis*, ranging between 1-5% and 50-75% cover (average cover class 18-34%), and with a dbh ranging from 5.0-41.7 cm (average dbh 12.8 cm). *Juniperus osteosperma* is occasionally the dominant tree or is codominant with *Pinus edulis*. It ranges between 0% and 10-25% cover (average cover class 2-6%) and has a drc that ranges from 14.0-68.3 cm (average drc 34.1 cm). *Pinus ponderosa* covers 5-10% of two relevés and 1-5% of a third relevé and has a dbh that ranges from 12.6-53.0 cm (average dbh 32.6 cm). *Juniperus scopulorum* is also occasionally present and has a dbh that varies from 5.9-14.8 cm (average dbh 8.0 cm).

The shrub stratum has a tall shrub layer that ranges in height between 1-2 m and 2-5 m and a short shrub layer of 0.5-1 m to 1-2 m. The tall shrub layer is present in all of the relevés and ranges in cover from 1-5% to 50-75%. The short shrub layer is present in two thirds of the relevés and ranges between trace-1% and 10-25% where present. The shrub stratum is dominated by *Artemisia tridentata*, which ranges from 1-5% to 50-75% cover (average cover class 10-21%). Also present in the shrub stratum are *Ephedra viridis*, *Gutierrezia microcephala*, and *Gutierrezia sarothrae*. The herbaceous stratum is dominated by *Bouteloua gracilis*, which ranges in cover from trace-1% to 10-25% (average cover class 3-9%). There are a diversity of other herbaceous species with the most common being *Bromus tectorum*, *Chaetopappa ericoides*, *Elymus elymoides*, and *Poa fendleriana*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus osteosperma, Juniperus scopulorum, Pinus edulis*	*Juniperus osteosperma, Juniperus scopulorum, Pinus edulis, Pinus ponderosa*
Tall shrub/sapling	*N/A*	*Artemisia tridentata*
Short shrub/ sapling	*Artemisia tridentata* ssp. *vaseyana*	*Ephedra viridis*
Herbaceous	*N/A*	*Gutierrezia microcephala, Gutierrezia sarothrae, Bouteloua gracilis, Bromus tectorum*

Other noteworthy species:

Global species	Canyon de Chelly species
N/A	*Bromus tectorum*

Authors:

Global descriptions. K.A. Schulz, mod. J. Drake and J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Bourgeron and Engelking 1994, Bunting 1987, CONHP unpubl. data 2003, Cogan et al. 2004, Dick Peddie 1993, Driscoll et al. 1984, Erdman 1970, Everett 1987, Heinze et al. 1962, Isaacson 1967, Jameson et al. 1962, Johnston 1987, Larson and Moir 1987, Mason et al. 1967, Moir and Carleton 1987, NVNHP 2003, Stuever and Hayden 1997a, Tiedemann 1978, USFS 1983a, USFS 1985a, USFS 1985d, Warren et al. 1982, Wright et al. 1979.

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

NatureServe common name	Two needle Pinyon - Juniper species / Mountain mahogany - Mixed Shrubs Woodland
NatureServe code	CEGL000780

Summary:

This broadly defined woodland association is common on the Colorado Plateau, occurring on sheltered colluvial slopes, sandstone hogbacks, dry foothills and mesas from north central New Mexico and southern Colorado west to the Mogollon Rim of Arizona, and in western Colorado and adjacent Utah. It can be found on any slope position, though lower slopes are less common. Elevations range from 1472 to 2480 m (4830-8135 feet). Stands occur on gentle to steep slopes on all aspects. The soils are variable but generally shallow, poorly developed and skeletal, ranging from clayey marl to loamy sands. The unvegetated surface is characterized by bedrock, large and small rocks, and/or bare soil with little litter. Sandstone or shale are the most common parent materials. This association is characterized by an open to moderately dense tree canopy (10-60% cover) dominated by a combination of *Pinus edulis* and *Juniperus* spp. with a shrub layer dominated by *Cercocarpus montanus*. The tree canopy averages 2-5 m tall, but some stands may be as tall as 10 m. *Pinus edulis* and *Juniperus* spp. codominate in most stands, but sometimes one may be more prevalent than the other. The species of *Juniperus* varies with geography and elevation and includes *Juniperus deppeana*, *Juniperus monosperma*, *Juniperus osteosperma*, and *Juniperus scopulorum*. The total shrub cover may range from sparse to moderate. *Cercocarpus montanus* is the dominant shrub with up to 35% cover. It typically occurs as a short shrub but can be a tall shrub on some sites. Other shrubs may be present, including *Amelanchier* spp., *Artemisia bigelovii*, *Artemisia tridentata*, *Ephedra viridis*, *Chrysothamnus viscidiflorus*, *Gutierrezia sarothrae*, *Fendlera rupicola*, *Garrya ovata*, *Mahonia* spp., *Nolina microcarpa*, *Quercus gambelii*, *Quercus grisea*, *Rhus trilobata*, or species of *Yucca* and *Opuntia*. Herbaceous cover is variable, ranging from sparse to moderately dense, and generally dominated by graminoids (>5% cover) with scattered forbs. Extremely open stands of this association, usually occurring on fractured slickrock exposures, may have as little as 5% total vegetation cover and an upper canopy only 2 m tall.

Classification confidence: 2 - Moderate**.**

Classification comments:

Globally. This is a widely distributed and variable association, found throughout much of the Colorado Plateau, edges of the Colorado Rockies and south into New Mexico. On dry, rocky or slickrock sites on the Colorado Plateau, this pinyon juniper woodland association may include stands with very open tree canopies (5-10% cover) in cases where the total vegetation cover is less than 15%. These stands may be similar to open *Cercocarpus montanus* shrublands with scattered pinyon and juniper trees but is considered a variation of the woodland type because of the ecological values of the trees.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.766	Colorado Plateau Pinyon Juniper Shrubland
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. G5 (23 Feb 1994).

Distribution:

Globally. This widespread woodland association is found from southern Colorado and north central New Mexico to the Mogollon Rim of Arizona, north across the Colorado Plateau into western Colorado and adjacent Utah.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrubs Woodland occurs on eight relevés on hills, ridges, plateaus, and canyons within Canyon de Chelly National Monument. The relevés for this association were sampled throughout the monument, including Canyon de Chelly proper, Twin Trail Canyon, Middle Trail Canyon, Monument Canyon, Black Rock Canyon, and Canyon del Muerto near Standing Rock.

Environmental summary:

Globally. This broadly defined woodland association is common on the Colorado Plateau, occurring on sheltered colluvial slopes, sandstone hogbacks, dry foothills and mesas. It can be found on any slope position (upper, middle, or lower), though lower slopes are the least common. Elevations range from 1472 to 2480 m (4830-8135 feet). Stands occur on gentle to steep (3 to 35 degree) slopes on all aspects. The soils are variable but generally shallow, poorly developed and skeletal, ranging from clayey marl to loamy sands. The unvegetated surface is characterized by bedrock, large and small rocks, and/or bare soil. Litter has low cover. Parent materials are often sandstone or shale, but others are possible.

Canyon de Chelly National Monument. This association occurs on sand, sandy loam, and silt loam soils between the elevations of 1860 and 2268 m (6102-7441 feet) (average 2082 m [6831 feet]). The slope ranges from 0-23% (average 8%) at mostly south and west aspects. The litter cover is variable and ranges from 1-5% to 50-75% (average cover class of 9-18%). Half of the relevés have small washes or drainages. The association often occurs on thin soil layers over bedrock, and three of the relevés had noteworthy *Pinus edulis* mortality.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by an open to moderately dense tree canopy (10-60% cover) dominated by a combination of *Pinus edulis* and *Juniperus* spp. The canopy averages 2-5 m tall, but some stands may be as tall as 10 m. *Pinus edulis* and *Juniperus* spp. codominate in most stands, but sometimes one may be more prevalent than the other. *Pinus edulis* and *Juniperus* spp. are also present as smaller individuals in the shrub and field strata. The species of *Juniperus* varies with geography and elevation. *Juniperus monosperma* is common in north central New Mexico and southern Colorado. *Juniperus deppeana* is common in southern New Mexico, and *Juniperus osteosperma* is common from northwestern New Mexico west into Arizona and north into western Colorado and Utah. *Juniperus scopulorum* is more common in higher elevation stands. The total shrub cover may range from sparse to moderate. *Cercocarpus montanus* is the dominant shrub with 1-35% cover. It typically occurs as a short shrub <2 m tall but can be a tall shrub (2-5 m) on some sites. Other shrubs may be present, including *Amelanchier* spp., *Artemisia bigelovii*, *Artemisia tridentata*, *Ephedra viridis*, *Chrysothamnus viscidiflorus*, *Gutierrezia sarothrae*, *Fendlera rupicola*, *Garrya ovata*, *Mahonia* spp., *Nolina microcarpa*, *Quercus gambelii*, *Quercus grisea*, *Rhus trilobata*, or species of *Yucca*

and *Opuntia*. Herbaceous cover is variable, ranging from sparse to moderately dense, and generally dominated by graminoids (>5% cover) with scattered forbs. Associated graminoids include *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Andropogon gerardii*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Bouteloua hirsuta*, *Carex rossii*, *Hesperostipa comata*, *Koeleria macrantha*, *Leymus salinus* (= *Elymus salinus*), *Muhlenbergia pauciflora*, *Pascopyrum smithii*, *Pleuraphis jamesii*, *Poa fendleriana*, *Pseudoroegneria spicata*, and *Schizachyrium scoparium*. Common forbs include species of *Cryptantha*, *Eriogonum*, *Penstemon*, *Petradoria*, and *Phlox*. Extremely open stands of this association occurring on exposed and fractured slickrock may have as little as 5% total vegetation cover and an upper canopy only 2 m tall.

Canyon de Chelly National Monument. Eight relevés are classified as *Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrubs Woodland. The total vegetation cover class for this association ranges from 5-10% to 50-75% (average cover class 27-48%). The tree stratum is usually moderate and ranges in cover class between 5-10% and 50-75% (average cover class 24-43%). The shrub stratum has a fairly low cover class which ranges from 1-5% to 10-25% (average cover 5-11%). The herbaceous stratum is sparse, ranging between trace-1% and 1-5% (average cover class 1-4%). The species richness ranges from 14 to 26 species (average of 21 species). The tree stratum consists of a main canopy (cover ranging between 5-10% and 50-75%), an emergent layer in one relevé with 1-5% cover, a subcanopy which ranges in cover from trace-1% to 25-50%, and a seedling layer that covers trace-1% in all relevés. The main canopy layer varies between 5-10 m and 10-20 m in height, the emergent layer (where present) is 10-20 m, the subcanopy ranges from 2-5 m to 5-10 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Pinus edulis*, ranging between 1-5% and 50-75% cover (average cover class 16-29%), and with a dbh ranging from 5.4-23.0 cm (average dbh 11.0 cm). *Juniperus osteosperma* is occasionally co-dominant with *Pinus edulis*. It ranges between 1-5% and 5-10% cover (average cover class 3-8%) and has a drc that ranges from 12.6-65.4 cm (average drc 35.7 cm). *Pinus ponderosa* is found in one relevé and has a dbh of 24 cm.

The shrub stratum has a tall shrub layer that ranges in height between 2-5 m and 5-10 m and a short shrub layer of 0.5-1 m to 1-2 m. Both shrub layers are found in all relevés, with the tall shrub layer covering between 1-5% and 5-10%, and the short shrub layer covering between trace-1% and 1-5%. The shrub stratum is dominated by *Cercocarpus montanus*, which ranges in cover from 1-5% to 5-10% (average cover class 2-6%). Also present in the shrub stratum are *Ephedra viridis*, *Gutierrezia microcephala*, *Gutierrezia sarothrae*, *Opuntia phaeacantha*, *Opuntia polyacantha* var. *polyacantha*, *Purshia stansburiana*, and *Yucca baccata*. The herbaceous stratum has a diversity of species (all with <1% cover) with the most common being *Bahia dissecta*, *Bromus tectorum*, *Hymenopappus filifolius* var. *lugens*, *Tetraneuris acaulis* (= *Hymenoxys acaulis*), *Hymenoxys richardsonii*, *Ipomopsis aggregata*, *Lepidium densiflorum*, *Lesquerella fendleri*, *Poa fendleriana*, and *Packera neomexicana* (= *Senecio neomexicanus*).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus monosperma, Juniperus osteosperma, Pinus edulis*	*Juniperus osteosperma, Pinus edulis*
Tall shrub/sapling	*N/A*	*Quercus gambelii, Cercocarpus montanus*
Short shrub/ sapling	*Cercocarpus montanus*	*Ephedra viridis*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Bromus tectorum*

Authors:

Global descriptions. K.A. Schulz, mod. J. Drake and J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Baker 1983b, Baker 1984, Baker and Kennedy 1985, Bourgeron and Engelking 1994, Bradley et al. 1992, CONHP unpubl. data 2003, Cogan et al. 2004, Driscoll et al. 1984, Erdman 1962, Erdman 1969, Hess and Wasser 1982, Isaacson 1967, Johnston 1987, Kennedy 1983, Larson and Moir 1987, Marr et al. 1979, Medina 1986, Moir 1963, Moir and Carleton 1987, Moir and Ludwig 1979, Pase and Lindenmuth 1971, Stuever and Hayden 1997a, USFS 1981a, USFS 1981b, USFS 1983a, USFS 1985c, USFS 1985d, USFS 1985e, Vories 1974, Wright et al. 1979.

20. *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland

NatureServe common name	Two needle Pinyon - Juniper species / Muttongrass Woodland
NatureServe code	CEGL000787

Summary:

This association is widespread and common throughout the Colorado Plateau of Utah, Arizona, New Mexico and Colorado. It occurs on the slopes of canyons, ridges, toeslopes, alluvial fans, benches and plateaus at elevations ranging from 1525 to 2560 m (5000-8400 feet). Stands may occur on slopes ranging from 7 to 48% that are oriented to any aspect. Most stands are on sandy soils, with a few on silt loam or clay loam soils derived from sedimentary, granitic or metamorphic rocks. Total vegetation cover ranges from 40% to more than 75%. This woodland association is characterized by an open to moderately closed, mixed canopy of *Pinus edulis* and *Juniperus osteosperma* 2 -10 m tall. In the southern part of the range, *Juniperus monosperma* and *Juniperus scopulorum* may be present in the canopy. The understory is dominated by the bunchgrass *Poa fendleriana* with between 1 and 25% cover. Scattered shrubs fail to form a stratum but may include *Amelanchier utahensis*, *Artemisia nova*, *Cercocarpus montanus*, *Ephedra viridis*, *Quercus gambelii*, *Purshia tridentata*, *Yucca baccata*, *Opuntia* spp., *Symphoricarpos oreophilus*, *Fallugia paradoxa*, and *Fendlera rupicola*. Other common herbaceous species (always with less cover than *Poa fendleriana*) include *Achnatherum hymenoides*, *Koeleria macrantha*, *Muhlenbergia montana*, *Blepharoneuron tricholepis*, *Pascopyrum smithii*, *Bouteloua gracilis*, *Balsamorhiza sagittata*, *Mirabilis multiflora*, *Penstemon linarioides*, and *Petradoria pumila*.

Classification confidence: 1 - Strong.

Classification comments:

Globally. Even if stands have relatively sparse cover of *Poa fendleriana* (<5%), if no other species are present with more than trace cover, they have been placed in this association rather than *Pinus edulis Juniperus osteosperma* / Sparse Understory Woodland (CEGL002148).

Canyon de Chelly National Monument. *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland has low cover of *Purshia stansburiana* in the shrub layer and high cover of *Poa fendleriana* in the herbaceous layer. These are the distinguishing characteristics separating *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland from *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland. However, *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland has a consistent cover of *Poa fendleriana* in the understory. On the aerial photography these two associations are not discernable, and they are combined into one map class. We think that *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland could be an ecotonal variation of *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland and should be reconsidered as a variation of *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. G5 (23 Feb 1994).

Distribution:

Globally. This association occurs at moderate elevations in the Colorado Plateau region of western Colorado, northern Arizona and New Mexico and eastern Utah.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland was only sampled from two relevé locations within Canyon de Chelly National Monument. One relevé is located northeast of Black Rock Butte and the other west of Monument Canyon.

Environmental summary:

Globally. This association is widespread and common throughout the Colorado Plateau of Utah, Arizona, New Mexico and Colorado. It occurs on the gentle to moderate slopes of canyons, ridges, toeslopes, benches and plateaus at elevations ranging from 1525 to 2560 m (5000-8400 feet). Stands may occur on slopes ranging from 7 to 48% and oriented to any aspect. Most stands are on sandy soils, with a few on silt loam or clay loam soils derived from sedimentary, granitic or metamorphic rocks. A third to half the unvegetated ground surface is bare ground and in some plots large rocks and gravel cover up to a third of the surface. In some cases, cryptogamic crusts and moss or litter cover up to 25% of the soil surface.

Canyon de Chelly National Monument. This association occurs on silt loam soils at the elevations of 2165 and 2248 m (7103 and 7375 feet). The relevés are found on a valley side and ridge location with a slope of 7% and 22%, respectively, both with a northeastern aspect. The litter cover for these relevés is moderate to high (25-50% and 50-75%).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This woodland association is widespread and relatively common at moderate elevations throughout the Colorado Plateau. Total vegetation cover ranges from 40% to more than 75%. This woodland association is characterized by an open to moderately closed, mixed canopy of *Pinus edulis* and *Juniperus osteosperma* 2-10 m tall. In the southern part of the range, *Juniperus monosperma* and *Juniperus scopulorum* may be present in the canopy. The understory is dominated by the bunchgrass *Poa fendleriana* with between 1 and 25% cover. Scattered shrubs present include *Amelanchier utahensis*, *Artemisia nova*, *Cercocarpus montanus*, *Quercus gambelii*, *Purshia tridentata*, *Yucca baccata*, *Opuntia* spp., *Symphoricarpos oreophilus*, *Fallugia paradoxa*, and *Fendlera rupicola*. Other common herbaceous species (always with less cover than *Poa fendleriana*) include *Achnatherum hymenoides*, *Koeleria macrantha*, *Muhlenbergia montana*, *Blepharoneuron tricholepis*, *Pascopyrum smithii*, *Bouteloua gracilis*, *Balsamorhiza sagittata*, *Mirabilis multiflora*, *Penstemon linarioides*, and *Petradoria pumila*.

Canyon de Chelly National Monument. Two relevés are classified as *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland. The total vegetation cover class for this association is high in both relevés (50-75% and 75-100%). The tree stratum is dense, with a cover class of 50-75% in one relevé and 75-100% in the other. The shrub stratum has a low cover class (1-5% in both relevés), and the herbaceous stratum is moderate to sparse, with the cover classes of 5-10% and 10-25%. The species richness is 19 and 23 species, respectively. The tree stratum is dominated by *Pinus edulis*, which covers 25-50% in one relevé and 50-75% in the other, and has a dbh that ranges from 6.0-42.6 cm (average dbh 20.9 cm). *Juniperus osteosperma* is the second most common tree, with 1-5% and 10-25% coverage and a

drc that ranges from 6.8-60.5 cm (average drc 24.3 cm). Other species in the tree stratum include *Pinus ponderosa*, which covers 1-5% of both relevés (one dbh measurement at 9.2 cm), and *Quercus gambelii*, which occurs in one of the relevés and has a dbh of 5.7 cm. The tree stratum is composed of a main canopy layer that covers 25-50% or 50-75% and is 10-20 m in height, a subcanopy that covers 10-25% of both relevés and is 5-10 m tall, and a trace seedling layer (<1% cover) that is 0.5-1 m tall.

The shrub stratum has two distinct shrub layers. The tall shrub layer covers 5-10% and has a height class of 1-2 m in one relevé and 2-5 m in the other. The short shrub layer covers trace-1% and is 0.5-1 m or 1-2 m tall. The shrub stratum has a diversity of species (all covering <1%), including *Artemisia tridentata*, *Fendlera rupicola*, *Opuntia phaeacantha*, *Purshia stansburiana*, and *Yucca baccata*. The herbaceous stratum is dominated by *Poa fendleriana*, which covers 1-5% of one relevé and 10-25% of the other. There is a diversity of other herbaceous species (each with <1% cover), with the most common being *Androsace septentrionalis*, *Hymenoxys richardsonii*, *Lappula occidentalis*, *Penstemon barbatus*, and *Packera neomexicana* (= *Senecio neomexicanus*).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus osteosperma, Pinus edulis*	*Juniperus osteosperma, Pinus edulis*
Herbaceous	*Poa fendleriana*	*Poa fendleriana*

Other noteworthy species:

Global species	Canyon de Chelly species
Arabis fernaldiana var. *fernaldiana, Bromus tectorum*	*Data are not available.*

Authors:

Global descriptions. J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Baker 1982, Barnes 1987, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Driscoll et al. 1984, Erdman 1962, Erdman 1969, Erdman et al. 1969, Floyd 2003, Floyd et al. 2001, Isaacson 1967, Johnston 1987, Larson and Moir 1987, Moir and Carleton 1987, USFS 1985a.

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

NatureServe common name	Two needle Pinyon - Juniper species / Gambel Oak Woodland
NatureServe code	CEGL000791

Summary:

This widespread woodland association is known from the Colorado Plateau and southern Rocky Mountains, occurring from south central Colorado to south central New Mexico, west along the Mogollon Rim of Arizona, and north into Utah and western Colorado. Elevations normally range from 1580-2665 m but may be higher in stands in southern New Mexico. Sites are variable but generally are relatively mesic. Stands occur on flat to moderate slopes along drainages and on mesatops, and on moderate to steep, rocky slopes of foothills, mountains and canyons, especially in draws where soil moisture is concentrated, or on northern aspects or where shaded by upper canyon walls. The soils are variable and range from deep to shallow, silty clay to sandy loam, and often gravelly. Litter from *Quercus gambelii* and other shrubs is often extensive (over 50% cover). The vegetation is characterized by an open to moderately dense tree canopy (10-60% cover) codominated by *Pinus edulis* and *Juniperus* spp. The species of *Juniperus* varies with geography and elevation. *Juniperus monosperma* is common in north central New Mexico and southern Colorado. *Juniperus deppeana* is common in southern New Mexico, and *Juniperus osteosperma* is common in northwestern New Mexico, northern Arizona and in Utah. *Juniperus scopulorum* is more common in higher elevation stands. An occasional *Pinus ponderosa* tree may be present in some stands. *Quercus gambelii* dominates the often patchy, moderately dense tall shrub layer with at least 5% cover, but often over 25% cover. *Amelanchier utahensis*, *Cercocarpus montanus*, *Symphoricarpos oreophilus*, or species of *Yucca* and *Opuntia* are common shrub associates. Herbaceous cover is variable, ranging from sparse to moderately dense, but generally dominated by graminoids (>5% cover) with scattered forbs. Associated graminoids include *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua gracilis*, *Carex geyeri*, *Carex rossii*, *Elymus elymoides*, *Festuca arizonica*, *Koeleria macrantha*, *Muhlenbergia montana*, *Poa fendleriana*, and *Schizachyrium scoparium*.

Classification confidence: 1 - Strong.

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (A.516) Two needle Pinyon - (Juniper species) Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.767	Colorado Plateau Pinyon Juniper Woodland

NatureServe conservation status:

Global rank. G5 (23 Feb 1994).

Distribution:

Globally. This woodland association occurs in foothills and mesas from southern Colorado to south central New Mexico, west along the Mogollon Rim of Arizona, and north into Utah and western Colorado.

Canyon de Chelly National Monument. *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland occurs on five relevés on hills, plateaus, and canyons within Canyon de Chelly National Monument. The relevés for this association were sampled from Canyon de Chelly proper, Monument Canyon, Bat Canyon (near Elephant Grass Spring), and at the Spider Rock overlook.

Environmental summary:

Globally. This widespread woodland association is known from the Colorado Plateau and southern Rocky Mountains, occurring from south central Colorado to south-central New Mexico, west along the Mogollon Rim of Arizona, and north into Utah and western Colorado. Elevations normally range from 1580-2665 m but may be higher in stands in southern New Mexico. Sites are variable but generally are relatively mesic. Stands occur on flat to moderate slopes along drainages and on mesatops, and on moderate to steep, sometimes rocky slopes of foothills, mountains and canyons, especially in draws where soil moisture is concentrated, or on northern aspects or where shaded by upper canyon walls. Stands are less common on hot south facing slopes, unless they are located in a moisture concentrating gully. Soils are variable and range from deep to shallow, silty clay to sandy loam, and are often gravelly or rocky. Litter from *Quercus gambelii* and other shrubs is often extensive (over 50% cover). Parent materials include sandstone, shale, limestone and rhyolite.

Canyon de Chelly National Monument. This association occurs on sand, sandy loam, and silt loam soils between the elevations of 1829 and 2342 m (6001-7684 feet) (average 2050 m [6726 feet]). The slope ranges from 0-35% (average 19%) at various aspects. The litter cover is variable and ranges from trace-1% to 75-100%, with an average cover range of 22-36%. Three of the relevés occur on steep slickrock or talus slopes (one with 75-100% cover class of exposed bedrock) and the other two relevés are found in flat or gently sloping wooded areas.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This widespread association is characterized by an open to moderately dense tree canopy (10-60% cover) codominated by *Pinus edulis* and *Juniperus* spp. The species of *Juniperus* varies with geography and elevation. *Juniperus monosperma* is common in north central New Mexico and southern Colorado. *Juniperus deppeana* is common in southern New Mexico, and *Juniperus osteosperma* is common in northwestern New Mexico, northern Arizona and in Utah. *Juniperus scopulorum* is more common in higher elevation stands. An occasional *Pinus ponderosa* tree may be present is some stands. *Quercus gambelii* dominates the often patchy, moderately dense tall shrub layer with at least 5% cover, but often with more than 25% cover. *Amelanchier utahensis*, *Cercocarpus montanus*, *Symphoricarpos oreophilus*, or species of *Yucca* and *Opuntia* are common shrub associates. Other shrubs, depending on geography, may include *Artemisia tridentata*, *Artemisia nova*, *Arctostaphylos patula*, *Cercocarpus ledifolius*, *Ephedra viridis*, *Fendlera rupicola*, *Gutierrezia sarothrae*, *Garrya* spp., *Ptelea trifoliata*, *Prunus* spp., *Quercus* X *pauciloba*, *Robinia neomexicana*, or *Rosa* spp. Herbaceous cover is variable, ranging from sparse to moderately dense, but generally dominated by graminoids (>5% cover) with scattered forbs. Associated graminoids include *Achnatherum hymenoides* (= *Oryzopsis hymenoides*), *Bouteloua gracilis*, *Carex geyeri*, *Carex rossii*, *Elymus elymoides*, *Festuca arizonica*, *Koeleria macrantha*, *Muhlenbergia montana*, *Poa fendleriana*, and *Schizachyrium scoparium*. Common forbs may include *Artemisia frigida*, *Balsamorhiza sagittata*, *Geranium caespitosum*,

Packera neomexicana, *Thalictrum fendleri*, or *Vicia americana*.

Canyon de Chelly National Monument. Five relevés are classified as *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland. The total vegetation cover class for this association ranges from 10-25% to 50-75% (average cover class 37-60%). The tree stratum is usually moderate and ranges in cover class between 5-10% and 50-75% (average cover class 26-47%). The shrub stratum has a moderate to low cover class which ranges from 1-5% to 25-50% (average cover 8-19%). The herbaceous stratum usually has low cover, ranging between 1-5% and 10-25% (average cover class 4-10%). The species richness ranges from 20-31 species (average of 25 species). The tree stratum consists of a main canopy (cover ranging between 5-10% and 25-50%), an emergent layer in three relevés with cover class ranging between 1-5% or 5-10%, a subcanopy which ranges in cover from 1-5% to 25-50%, and a seedling layer that covers trace-1% of all relevés. The main canopy layer varies between 2-5 m and 10-20 m in height, the emergent layer (where present) varies from 5-10 m to >30 m, the subcanopy ranges from 2-5 m to 5-10 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Pinus edulis*, ranging between 1-5% and 10-25% cover (average cover class 7-18%), and with a dbh ranging from 5.0-22.6 cm (average dbh 11.0 cm). *Juniperus osteosperma* occurs in some of the relevés and can occasionally co-dominant the tree layer. It ranges between no cover and 10-25% cover (average cover class 3-8%) and has a drc that ranges from 13.0-86.3 cm (average drc 35.3 cm). Two trees of *Juniperus osteosperma* have dbh measurements of 28.5 cm and 35.6 cm. *Quercus gambelii* is also occasionally tall enough to occur in the tree layer and codominate with *Pinus edulis*, has a cover class that ranges between 1-5% and 10-25% (4-11% average cover) and has a dbh of 5.3-25.0 cm (14.4 cm average dbh). *Pinus ponderosa* was identified from two relevés and has a dbh of 6.5-66.7 cm (25.0 cm average dbh).

The shrub stratum has a tall shrub layer that ranges in height between 1-2 m and 5-10 m and a short shrub layer of 1-2 m. The tall shrub layer is found in all relevés and covers between 1-5% and 10-25%, and the short shrub layer is found in only three relevés and covers between trace-1% and 5-10%. The shrub stratum is dominated by *Purshia stansburiana*, which ranges from no cover to 10-25% (average cover class 2-7%). Also present in the shrub stratum are *Artemisia tridentata*, *Amelanchier utahensis*, *Fendlera rupicola*, *Gutierrezia microcephala*, and *Yucca angustissima*. The herbaceous stratum has a diversity of species (all having a cover class <1%) with the most common being *Bouteloua gracilis*, *Galium wrightii*, *Lesquerella fendleri*, *Penstemon linarioides*, *Packera neomexicana* (= *Senecio neomexicanus*), *Stephanomeria minor* var. *minor*, and *Vitis arizonica*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus monosperma, Juniperus osteosperma, Juniperus scopulorum, Pinus edulis*	*Juniperus osteosperma, Pinus edulis, Pinus ponderosa, Quercus gambelii*
Tall shrub/sapling	*Amelanchier utahensis, Quercus gambelii, Cercocarpus montanus*	*Artemisia tridentata, Purshia stansburiana*
Short shrub/ sapling	*Symphoricarpos oreophilus*	*N/A*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K.A. Schulz, mod. J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Bassett 1987, Bourgeron and Engelking 1994, CONHP unpubl. data 2003, Cogan et al. 2004, Driscoll et al. 1984, Harmon 1980, Hess and Wasser 1982, Holm 1927, Isaacson 1967, Johnston 1987, Kallender 1959, Larson and Moir 1987, Marr et al. 1973b, Muldavin et al. 1994, Muldavin et al. 2000b, Steinhoff 1978, Stuever and Hayden 1997a, Vories 1974, Warren et al. 1982, Wright 1972, Wright et al. 1979.

22. *Pinus ponderosa / Artemisia nova* Woodland

NatureServe common name	Ponderosa Pine / Black Sagebrush Woodland
NatureServe code	CEGL000846

Summary:

This Colorado Plateau woodland has been reported from mountains and plateaus in southern Utah and northern Arizona. Stands occur on rocky ridges and benches with various aspects. Elevation ranges from 2100-2750 m (6900-9000 feet). Substrates are typically shallow, gravelly loam, clay loam or silt loam soils derived from basalt or a mix of colluvial shale and sandstone, sometimes with an impermeable subsurface horizon that restricts rooting. Some sites are known to have seasonally high water tables. The vegetation is characterized by an open tree canopy (5-30% cover) that is dominated by *Pinus ponderosa*. Scattered *Juniperus scopulorum* or *Pinus flexilis* trees may also be present. *Artemisia nova* or *Artemisia arbuscula* dominates the typically sparse dwarf shrub layer with 5-20% cover. Occasionally, this association may occur as sparse woodland, with total vegetation cover not exceeding 15%. Other shrub species present may include *Purshia tridentata*, *Chrysothamnus viscidiflorus*, *Ericameria parryi*, *Gutierrezia sarothrae*, *Quercus gambelii*, *Symphoricarpos oreophilus*, and *Tetradymia canescens*. If *Quercus gambelii* is present, it has less than 5% cover and much less cover than *Artemisia*. The sparse herbaceous layer (<10% cover) is primarily composed of graminoids with scattered forbs and includes *Achnatherum hymenoides*, *Bouteloua gracilis*, *Carex rossii*, *Elymus elymoides*, *Leymus salinus* (= *Elymus salinus*), *Piptatherum micranthum*, *Poa fendleriana*, *Poa secunda*, *Eriogonum alatum*, *Eriogonum racemosum*, *Opuntia* spp., and *Penstemon caespitosus*.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. *Pinus ponderosa* / *Artemisia nova* Woodland was mapped as a mixed shrub understory of *Artemisia nova* and *Artemisia tridentata*. The two shrub species were difficult to discern on the aerial photography and in some areas these two species co occur.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		Pinus ponderosa Woodland Alliance (A.530) Ponderosa Pine Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES303.648	Southern Rocky Mountain Ponderosa Pine Woodland

NatureServe conservation status:

Global rank. G5 (23 Feb 1994).

Distribution:

Globally. This association occurs on mountains and plateaus in southern Utah.

Canyon de Chelly National Monument. *Pinus ponderosa* / *Artemisia nova* Woodland was only sampled from two relevé locations within Canyon de Chelly National Monument. One relevé was located in Monument Canyon and the other is near the confluence of Crystal Creek and Cattail Wash.

Environmental summary:

Globally. This association occurs on silt loam and sandy loam soils at the elevations of 2195 and 2261 m (7201 and 7418 feet). Both relevés are found on hillsides with a slope of 3% and 17%, respectively, at a northeastern and northwestern aspect. The litter cover for these relevés is moderate (10-25% and 25-50%).

Canyon de Chelly National Monument. This Colorado Plateau woodland has been reported from hills, mountains and plateaus in southern Utah and northern Arizona. Stands occur on rocky ridges and benches with various aspects. Sites are on gentle to moderate slopes. Elevation ranges from 2100-2750 m (6900-9000 feet). Substrates are typically shallow, gravelly loam, sandy loam, clay loam or silt loam soils derived from basalt or a mix of colluvial shale and sandstone, sometimes with an impermeable subsurface horizon that restricts rooting. Some sites are known to have seasonally high water tables.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by a typically open (5-30% cover) to moderately dense (60%) tree canopy that is dominated by *Pinus ponderosa*. Scattered *Juniperus monosperma*, *Juniperus scopulorum*, *Pinus edulis*, or *Pinus flexilis* trees may also be present. *Artemisia nova* dominates the typically sparse dwarf shrub layer with 5-20% cover. Occasionally, this association may occur as sparse woodland, with total vegetation cover not exceeding 15%. Other shrub species present may include *Purshia tridentata*, *Chrysothamnus viscidiflorus*, *Ericameria parryi*, *Gutierrezia sarothrae*, *Quercus gambelii*, *Symphoricarpos oreophilus*, and *Tetradymia canescens*. If *Quercus gambelii* is present, it has less than 5% cover and much less cover than *Artemisia*. The sparse but often diverse herbaceous layer (<10% cover) is primarily composed of graminoids with scattered forbs and includes *Achnatherum hymenoides*, *Antennaria parvifolia*, *Bouteloua gracilis*, *Carex rossii*, *Elymus elymoides*, *Erigeron divergens*, *Leymus salinus* (= *Elymus salinus*), *Piptatherum micranthum*, *Poa fendleriana*, *Poa secunda*, *Eriogonum alatum*, *Eriogonum racemosum*, *Hymenoxys richardsonii*, *Ipomopsis aggregata*, *Eriogonum racemosum*, *Opuntia* spp., *Penstemon caespitosus*, and *Sporobolus contractus*.

Canyon de Chelly National Monument. Two relevés are classified as *Pinus ponderosa* / *Artemisia nova* Woodland. The total vegetation cover class for this association is high (50-75% in both relevés). The tree stratum is dense, also with a cover class of 50-75% in both relevés. The shrub stratum has moderately low cover (5-10% in one relevé and 10-25% in the other), and the herbaceous stratum is moderate, with the cover class of 10-25% in both relevés. The species richness is 22 and 26 species, respectively. The tree stratum is dominated by *Pinus ponderosa*, which covers 10-25% in one relevé and 25-50% in the other, and has a dbh that ranges from 6.2-49.7 cm (average dbh 22.1 cm). *Pinus edulis* is the second most abundant tree, having 5-10% cover in both relevés and a dbh that ranges from 5.6-20.5 cm (average dbh 10.0 cm). *Juniperus scopulorum* occurs with trace-1% cover in one relevé and 5-10% cover in the other and has a dbh of 5.9-17.7 cm (average dbh 10.1 cm). *Juniperus monosperma* occurs in one relevé with a cover class of 5-10% and two drc measurements of 20.5 cm and 24.0 cm. The tree stratum is composed of a main canopy layer with 25-50% cover, an emergent layer in one relevé with 5-10% cover, a subcanopy with 5-10% and 10-25% cover, and a seedling layer that covers trace-1% in one relevé and 1-5% in the other. The canopy layer is 10-20 m in height, the emergent layer (where present) is 20-30 m, the subcanopy is 5-10 m, and the seedling layer is 0.5-1 m tall.

The shrub stratum has only one distinct layer that is 0.5-1 m tall in one relevé and 1-2 m tall in the other. The dominant species is *Artemisia nova*, which has a cover class of 5-10% or 10-25%, respectively. Also present in the shrub layer is *Yucca angustissima*. The herbaceous stratum has a diversity of species (all of which have <1% cover) with the most common being *Antennaria parvifolia*, *Bouteloua gracilis*, *Elymus elymoides*, *Erigeron divergens*, *Eriogonum racemosum*, *Hymenoxys richardsonii*, *Ipomopsis aggregata*, *Poa fendleriana*, and *Sporobolus contractus*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Pinus ponderosa*	*Juniperus monosperma, Juniperus scopulorum, Pinus edulis, Pinus ponderosa*
Short shrub/ sapling	*N/A*	*Artemisia nova*
Herbaceous	*Artemisia nova*	*N/A*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K.A. Schulz, mod. J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas, mod. K.A. Schulz.

References:

Bourgeron and Engelking 1994, Cogan et al. 2004, Driscoll et al. 1984, FEIS 2001, Johnston 1987, Larson and Moir 1987, Roberts et al. 1992, Stuever and Hayden 1997b, West and Hassan 1985, Wright et al. 1979, Youngblood and Mauk 1985.

23. *Pinus ponderosa / Artemisia tridentata* ssp. *vaseyana* Woodland

NatureServe common name	Ponderosa Pine / Mountain Big Sagebrush Woodland
NatureServe code	CEGL002794

Summary:

This open ponderosa pine woodland is described from the southern Rocky Mountains on sites at 2200 to 2865 m (7215-9400 feet) elevation on dry, moderate to somewhat steep slopes with southerly to easterly aspects. Stands often occur adjacent to sagebrush shrublands. Soils are well drained or rapidly drained sandy loams and loamy sands derived from granite or sandstone. The vegetation is characterized by an open tree canopy (10-30% cover) dominated by *Pinus ponderosa* with a moderately dense short shrub layer dominated by *Artemisia tridentata* ssp. *vaseyana* (10-30% cover). Tree canopy may have low cover of *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus scopulorum*. The shrub layer may be diverse. Associated shrubs and dwarf shrubs may include *Amelanchier utahensis*, *Artemisia frigida*, *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Mahonia repens*, *Opuntia fragilis*, *Paxistima myrsinites*, *Purshia tridentata*, *Ribes cereum*, and *Symphoricarpos oreophilus*, usually with <5% cover each. The herbaceous layer ranges from sparse to moderately dense and is typically dominated by graminoids (to 40% cover). Common associates include *Achnatherum hymenoides*, *Bouteloua gracilis*, *Elymus* spp., *Hesperostipa comata*, *Koeleria macrantha*, *Muhlenbergia montana*, *Poa secunda*, and introduced species *Bromus inermis*, *Bromus tectorum*, and *Poa pratensis*. Forbs are less significant and few species contribute >1% cover.

Classification confidence: 2 - Moderate**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. This association was mapped with *Pinus ponderosa* / *Artemisia nova* Woodland.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus ponderosa* Woodland Alliance (A.530) Ponderosa Pine Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES303.648	Southern Rocky Mountain Ponderosa Pine Woodland

NatureServe conservation status:

Global rank. GNR (26 May 2005).

Distribution:

Globally. This association is known from the east side of Rocky Mountain National Park and Dinosaur National Park (Douglas Mountain) in Colorado and may extend into northern Utah.

Canyon de Chelly National Monument. Data are not available.

Environmental summary:

Globally. This open ponderosa pine woodland is described from the southern Rocky Mountains on sites at 2200 to 2865 m (7215-9400 feet) elevation on dry, moderate to somewhat steep slopes (10-49%) with southerly to easterly aspects. Stands often occur adjacent to sagebrush shrublands. Soils are well drained or rapidly drained sandy loams and loamy sands derived from granite or sandstone. The ground cover is a mosaic of bedrock, gravel, sandy soils, organic litter and duff under trees and boulders.

Canyon de Chelly National Monument. This association occurred in upland habitats on sandy to silty loam.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This woodland association is characterized by an open tree canopy (10-30% cover) dominated by *Pinus ponderosa* with a moderately dense short shrub layer dominated by *Artemisia tridentata* ssp. *vaseyana* (10-30% cover). Tree canopy may have low cover of *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus scopulorum*. The shrub layer may be diverse. Other shrubs and dwarf shrubs may include *Amelanchier utahensis*, *Artemisia frigida*, *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Mahonia repens*, *Opuntia fragilis*, *Paxistima myrsinites*, *Purshia tridentata*, *Ribes cereum*, and *Symphoricarpos oreophilus*, usually with <5% cover each. The herbaceous layer ranges from sparse to moderately dense and is typically dominated by graminoids (to 40% cover). Common associates include *Achnatherum hymenoides*, *Bouteloua gracilis*, *Elymus elymoides*, *Elymus scribneri*, *Elymus trachycaulus*, *Hesperostipa comata*, *Koeleria macrantha*, *Muhlenbergia montana*, *Poa secunda*, and introduced species *Bromus inermis*, *Bromus tectorum*, and *Poa pratensis*. Forbs are less significant and few species contribute >1% cover. Possible forbs include *Antennaria* spp., *Achillea millefolium*, *Artemisia ludoviciana*, *Eriogonum umbellatum*, *Heterotheca villosa*, *Potentilla effusa*, and *Symphyotrichum campestre* var. *campestre*.

Canyon de Chelly National Monument. *Pinus ponderosa* dominated the tree canopy (25-50% and 10-25% cover) with associated *Pinus edulis* (10-25% and 5-10% cover). *Juniperus scopulorum* occurred with low cover. *Artemisia tridentata* was present but generally with low cover (1-5% cover on each of the two relevés). Other shrubs and forbs occurred but with lower cover. Grasses present included *Bouteloua gracilis* (1-5% and <1% cover), *Poa fendleriana* (1-5% cover on one relevé), and *Bromus tectorum* (1-5% cover on one relevé).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Pinus ponderosa var. scopulorum*	*Pinus ponderosa*
Shrub	*N/A*	*Artemisia tridentata* ssp. *vaseyana*
Herbaceous	*Artemisia tridentata* ssp. *vaseyana*	*N/A*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus inermis, Bromus tectorum, Poa pratensis	*Pinus edulis*

Authors:

Global descriptions. K.A. Schulz.

References: Driscoll et al. 1984, Johnston and Huckaby 2001, Mauk and Henderson 1984.

24. *Pinus ponderosa / Bouteloua gracilis* Woodland

NatureServe common name	Ponderosa Pine / Blue Grama Woodland
NatureServe code	CEGL000848

Summary:

This widespread woodland occurs at foothill and lower montane elevations from the southern Rocky Mountains, extending east on southern Great Plains escarpments, south to the mountains of western Texas, west to the Colorado Plateau and Mogollon Rim of New Mexico, Arizona and Utah. Sites occur on dry, gentle to steep slopes on all aspects, but are more common on southern and western aspects, especially at higher elevations. Substrates are quite variable and include shallow sandy loam soils derived from granitic parent materials, coarse cinder soils, and clayey soil with or without high coarse fragment content. The vegetation is characterized by an open to moderately dense evergreen, needle leaved tree canopy 10-30 m tall that is either dominated by *Pinus ponderosa* or codominated by *Pinus ponderosa* and *Pinus edulis*. Species of *Juniperus* may be important subdominants. The typically moderately dense herbaceous layer has greater cover than the shrub layer, and is dominated by graminoids. *Bouteloua gracilis*, the warm season, sod forming, shortgrass, dominates the herbaceous layer. Common graminoid associates include *Aristida* spp., *Bouteloua hirsuta*, *Carex geophila*, *Elymus elymoides*, *Hesperostipa comata*, *Koeleria macrantha*, *Muhlenbergia montana*, *Poa fendleriana*, or *Schizachyrium scoparium*. *Quercus gambelii* may be present in the sparse shrub layer (<10% cover) with low cover (<5%). Other shrubs may include scattered *Artemisia tridentata*, *Ceanothus fendleri*, *Cercocarpus montanus*, *Ericameria nauseosa*, *Purshia tridentata*, *Rhus trilobata*, and *Tetradymia canescens*. Forb cover is typically sparse.

Classification confidence: 1 - Strong.

Classification comments:

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

Canyon de Chelly National Monument. This association and other *Pinus ponderosa* woodlands with a grass or sparse understory were mapped together as a base map class.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus ponderosa* Woodland Alliance (A.530) Ponderosa Pine Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES303.648	Southern Rocky Mountain Ponderosa Pine Woodland
CES303.649	Southern Rocky Mountain Ponderosa Pine Savanna

NatureServe conservation status:

Global rank. G4 (1 Feb 1996).

Distribution:

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

Canyon de Chelly National Monument. Data are not available.

Environmental summary:

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

Canyon de Chelly National Monument. This association has been observed on three accuracy assessment observation sites at Canyon de Chelly National Monument; however, environmental data for sites was not collected during the accuracy assessment.

USFWS wetland system: Not applicable.

Vegetation description:

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

Canyon de Chelly National Monument. *Pinus ponderosa* was the dominant tree at all three observation sites with (>5-50% cover). *Pinus edulis* also occurred at two of the sites with cover of >10 to 50%. Shrub cover was less than 10%; *Artemisia nova* occurred at two sites with cover of >1 to 10%. The dominant grasses were *Bouteloua gracilis* (>5-10% cover at two sites), *Muhlenbergia* sp. (>5-10% cover at two sites), *Bouteloua eriopoda* at one site (>5-10% cover) and *Poa fendleriana* also at one site (>1-5% cover).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Juniperus deppeana, Juniperus monosperma, Juniperus osteosperma, Juniperus scopulorum, Pinus edulis, Pinus ponderosa*	*Pinus ponderosa, Pinus edulis*
Herbaceous	*Artemisia tridentata* ssp. *vaseyana*	*Bouteloua gracilis*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K.A. Schulz.

References:

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

25. *Pinus ponderosa / Quercus gambelii* Woodland

NatureServe common name	Ponderosa Pine / Gambel Oak Woodland
NatureServe code	CEGL000870

Summary:

This major woodland association is widespread and has been reported from foothills, mountains and plateaus from Colorado to Texas, west to Arizona and Nevada. Elevation ranges from 1830 2800 m (6000-9200 feet). Stands often occur along drainages, on lower and middle slopes and benches on all aspects. Soils are typically shallow and rocky ranging from sandy loams to clay loams. *Pinus ponderosa* dominates or sometimes codominates the sparse to moderately dense tree canopy with *Pinus edulis* and *Juniperus* spp. *Pseudotsuga menziesii* is accidental and *Abies concolor* is not present. *Quercus gambelii* dominates both the subcanopy (tree form, if present) and the typically moderately dense tall shrub layer consisting of dense clumps of oak. *Quercus gambelii* must have at least 5% cover, but there is frequently over 25%. At higher elevations, the *Quercus gambelii* are more tree like and *Symphoricarpos oreophilus* will be present with significant cover in the short shrub layer. At lower elevations, scattered *Artemisia tridentata* ssp. *vaseyana*, *Pinus edulis*, and *Juniperus osteosperma* are often present. Other common shrub species may include *Amelanchier* spp., *Mahonia repens*, and *Rosa woodsii*. The herbaceous layer is generally sparse and composed of mostly graminoids and scattered forbs.

Classification confidence: 1 - Strong.

Classification comments:

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

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.a.	Rounded crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pinus ponderosa* Woodland Alliance (A.530) Ponderosa Pine Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES303.649	Southern Rocky Mountain Ponderosa Pine Savanna

NatureServe conservation status:

Global rank. G5 (1 Feb 1996).

Distribution:

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

Canyon de Chelly National Monument. *Pinus ponderosa* / *Quercus gambelii* Woodland occurs on five relevés on hills, plateaus, and canyons within Canyon de Chelly National Monument. The relevés for this association were sampled primarily from Monument Canyon and one from Canyon de Chelly proper.

Environmental summary:

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

Canyon de Chelly National Monument. This association occurs on sandy loam, silt loam, sandy clay loam, and sandy clay soils between the elevations of 1903 and 2293 m (6244-7523 feet) (average 2193 m [7195 feet]). The slope ranges from 6-17% (average 13%) at various aspects. The litter cover is moderate to high and ranges from 25-50% to 50-75%, with an average cover range of 40-65%. All relevés but one had signs of wood cutting and two showed evidence of fire.

USFWS wetland system: Not applicable.

Vegetation description:

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

Canyon de Chelly National Monument. Five relevés are classified as *Pinus ponderosa* / *Quercus gambelii* Woodland. The total vegetation cover class for this association ranges

from 25-50% to 75-100% (average cover class 50-75%). The tree stratum is usually moderate to dense and ranges in cover class between 25-50% and 50-75% (average cover class 40-65%). The shrub stratum has a moderate to low cover class which ranges from trace-1% to 10-25% (average cover 7-17%). The herbaceous stratum usually has low cover, ranging between 1-5% and 10-25% (average cover class 4-11%). The species richness ranges from 12-29 species (average of 23 species). The tree stratum consists of a main canopy (cover ranging between 10-25% and 50-75%), an emergent layer (only one relevé has an emergent layer that covers 10-25%), a subcanopy which covers 10-25%, and a seedling layer that ranges in cover from trace-1% to 5-10%. The main canopy layer varies between 10-20 m and >30 m in height, the emergent layer (where present) is >30 m, the subcanopy ranges from 2-5 m to 10-20 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Pinus ponderosa*, ranging between 10-25% and 50-75% cover (average cover class 21-40%), and with a dbh ranging from 5.3-71.3 cm (average dbh 25.8 cm). The second most abundant tree is *Quercus gambelii*, which ranges in cover from 10-25% to 25-50% (13-30% average cover class) and has a dbh of 5.0-17.6 cm (average dbh 7.6 cm). *Pinus edulis* ranges in cover from trace-1% to 10-25% (3-8% average cover class) and has a dbh of 5.7-25.4 cm (average dbh 12.4 cm). *Juniperus osteosperma* ranges between 0% and 5-10% cover (average cover class 2-5%) and has a drc that ranges from 7.7-39.7 cm (average drc 26.9 cm). Two trees of *Juniperus osteosperma* had dbh measurements of 11.1 cm and 70.0 cm. Two relevés have 1-5% cover of *Pseudotsuga menziesii*, which has a dbh that ranges from 6.6-19.3 cm (average dbh 13.1 cm).

The shrub stratum has a tall shrub layer that ranges in height between 0.5-1 m and 2-5 m and a short shrub layer of 1-2 m. The tall shrub layer is found in all relevés and covers between trace-1% and 10-25%, and the short shrub layer is found in only one relevé and covers 1-5%. The shrub stratum is dominated by *Purshia stansburiana*, which ranges in cover from 0% to 10-25% (average cover class 5-12%). Other species frequently present in the shrub stratum are *Rhus trilobata*, *Yucca angustissima*, and *Yucca baccata*. The herbaceous stratum is dominated by *Poa fendleriana*, which covers trace-1% to 5-10% (average cover class 2-5%). The herbaceous stratum has a diversity of other species (all having a cover class <1%) with the most common being *Elymus elymoides*, *Hedysarum boreale*, *Hymenoxys richardsonii*, and *Packera neomexicana* (= *Senecio neomexicanus*).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Pinus ponderosa*	*Juniperus osteosperma, Pinus edulis, Pinus ponderosa, Quercus gambelii*
Tall shrub/sapling	*Quercus gambelii*	*N/A*
Tall/short shrub/ sapling	*N/A*	*Purshia stansburiana*
Herbaceous	*N/A*	*Poa fendleriana*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K.A. Schulz, mod. J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Alexander et al. 1984a, Alexander et al. 1987, Bader 1932, Blackburn et al. 1969a, Blackburn et al. 1969b, Bourgeron and Engelking 1994, Bradley et al. 1992, Bunin 1975, CONHP unpubl. data 2003,

Clary 1992, Cogan et al. 2004, DeVelice et al. 1986, Diamond 1993, Dixon 1935, Donart et al. 1978, Driscoll et al. 1984, Fitzhugh et al. 1987, Hanks et al. 1983, Hansen et al. 2004b, Hanson and Ball 1928, Harmon 1980, Helm 1977, Hess and Wasser 1982, Johnston 1987, Johnston and Hendzel 1985, Larson and Moir 1987, Madany and West 1980, Marr et al. 1973a, Muldavin et al. 1996, NVNHP 2003, Nixon 1967, Peet 1975, Peet 1981, Roberts et al. 1992, Savage and Swetnam 1990, Schmoll 1935, Somers et al. 1980, Steinhoff 1978, Stuever and Hayden 1997b, Terwilliger et al. 1979, USFS 1983b, Wasser and Hess 1982, Wright et al. 1973, Youngblood and Mauk 1985

26. *Populus deltoides* ssp. *wislizeni / Disturbed Understory* Woodland

NatureServe common name	Rio Grande Cottonwood / Disturbed Understory Woodland
NatureServe code	CEGL003810

Summary:

This association has only been described from Canyon de Chelly and Dinosaur national monuments, but it is likely to occur on abandoned floodplain terraces of low gradient rivers and streams throughout the eastern Colorado Plateau of Colorado, Utah, New Mexico and northeastern Arizona. The association is best developed on level valley bottom sites that no longer flood and that have been subjected to a long history of domestic livestock grazing. The vegetation underneath the open gallery canopy of *Populus deltoides* ssp. *wislizeni* consists primarily of upland plants and is dominated by aggressive exotic species such as *Bromus tectorum*, *Elymus repens*, *Acroptilon repens*, *Lepidium latifolium*, and *Poa pratensis*. Relict native grasses, shrubs and forbs may be present with relatively low cover.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. According to Gwen Kittel, University of Colorado graduate student Mary Ellen Ford is revising the taxonomy of western cottonwood species. If the taxonomic community accepts her work, *Populus fremontii* may be reduced to a subspecies of *Populus deltoides*. In this case, there will be four subspecies of *Populus deltoides*: ssp. *deltoides* of the eastern and midwestern states, ssp. *monilifera* of the Great Plains, ssp. *wislizeni* of western Colorado and the upper Rio Grande River drainage, and ssp. *fremontii* of the desert southwest. Associations based on ssp. *deltoides* in any case should be kept separate from the other three, as there is no overlap in ranges. Associations based on the three western subspecies should probably be considered as a single set, rather than three sets of parallel associations. The name of this association would therefore change to something like "*Populus deltoides* (ssp. *fremontii*, ssp. *monilifera*, ssp. *wislizeni*) / Disturbed Understory Woodland."

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.B.	Deciduous woodland
Physiognomic group	II.B.2.	Cold deciduous woodland
Physiognomic subgroup	II.B.2.N.	Natural/Semi natural cold deciduous woodland
Formation name	II.B.2.N.b.	Temporarily flooded cold deciduous woodland
Alliance name		*Populus deltoides* Temporarily Flooded Woodland Alliance (A.636) Eastern Cottonwood Temporarily Flooded Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.821	Rocky Mountain Lower Montane Foothill Riparian Woodland and Shrubland

NatureServe conservation status:

Global rank. GNR (11 May 2006).

Distribution:

Globally. The range of *Populus deltoides* ssp. *wislizeni* extends from extreme southwestern Wyoming through Colorado west of the Continental Divide to northwestern New Mexico and northeastern Arizona; this association is likely to be common throughout this range on the high terraces of well developed floodplains. It is currently known from Arizona, Colorado and Utah.

Canyon de Chelly National Monument. *Populus deltoides* ssp. *wislizeni* / Disturbed Understory Woodland was only sampled from one relevé location west of Wild Cherry Canyon (in the vicinity of Neboyia's West Well) within Canyon de Chelly National Monument.

Environmental summary:

Globally. This Colorado Plateau association is documented from canyons and broad valley bottoms that support developed floodplains with multiple terraces. Landforms include abandoned stream terraces and oxbows high enough above stream level that they rarely flood. The vegetation is isolated from the water table. Stands tend to occur on level to gently sloping sites, that in northwestern Colorado lie between 1488 and 1720 m elevation. Soils are poorly developed and derived from sandy or silty alluvium, and large dead cottonwood branches and trunks litter the ground. Litter cover may be dense in some stands.

Canyon de Chelly National Monument. This association occurs on sandy soil at an elevation of 1689 m (5541 feet). The relevé occurs on a level terrace which supports a plant community that differs from the main riparian channel. There is evidence of fire that is approximately two years old. The litter layer is dense, having a 75-100% cover class.

USFWS wetland system: Palustrine.

Vegetation description:

Globally. Because stands of this association are isolated from flood events and from the water table, the canopy generally consists of mature to decadent gallery stands of *Populus deltoides* ssp. *wislizeni* with no saplings or seedlings present. Canopy closure ranges between 10 and 40%. Other trees present in the canopy or subcanopy may include individuals or clumps of *Acer negundo*, *Juniperus scopulorum*, or exotic species *Elaeagnus angustifolia* and *Tamarix ramosissima*. The understory is composed primarily of upland plants, although relict riparian species such as *Salix exigua* or *Juncus balticus* may be present. Herbaceous species, especially invasive exotics, dominate the understory; the exotic grasses *Bromus tectorum*, *Bromus rigidus*, *Poa pratensis*, or *Elymus repens* (or a hybrid of *Pascopyrum smithii* and *Elymus repens*) can contribute up to 65% cover. Other stands have high cover of the exotic forbs *Lepidium latifolium*, *Acroptilon repens* (= *Centaurea repens*), or *Sisymbrium altissimum*. Relict native species may occur scattered throughout stands, including *Hesperostipa comata*, *Sporobolus cryptandrus*, *Iva axillaris*, and *Heterotheca villosa*. Shrubs such as *Artemisia tridentata* ssp. *tridentata* and *Ericameria nauseosa* are often present, although they do not contribute enough cover (less than 5%) to constitute a stratum.

Canyon de Chelly National Monument. One relevé is classified as *Populus deltoides* ssp. *wislizeni* / Disturbed Understory Woodland. The total vegetation cover class for this association is 75-100%. The tree stratum is characterized by a total cover class range of 75-100%, the shrub stratum has 0% cover, and the herbaceous stratum covers 1-5%. The species richness is 8 species. The tree stratum is dominated by *Populus deltoides* ssp. *wislizeni*, which has a cover class of 75-100% and a dbh that ranges from 9.4-42.5 cm (average dbh 29.3 cm). Also present in the tree stratum is *Elaeagnus angustifolia*, which covers 10-25%. This relevé has a main canopy height of 20-30 m with a cover class of 75-100% and a subcanopy layer that covers 10-25% and is 2-5 m in height. The emergent and seedling layers are absent. The shrub stratum is lacking in this association. The herbaceous layer is sparse and is dominated by *Bromus rigidus* and *Bromus tectorum*, each covering 1-5%. All other herbaceous species have a cover class <1%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Populus deltoides* ssp. *wislizeni*	*Elaeagnus angustifolia, Populus deltoides* ssp. *wislizeni*
Herbaceous	*Acroptilon repens, Lepidium latifolium, Bromus rigidus, Bromus tectorum*	*N/A*

Other noteworthy species:

Global species	Canyon de Chelly species
Acroptilon repens, Bromus rigidus, Bromus tectorum, Elymus repens, Lepidium latifolium, Poa pratensis, Salsola kali ssp. *tragus, Sisymbrium altissimum, Tamarix ramosissima*	*Data are not available.*

Authors:

Global descriptions. J. Coles, mod. K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

27. *Pseudotsuga menziesii / Poa fendleriana* Woodland

NatureServe common name	Douglas fir / Muttongrass Woodland
NatureServe code	CEGL002809

Summary:

This woodland association is only known from a few stands in Curecanti National Recreation Area in western Colorado and from Dinosaur National Monument in Utah. Stands occupy the slopes of canyons and gulches and are on moderately steep to steep (38-70%) sites, between 2178 and 2363 m elevation, and are oriented to northerly aspects. Soils are rapidly drained, coarse textured and derived from sedimentary rocks. The vegetation is characterized by an open to moderately dense (25 to 50%) tree canopy 10-35 m tall composed of *Pseudotsuga menziesii*, with an open to moderately dense herbaceous layer dominated by the short bunchgrass *Poa fendleriana* providing 5 to 25% cover. Single trees of *Pinus ponderosa* may occur in the canopy, and scattered sapling *Pseudotsuga menziesii* and *Juniperus scopulorum* 2-10 m tall form an open subcanopy. Shrubs are generally present but too sparse to constitute a stratum; *Cercocarpus montanus*, *Cercocarpus intricatus*, *Artemisia tridentata*, *Ribes* spp., *Quercus gambelii*, and *Symphoricarpos oreophilus* are common species. The remaining herbaceous layer is mostly composed of graminoids, such as *Achnatherum hymenoides*, *Elymus elymoides*, *Koeleria macrantha*, *Poa secunda*, and sparse cover of forbs. *Pseudoroegneria spicata* is absent. Lichens and mosses provide up to 25% cover.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. This association has only been documented from two locations in Curecanti National Recreation Area and one site in Dinosaur National Monument in western Colorado and adjacent Utah. More survey and classification work are needed to change the provisional status of this association.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.b.	Conical crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pseudotsuga menziesii* Woodland Alliance (A.552) Douglas fir Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.823	Southern Rocky Mountain Dry Mesic Montane Mixed Conifer Forest and Woodland

NatureServe conservation status:

Global rank. GNR (27 Jun 2005).

Distribution:

Globally. This association is only known from the Curecanti National Recreation Area in

western Colorado along the Gunnison River and West Elk Creek. It was also sampled on Split Mountain in Dinosaur National Monument in eastern Utah and at Canyon de Chelly in Arizona. More survey and classification work are needed to document the global range of this association.

Canyon de Chelly National Monument. *Pseudotsuga menziesii* / *Poa fendleriana* Woodland was only sampled from two relevé locations within Canyon de Chelly National Monument. One is located in Black Rock Canyon, and the other is found west of Monument Canyon.

Environmental summary:

Globally. This woodland association is known from only a handful of stands in the Curecanti National Recreation Area and Dinosaur National Monument in western Colorado. More survey and classification work are needed to document the global range of this association. Stands occur on the slopes of canyons and gulches and are on moderately steep to steep (38-70%) sites, between 2178 and 2363 m (7155-7750 feet) elevation, and are oriented to northwest to northeast aspects. Litter, rocks and downed wood cover most of the unvegetated surface. Soils are rapidly drained sandy loam or loamy sand derived from sandstone, alluvium or shale.

Canyon de Chelly National Monument. This association occurs on sandy loam soils at the elevations of 2073 and 2244 m (6801 and 7362 feet). One relevé is found on a canyon wall and has a slope of 38%, and the other occurs on a ridge and has a slope of 6%. Both relevés have a generally north facing aspect. The litter cover for these relevés is moderate to high (25-50% and 50-75%), and both have notable amounts of exposed bedrock, boulders, stones and cobble.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation is characterized by an open to moderately dense (25 to 50%) tree canopy 10-35 m tall composed of *Pseudotsuga menziesii*, with an open to moderately dense herbaceous layer dominated by the short bunchgrass *Poa fendleriana* providing 5 to 25% cover. Large *Pinus ponderosa* may be scattered throughout the canopy, with not more than 10% cover. Scattered young *Pseudotsuga menziesii* and *Juniperus scopulorum*, 2-10 m tall, form a subcanopy. Shrubs are generally present but do not provide enough cover to constitute a stratum; *Cercocarpus montanus*, *Cercocarpus intricatus*, *Artemisia tridentata*, *Ribes cereum*, *Ribes inerme*, *Quercus gambelii*, and *Symphoricarpos oreophilus* are common species. The remaining herbaceous layer is moderately diverse and mostly composed of graminoids, such as *Achnatherum hymenoides*, *Elymus elymoides*, *Koeleria macrantha*, and *Poa secunda*. *Pseudoroegneria spicata* is absent. Forbs are sparse and inconsistent among sites; recorded species include *Arenaria congesta*, *Artemisia frigida*, *Clematis* sp., and *Erigeron* sp. Lichens and mosses provide up to 25% cover.

Canyon de Chelly National Monument. Two relevés are classified as *Pseudotsuga menziesii* / *Poa fendleriana* Woodland. The total vegetation cover class for this association is high (50-75% in both relevés). The tree stratum is dense, covering 25-50% in one relevé and 50-75% in the other. The shrub stratum has a low cover class (1-5% in both relevés), and the herbaceous stratum is moderately high, with 25-50% cover in both relevés. The species richness is 16 and 20 species, respectively. The tree stratum is dominated by *Pseudotsuga menziesii*, which covers 10-25% in one relevé and 25-50% in the other, and has a dbh that ranges from 7.3-52.3 cm (average dbh 33.2 cm). *Pinus edulis* is the second most abundant tree, covering 10-25% of both relevés and having a dbh that ranges from 6.2-23.2 cm (average dbh 13.6 cm). *Juniperus scopulorum* is present in one of the relevés, where it covers 5-10% and has a drc of 35.1-61.3 cm (average drc 50.0 cm). Two dbh measurements for *Juniperus scopulorum* were also taken at 12.7 cm and 40.1 cm. The tree stratum is composed of a main canopy layer that covers 25-50% of both relevés, an emergent layer (one relevé has an emergent layer that covers 10-25%), a subcanopy which covers trace-1% in one relevé and 10-25% in the other, and a seedling layer that covers trace-1% in one relevé and 1-5% in the other. The canopy layer is 10-20 m or >30 m in height, the emergent layer (where present) is 20-30

m, the subcanopy is 5-10 m, and seedling layer is 0.5-1 m tall. The shrub stratum has only one distinct layer that is 2-5 m tall. The shrub species are diverse, with no one species covering >1% or occurring in both relevés. One relevé has primarily *Artemisia tridentata*, while the other is characterized by *Fendlera rupicola* and *Cercocarpus montanus*. The herbaceous stratum has a diversity of species (all of which have <1% cover) with the most common being *Arabis fendleri* and *Packera neomexicana* (= *Senecio neomexicanus*).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Pseudotsuga menziesii*	*Juniperus scopulorum, Pinus edulis, Pseudotsuga menziesii*
Herbaceous	*Poa fendleriana*	*Poa fendleriana*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K.A. Schulz and J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

28. *Pseudotsuga menziesii* Scree Woodland

NatureServe common name	Douglas-fir Scree Woodland
NatureServe code	CEGL000911

Summary:

This association occurs throughout the interior western U.S. but is restricted to steep slopes covered by loose rock and colluvium on mountain or canyon slopes. It has the appearance of a stand of scattered trees with a sparse understory; the vegetation is limited by the lack of soil development. Slopes generally exceed 60% and are generally unstable, with constantly shifting rocks on the slopes as well as additional rockfall from outcrops upslope. Elevations at the northern end of the range (Montana) are from 915 to 2180 m (3100-7150 feet), and sites are usually limited to warm, south to west facing slopes in canyons. In northern Arizona, stands occur on various aspects around 2930 m (9600 feet) elevation, and in southern Colorado stands have been documented at around 2560 m (8400 feet). Most of the unvegetated ground surface is covered by rocks and boulders, with small amounts of litter and dead wood. Soils are poorly developed and often too rocky to sample. The rocky slope is the dominant visual element of the community. The sparse to open canopy of this association is generally mixed and rarely exceeds 35% cover. *Pseudotsuga menziesii* is always present and dominant or codominant; other tree species may include *Juniperus osteosperma*, *Juniperus scopulorum*, *Picea engelmannii*, *Pinus edulis*, *Pinus flexilis*, *Pinus strobiformis*, *Pinus ponderosa*, *Populus tremuloides*, *Abies concolor*, and *Abies lasiocarpa*. Shrubs are variable depending on the site, but cover is too sparse and the mix either lacks a diagnostic species in the understory or the shrub layer is too poorly developed to be diagnostic. Shrub species present may include *Arctostaphylos uva-ursi*, *Acer glabrum*, *Amelanchier utahensis*, *Juniperus communis*, *Dasiphora fruticosa* ssp. *floribunda*, *Holodiscus dumosus*, *Prunus virginiana*, *Ribes inerme*, *Ribes montigenum*, *Salix scouleriana*, *Shepherdia canadensis*, *Shepherdia rotundifolia*, and *Symphoricarpos oreophilus*. Herbaceous species are sparse and inconsistent among sites.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. This association is distinguished from other scree woodland associations by the clear dominance of *Pseudotsuga menziesii* in the canopy and a shrub layer that is too sparse and scattered to be diagnostic.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	II	Woodland
Physiognomic subclass	II.A.	Evergreen woodland
Physiognomic group	II.A.4.	Temperate or subpolar needle leaved evergreen woodland
Physiognomic subgroup	II.A.4.N.	Natural/Semi natural temperate or subpolar needle leaved evergreen woodland
Formation name	II.A.4.N.b.	Conical crowned temperate or subpolar needle leaved evergreen woodland
Alliance name		*Pseudotsuga menziesii* Woodland Alliance (A.552) Douglas fir Woodland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.815	Rocky Mountain Cliff, Canyon and Massive Bedrock
CES306.823	Southern Rocky Mountain Dry Mesic Montane Mixed Conifer Forest and Woodland

NatureServe conservation status:

Global rank. G5 (23 Feb 1994).

Distribution:

Globally. This association has been documented from sites scattered throughout the interior western U.S., including Montana, Utah, New Mexico, Arizona and Colorado.

Canyon de Chelly National Monument. *Pseudotsuga menziesii* Scree Woodland was only sampled from one relevé location east of Spider Rock within Canyon de Chelly National Monument.

Environmental summary:

Globally. This association occurs throughout the interior western U.S. but is restricted to steep slopes covered by loose rock and colluvium on mountain or canyon slopes. Slopes generally exceed 60% and are generally unstable, with constantly shifting rocks on the slopes as well as additional rockfall from outcrops upslope. Elevations at the northern end of the range (Montana) are from 915 to 2180 m (3100-7150 feet), and sites are usually limited to warm, south to west facing slopes in canyons. In northern Arizona, stands occur on various aspects around 2930 m (9600 feet) elevation, and in southern Colorado stands have been documented at around 2560 m (8400 feet). Most of the unvegetated ground surface is covered by rocks and boulders, with small amounts of litter and dead wood. Soils are poorly developed and often too rocky to sample.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 1951 m (6401 feet). The relevé occurs on a north facing canyon side with a slope of 35%. This particular relevé has some exposure of bedrock and boulders (each having a 5-10% cover class) and it is adjacent to areas of slickrock.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has the appearance of a stand of scattered trees with a sparse understory; the vegetation is limited by the lack of soil development. The rocky slope is the dominant visual element of the community. The sparse to open canopy of this association is generally mixed and rarely exceeds 35% cover. *Pseudotsuga menziesii* is always present and dominant or codominant; other tree species may include *Juniperus osteosperma*, *Juniperus scopulorum*, *Picea engelmannii*, *Pinus edulis*, *Pinus flexilis*, *Pinus strobiformis*, *Pinus ponderosa*, *Populus tremuloides*, *Abies concolor*, and *Abies lasiocarpa*. Shrubs are variable depending on the site, but cover is too sparse and the mix either lacks a diagnostic species in the understory or the shrub layer is too poorly developed to be diagnostic. Shrub species present may include *Arctostaphylos uva-ursi*, *Acer glabrum*, *Amelanchier utahensis*, *Juniperus communis*, *Dasiphora fruticosa* ssp. *floribunda*, *Holodiscus dumosus*, *Prunus virginiana*, *Ribes inerme*, *Ribes montigenum*, *Salix scouleriana*, *Shepherdia canadensis*, *Shepherdia rotundifolia*, and *Symphoricarpos oreophilus*. Herbaceous species are sparse and inconsistent among sites.

Canyon de Chelly National Monument. One relevé is classified as *Pseudotsuga menziesii* Scree Woodland. The total vegetation cover class for this association is 25-50%. The tree stratum is characterized by a total cover class range of 10-25%, the shrub stratum covers 5-10%, and the herbaceous stratum covers 1-5%. The species richness is 23 species. The tree stratum is dominated by *Pseudotsuga menziesii*, which has a cover class of 1-5%. Two dbh measurements were taken at 6.9 cm and 29.6 cm. Also present in the tree stratum is *Pinus edulis* with 1-5% cover (one dbh measurement at 10.6 cm) and *Juniperus osteosperma* (>1% cover). This relevé has a main canopy height of 5-10 m with a cover class of 5-10%, an emergent layer with a height of >30 m that covers 1-5%, a subcanopy layer that covers 1-5% and is 2-5 m in height, and a trace seedling layer (<1% cover) that is 0.5-1 m tall. The shrub stratum has two distinct layers. The tall shrub layer covers 5-10% and is 2-5 m in height, and the short shrub layer covers 1-5% and is 1-2 m tall. The tall shrub layer is dominated

by *Amelanchier utahensis* and *Cercocarpus montanus* (each with 1-5% cover), and the short shrub layer is composed of *Ericameria nauseosa* with 1-5% and *Artemisia tridentata* (<1% cover). The herbaceous stratum is sparse and has a diversity of species, all having a cover class <1%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Pseudotsuga menziesii*	*Pseudotsuga menziesii*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum	*Data are not available.*

Authors:

Global descriptions. J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Bourgeron and Engelking 1994, DeVelice et al. 1986, Driscoll et al. 1984, Fitzhugh et al. 1987, MTNHP 2002, Pfister et al. 1977.

C.4. Shrubland

29. *Amelanchier utahensis* Shrubland

NatureServe common name	Utah Serviceberry Shrubland
NatureServe code	CEGL001067

Summary:

This mountain shrubland association occurs at middle elevations in the foothills, mountains and mesas in north central Utah, the Colorado Plateau and Great Basin of the western U.S. Stands occur on moderate to steep slopes characterized by talus or rockfall from further upslope. It is found on relatively warm southern aspects in the Wasatch Mountains but also occurs on northern aspects or in cold air drainages at lower elevations and more southern latitudes. Substrates are moderately deep, rocky loams and clays. The sparse to moderately dense tall shrub layer (10-60% cover) is dominated by the cold deciduous shrub *Amelanchier utahensis*. *Symphoricarpos oreophilus* often dominates in the short shrub layer. Other shrub associates may include low cover of *Acer grandidentatum*, *Artemisia tridentata*, *Chrysothamnus viscidiflorus*, *Ephedra viridis*, *Mahonia repens*, *Purshia tridentata*, *Rhus trilobata*, and *Rosa woodsii*. *Quercus gambelii* may also be present, but it is always poorly represented (<5%). Tree species are sometimes present with the tall shrubs or as a very sparse emergent layer. The sparse to moderately dense herbaceous layer is a mixture of perennial graminoids and forbs. Introduced species such as *Agropyron cristatum* and *Bromus tectorum* are common in disturbed stands.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. This association is not well known. More survey work and classification work are needed to define further this type.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.B.	Deciduous shrubland
Physiognomic group	III.B.2.	Cold deciduous shrubland
Physiognomic subgroup	III.B.2.N.	Natural/Semi natural cold deciduous shrubland
Formation name	III.B.2.N.a.	Temperate cold deciduous shrubland
Alliance name		*Amelanchier utahensis* Shrubland Alliance (A.916) Utah Serviceberry Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.818	Rocky Mountain Gambel Oak Mixed Montane Shrubland

NatureServe conservation status:

Global rank. G4 (19 Sep 2000).

Distribution:

Globally. This shrubland association occurs in the foothills and mountain areas in north central Utah, Colorado Plateau and Great Basin of the western U.S.

Canyon de Chelly National Monument. *Amelanchier utahensis* Shrubland was only sampled from one relevé location within Canyon de Chelly National Monument. It is found in a side canyon of Canyon de Chelly proper in the vicinity of White House Ruins.

Environmental summary:

Globally. This montane shrubland association occurs in the foothills, canyons, mountains and mesas at elevations from 1480-2440 m (4855-8000 feet). Stands occur on moderate to steep slopes (9-37 degrees) with a high proportion of talus or rockfall. It is found on relatively warm southern aspects in the Wasatch Mountains (Yake and Brotherson 1979) but also occurs on northern aspects or in cold air drainages at lower elevations and more southern latitudes. Substrates are moderately deep, rocky loams and clays and are rapidly drained.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 1800 m (5906 feet). The relevé occurs on a north facing step in slope with an incline of 30% and is located at the base of a cliff. Boulders cover 25-50% of the relevé, and gravel, stone, and bedrock each cover an additional 5-10%.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation is characterized by a sparse to moderately dense (10-60% cover) tall shrub layer dominated by the cold deciduous shrub *Amelanchier utahensis*. *Symphoricarpos oreophilus* often forms a short shrub layer. Other shrub associates may include low cover of *Acer grandidentatum*, *Artemisia tridentata*, *Chrysothamnus viscidiflorus*, *Ephedra viridis*, *Fraxinus anomala*, *Mahonia repens*, *Purshia tridentata*, *Rhus trilobata*, and *Rosa woodsii*. *Quercus gambelii* may also be present, but it is always poorly represented (<5% cover). Short trees of *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus scopulorum* may be mixed in with the tall shrubs or emerge above as a very sparse tree layer. The sparse to moderate herbaceous layer is a mixture of perennial graminoids and forbs. Herbaceous species include *Bromus carinatus*, *Koeleria macrantha*, *Achnatherum nelsonii* ssp. *dorei* (= *Stipa columbiana*), *Poa fendleriana*, *Balsamorhiza sagittata*, *Chenopodium fremontii*, *Machaeranthera canescens*, and species of *Astragalus*, *Eriogonum*, *Mertensia*, and *Penstemon* (Yake and Brotherson 1979). Introduced species such as *Agropyron cristatum* and *Bromus tectorum* are common in disturbed stands.

Canyon de Chelly National Monument. One relevé is classified as *Amelanchier utahensis* Shrubland. The total vegetation cover class for this association is 25-50%. The tree stratum is characterized by a total cover class of 5-10%, the shrub stratum covers 10-25%, and the herbaceous stratum covers 10-25%. The species richness is 21 species. The tree stratum is dominated by *Juniperus osteosperma*, which has a cover class of 1-5% (one drc measurement taken at 12 cm), and large *Amelanchier utahensis*, which has a total cover class of 10-25% for the relevé. The main canopy has height of 2-5 m with a cover class of 5-10%, the emergent layer covers 5-10% and is 5-10 m in height, and there is a trace seedling layer (<1% cover) that is 0.5-1 m tall. The shrub stratum has only one distinct layer that is 1-2 m tall. The dominant shrub species are *Amelanchier utahensis*, which has 10-25% cover, *Chrysothamnus greenei* with 5-10% cover, and *Artemisia tridentata* and *Gutierrezia sarothrae*, which each cover 1-5%. The herbaceous stratum has a diversity of species, each having a cover class <1%, except for *Achnatherum hymenoides* and *Heterotheca villosa*, which have a cover class of 1-5%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tall shrub/sapling	*Amelanchier utahensis*	*Amelanchier utahensis, Chrysothamnus greenei*
Short shrub/ sapling	*Symphoricarpos oreophilus*	*N/A*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K.A. Schulz, mod. J. Drake.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Bourgeron and Engelking 1994, Carmichael et al. 1978, Cogan et al. 2004, Crane 1982, Driscoll et al. 1984, Eddleman and Jaindl 1994, NVNHP 2003, Yake and Brotherson 1979.

30. *Artemisia tridentata* ssp. *wyomingensis / Artemisia nova* Shrubland [Park Special]

NatureServe common name	Wyoming Big Sagebrush / Black Sage Shrubland [Park Special]
NatureServe code	Park Special

Summary:

This park special has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. This vegetation type has not been identified in other locations outside of Canyon de Chelly National Monument. Since this vegetation type is only known from five accuracy assessment locations in the monument, it is not currently included as a new vegetation association in the National Vegetation Classification (NVC) and is listed as a "park special." Park specials are vegetation communities that represent a unique vegetation assemblage that has not been described elsewhere. If additional data are collected on this vegetation type, then this community may be re-classified as an NVCS association.

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.788	Inter-mountain Basins Semi-desert Shrub-Steppe

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This park special has only been described from five accuracy assessment observations at Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This plant community occurred at lower elevations near disturbed areas such as the dirt roads and terraces along the riparian corridor. At higher elevations it occurred in patches within the wooded plant communities.

Environmental summary:

Globally. This park special has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. Environmental data was not collected at the five accuracy assessment sites.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This park special has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This vegetation type was observed on five accuracy assessment sites. The shrubs *Artemisia tridentata* or A.nova dominated with cover ranging from 10 to 75% for *Artemisia tridentata* and 5-25% for *Artemisia nova*. Tree cover, if present, was below 10%. Other shrubs were usually present with less than 10% cover. Other shrubs included *Opuntia* spp., *Gutierrezia sarothrae*, *Brickellia californica*, *Ephedra viridis*, and *Amelanchier utahensis*. Grasses, if present, could have cover up to 25%. The most dominant grasses present included: *Bouteloua gracilis*, *Bouteloua curtipendula*, *Bromus tectorum*, and *Poa fendleriana*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Shrub	*Data are not available.*	*Artemisia tridentata, Artemisia nova*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Bromus tectorum, Poa fendleriana, Bouteloua gracilis*

Authors:

Local descriptions. K. Thomas.

References:

None available.

31. *Artemisia tridentata* ssp. *wyomingensis / Bouteloua gracilis* Shrubland

NatureServe common name	Wyoming Big Sagebrush / Blue Grama Shrubland
NatureServe code	CEGL001041

Summary:

This common sagebrush shrubland association occurs on ridges, plateaus and benches, and valleys in Wyoming, western Colorado and southeastern Utah. Elevations range from 2200 to 2430 m (7215-7975 feet). Sites are on gentle to steep slopes and may be oriented to any aspect. Substrates include sandstone, granite and metamorphic rocks, and soils range from clay to sandy loam. The cover of bare ground is high in areas that are grazed by domestic livestock. Total vegetation cover may be sparse to moderately dense, depending on site conditions and grazing history. *Artemisia tridentata* ssp. *wyomingensis* dominates the shrub layer, which may also include lesser amounts of *Artemisia cana*, *Chrysothamnus viscidiflorus*, *Sarcobatus vermiculatus*, *Rhus trilobata*, *Opuntia polyacantha*, and *Atriplex canescens*. The understory usually is dominated by *Bouteloua gracilis* together with a combination of *Pascopyrum smithii*, *Pseudoroegneria spicata*, *Hesperostipa comata*, *Koeleria macrantha*, *Poa secunda*, *Pleuraphis jamesii*, *Achnatherum hymenoides*, *Sporobolus cryptandrus*, and *Elymus elymoides*. The introduced grasses *Bromus tectorum* and *Bromus japonicus* are often present. A mix of herbs, including *Artemisia frigida*, *Gutierrezia sarothrae*, *Vulpia octoflora* (= *Festuca octoflora*), *Phlox hoodii*, and *Sphaeralcea coccinea*, contribute little cover. The combination of relatively high cover by sagebrush and dominance of the understory by a grazing increaser such as *Bouteloua gracilis* indicate that this association may represent degraded forms of other Wyoming sagebrush / native grass associations.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. This association may represent a situation in which *Bouteloua gracilis* is dominant in the understory because other grasses have been removed by grazing. Jones (1992) states that some stands of this type may represent degraded forms of *Artemisia tridentata* ssp. *wyomingensis* / *Pascopyrum smithii* or *Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* shrublands.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.4.	Microphyllous evergreen shrubland
Physiognomic subgroup	III.A.4.N.	Natural/Semi natural microphyllous evergreen shrubland
Formation name	III.A.4.N.a.	Lowland microphyllous evergreen shrubland
Alliance name		*Artemisia tridentata* ssp. *wyomingensis* Shrubland Alliance (A.832) Wyoming Big Sagebrush Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.762	Colorado Plateau Mixed Low Sagebrush Shrubland
CES304.777	Inter Mountain Basins Big Sagebrush Shrubland

NatureServe conservation status:

Global rank. G5 (23 Feb 1994).

Distribution:

Globally. *Artemisia tridentata* ssp. *wyomingensis* / *Bouteloua gracilis* Shrubland occurs on five relevés on plateaus, canyon rims, hills and valley sides within Canyon de Chelly National Monument. The relevés for this association were sampled from Middle Mesa, Coyote Wash, and Canyon de Chelly proper.

Canyon de Chelly National Monument. This plant community occurred at lower elevations near disturbed areas such as the dirt roads and terraces along the riparian corridor. At higher elevations it occurred in patches within the wooded plant communities.

Environmental summary:

Globally. This common sagebrush shrubland association occurs on the slopes of ridges and valleys and on plateaus and benches in Wyoming, western Colorado, and southeastern Utah. Elevations range from 2200 to 2430 m (7215-7975 feet). Sites are on gentle to steep slopes and may be oriented to any aspect. Substrates include sandstone, granite, and metamorphic rocks, and soils range from clay to sandy loam. The cover of bare ground is high in areas that are grazed by domestic livestock.

Canyon de Chelly National Monument. This association occurs on sandy loam, silt loam, sandy clay loam, and silt clay loam soils between the elevations of 2000 and 2232 m (6562-7323 feet) (average 2129 m [6985 feet]). The slope ranges from 3-13% (average 6%) at various aspects.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. Total vegetation cover may be sparse to moderately dense, depending on site conditions and grazing history. *Artemisia tridentata* ssp. *wyomingensis* dominates the shrub layer, which may also include lesser amounts of *Artemisia cana*, *Chrysothamnus viscidiflorus*, *Sarcobatus vermiculatus*, *Rhus trilobata*, *Opuntia polyacantha*, and *Atriplex canescens*. The understory usually is dominated by *Bouteloua gracilis* together with a combination of *Pascopyrum smithii*, *Pseudoroegneria spicata*, *Hesperostipa comata*, *Carex filifolia*, *Koeleria macrantha*, *Poa secunda*, *Pleuraphis jamesii*, *Achnatherum hymenoides*, *Sporobolus cryptandrus*, and *Elymus elymoides*. The introduced grasses *Bromus tectorum* and *Bromus japonicus* are often present but generally contribute less cover. A mix of herbs, including *Artemisia frigida*, *Gutierrezia sarothrae*, *Vulpia octoflora* (= *Festuca octoflora*), *Phlox hoodii*, and *Sphaeralcea coccinea*, often are present but generally contribute little cover.

Canyon de Chelly National Monument. Five relevés are classified as *Artemisia tridentata* ssp. *wyomingensis* / *Bouteloua gracilis* Shrubland. The total vegetation cover class for this association ranges from 25-50% to 50-75% (average cover class 45-70%). The tree stratum is lacking or sparse, ranging in cover class between 0% and 5-10% (average cover class 1-3%). The shrub stratum is moderate to dense, ranging in cover class between 10-25% and 50-75% (average cover class 27-50%). The herbaceous stratum is mostly moderate to low, ranging between 5-10% and 25-50% (average cover class 11-24%). The species richness ranges from 16-21 species (average of 17 species). The tree stratum (where present) consists of a main canopy that ranges in cover from trace-1% to 1-5%, a subcanopy that ranges in cover from trace-1% to 1-5%, and a seedling layer that covers trace-1%. The main canopy layer varies between 2-5 m and 5-10 m in height, the subcanopy is 2-5 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Pinus edulis*, ranging between 0% and 5-10% cover (average cover class 1-3%).

The shrub stratum has a tall shrub layer that ranges in height between 0.5-1 m and 2-5 m and a short shrub layer of 1-2 m or 2-5 m. The tall shrub layer covers between 10-25% and 50-75% and is present in all relevés. The short shrub layer is present in only two of the relevés, where it covers 5-10% in each. The shrub stratum is dominated by *Artemisia tridentata*, which ranges in cover from 10-25% to 50-75% (average cover class 24-45%). Two relevés contain *Artemisia nova*, which covers trace-1% and 5-10%, respectively. Two other species

that are common in the shrub layer but consistently cover <5% are *Gutierrezia microcephala* and *Opuntia phaeacantha*. The herbaceous stratum is dominated by *Bouteloua gracilis*, which covers 5-10% to 10-25% (average cover class 8-19%). Two relevés contain *Bromus tectorum*, which has the cover class of 1-5% and 5-10% where present. Other frequently encountered herbaceous species (covering <1%) are *Escobaria vivipara* var. *vivipara*, *Hymenopappus filifolius* var. *lugens*, *Lappula occidentalis*, and *Lesquerella fendleri*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*N/A*	*Pinus edulis*
Tall shrub/sapling	*N/A*	*Artemisia tridentata*
Short shrub/ sapling	*Artemisia tridentata* ssp. *wyomingensis*	*Artemisia nova*
Herbaceous	*Bouteloua gracilis*	*Bouteloua gracilis, Bromus tectorum*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus japonicus, Bromus tectorum	*Bromus tectorum*

Authors:

Global descriptions. J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Bourgeron and Engelking 1994, Driscoll et al. 1984, Fisser 1964, Fisser 1970, Jones 1992, Keammerer 1987, Knight et al. 1987, MTNHP 2002, Nichols 1964a, Nichols 1964b, Smith unpubl. data , Van Pelt 1978.

32. *Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland

NatureServe common name	Wyoming Big Sagebrush / Disturbed Understory Semi-natural Shrubland
NatureServe code	CEGL002083

Summary:

This association has been found in western Colorado and eastern Utah but is likely widespread in other parts of the interior western U.S. It can occur on a variety of landscape positions on sites that are flat to moderately steep. This association has been sampled at elevations between 1455 and 2372 m (4770-7777 feet) but is probably found elsewhere. The unvegetated surface is mostly composed of litter, bare soil, and rocks. Soils are typically eolian, alluvial, colluvial loamy sands to sandy loams. This shrubland association has moderately open to dense vegetation cover with an open to closed short shrub layer. The dominant shrub is *Artemisia tridentata* ssp. *wyomingensis* with low to moderate cover. Scattered (2-5 m tall) *Pinus edulis*, *Juniperus osteosperma* and *Juniperus scopulorum* trees may be present with sparse cover. Other tall, short, and dwarf shrubs that may be found are *Ericameria nauseosa*, *Ephedra viridis*, *Gutierrezia sarothrae*, *Sarcobatus vermiculatus*, and succulents. The herbaceous stratum has low to high cover and diversity, but weedy, exotic and invasive species tend to dominate. Common graminoids include *Achnatherum hymenoides*, *Aristida purpurea*, *Bromus tectorum*, *Vulpia octoflora*, *Elymus elymoides*, *Hesperostipa comata*, *Poa fendleriana*, and *Pleuraphis jamesii*. Forbs provide sparse to high cover and include *Astragalus nuttallianus*, *Descurainia pinnata*, *Chenopodium album*, *Erodium cicutarium*, *Lappula occidentalis*, *Lepidium* sp., and *Phacelia crenulata*.

Classification confidence: 2 - Moderate**.**

Classification comments:

Globally. This association is closely related to *Artemisia tridentata* - (*Ericameria nauseosa*) / *Bromus tectorum* Semi-natural Shrubland (CEGL002699), and there may be overlap between the two. Clear criteria need to be developed to distinguish these associations from one another.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.4.	Microphyllous evergreen shrubland
Physiognomic subgroup	III.A.4.N.	Natural/Semi natural microphyllous evergreen shrubland
Formation name	III.A.4.N.a.	Lowland microphyllous evergreen shrubland
Alliance name		*Artemisia tridentata* ssp. wyomingensis Shrubland Alliance (A.832) Wyoming Big Sagebrush Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.777	Inter Mountain Basins Big Sagebrush Shrubland

NatureServe conservation status:

Global rank. GNA (invasive) (14 Dec 2004).

Distribution:

Globally. This association has been observed in western Colorado and eastern Utah. It is very

likely to occur in other parts of the western U.S.

Canyon de Chelly National Monument. *Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi natural Shrubland occurs on five relevés on hills, terraces and valley sides within Canyon de Chelly National Monument. The relevés for this association were sampled from Monument Canyon, Canyon del Muerto, Coyote Wash, and from northeast of Black Rock Butte.

Environmental summary:

Globally. This association has been found on a variety of landscape features, including mesatops, midslopes and low slopes of canyons, hills, and valleys, and on terraces. Sites can be flat to moderately steep (0-15 degrees) and have any aspect. Sampled sites have had elevations between 1455 and 2372 m (4770-7777 feet). The unvegetated surface can be composed of variable amounts of litter, bare soil, and large or small rocks. Soils are typically eolian, alluvial, or colluvial loamy sands to sandy loams.

Canyon de Chelly National Monument. This association occurs on sandy loam, silt loam, sandy clay loam, silt clay loam, and silt clay soils between the elevations of 2050 and 2201 m (6726-7221 feet) (average 2130 m [6988 feet]). The slope ranges from 3-8% (average 4%) at various aspects. Evidence of heavy grazing and erosion is present in some relevés.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This shrubland association has moderately open to dense vegetation cover (28-89%) with an open to closed short shrub layer. The dominant shrub, *Artemisia tridentata* ssp. *wyomingensis*, typically has 5-45% cover, though some stands may have more or less. Scattered (2-5 m tall) *Pinus edulis*, *Juniperus osteosperma* and *Juniperus scopulorum* trees may provide up to 5-10% cover. In addition to *Artemisia tridentata* ssp. *wyomingensis*, other tall, short, and dwarf shrubs that may be found are *Ericameria nauseosa*, *Ephedra viridis*, *Gutierrezia sarothrae*, *Sarcobatus vermiculatus*, and succulents. The herbaceous stratum has low to high cover and diversity and tends to be dominated by weedy and exotic species. Common graminoids include *Achnatherum hymenoides*, *Aristida purpurea*, *Bromus tectorum*, *Vulpia octoflora*, *Elymus elymoides*, *Hesperostipa comata*, *Poa fendleriana*, and *Pleuraphis jamesii*. Forbs provide sparse to high cover and include *Astragalus nuttallianus*, *Chenopodium album*, *Descurainia pinnata*, *Erodium cicutarium*, *Lappula occidentalis*, *Lepidium* sp., and *Phacelia crenulata*.

Canyon de Chelly National Monument. Five relevés are classified as *Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi natural Shrubland. The total vegetation cover class for this association ranges from 25-50% to 75-100% (average cover class 45-70%). The tree stratum is lacking or sparse, having a cover class of 1-5% where present. The shrub stratum is moderate to dense, ranging in cover class between 10-25% and 50-75% (average cover class 24-45%). The herbaceous stratum is mostly moderate to low, ranging between 5-10% and 25-50% (average cover class 8-19%). The species richness ranges from 10-22 species (average of 16 species). The tree stratum (where present) consists of a main canopy that covers 1-5%, a subcanopy that covers trace-1%, and a seedling layer that covers trace-1%. The main canopy layer is 5-10 m in height, the subcanopy is 2-5 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Pinus edulis*, ranging between 0% and 1-5% cover (average cover class 0-2%).

The shrub stratum has a tall shrub layer that ranges in height between 1-2 m and 2-5 m and a short shrub layer of 0.5-1 m to 1-2 m. The tall shrub layer covers between 5-10% and 25-50%, (average cover class 15-32%). The short shrub layer covers between 1-5% and 10-25% (average cover class 7-18%) The shrub stratum is dominated by *Artemisia tridentata*, which ranges in cover from 10-25% to 50-75% (average cover class 21-40%). One relevé also contains 10-25% cover of *Artemisia nova*. *Gutierrezia microcephala* is present in all but one relevé and ranges in cover from 0% to 10-25% (average cover class 4-12%). Three relevés contain *Opuntia phaeacantha*, one of which has a notable cover class of 5-10% for

this species. The herbaceous stratum is dominated by *Bromus tectorum*, which only covers trace-1% or 1-5%, but is present in every relevé. Other frequently encountered herbaceous species are *Achnatherum hymenoides*, *Elymus elymoides*, and *Erodium cicutarium*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tall shrub/sapling	*N/A*	*Artemisia tridentata*
Short shrub/ sapling	*Artemisia tridentata* ssp. *wyomingensis*	*Artemisia nova, Opuntia phaeacantha*
Herbaceous	*N/A*	*Gutierrezia microcephala*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. J. Drake, mod. J. Coles and K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

33. *Atriplex confertifolia / Pleuraphis jamesii* Shrubland

NatureServe common name	Shadscale / James' Galleta Shrubland
NatureServe code	CEGL001304

Summary:

This widespread western shrubland association is reported from the southwestern Great Plains, Colorado Plateau, Great Basin, and Mojave Desert mountains. It occurs in a variety of habitats and can be found on two distinct substrates: coarse textured, non saline soils derived from sandstone or gravel or deep, fine textured, alkaline, often saline soils derived from shale. Stands with coarse textured soils tend to be on slopes, while those with fine textured soils tend to be on low, relatively flat positions in the landscape (valley bottoms, basins, etc.). The common trait of these different substrates is that they are very dry either because of low precipitation or because of high internal plant moisture stress from soil salinity. The unvegetated surface is composed largely of bare soil, gravel, and large or small rocks. This association is characterized by a sparse to open canopy (1-25% cover) of short shrubs dominated by *Atriplex confertifolia* with a sparse to moderate graminoid layer dominated by *Pleuraphis jamesii*. Associated shrubs include *Artemisia bigelovii*, *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, *Ephedra torreyana*, *Ericameria nauseosa*, *Grayia spinosa*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia polyacantha*, *Picrothamnus desertorum*, and *Suaeda moquinii* (= *Suaeda fruticosa*), depending on substrate, or *Amphipappus fremontii*, *Ambrosia dumosa*, and *Lycium pallidum* in the Mojave Desert. If other *Atriplex* species are present, they do not dominate the canopy. Other graminoids include *Achnatherum hymenoides*, *Sporobolus cryptandrus*, and *Elymus elymoides* on sandy sites and *Bouteloua gracilis* and *Sporobolus airoides* on fine textured soil. Forbs generally have low cover and may include *Sphaeralcea grossulariifolia*, *Eriogonum inflatum*, and species of *Chaenactis*, *Lappula*, *Phacelia*, *Plantago*, and *Chenopodium*. Introduced species such as *Bromus tectorum* and *Salsola kali* are common on some sites.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. This widespread shrubland association is only defined by the codominance of *Atriplex confertifolia* and *Pleuraphis jamesii*. Stands are found in different regions (from southwestern Great Plains to Great Basin), in different environments (clay bottomlands, dunes, desert mountains) and with different associated species. This association will likely need to be subdivided as more classification information becomes available. Stands of this association with a sparse herbaceous layer are similar to *Atriplex confertifolia* Great Basin Shrubland (CEGL001294).

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.5.	Extremely xeromorphic evergreen shrubland
Physiognomic subgroup	III.A.5.N.	Natural/Semi natural extremely xeromorphic evergreen shrubland
Formation name	III.A.5.N.b.	Facultatively deciduous extremely xeromorphic subdesert shrubland
Alliance name		*Atriplex confertifolia* Shrubland Alliance (A.870) Shadscale Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.784	Inter Mountain Basins Mixed Salt Desert Scrub

NatureServe conservation status:

Global rank. G3G5 (23 Feb 1994).

Distribution:

Globally. This shrubland association is reported from the southwestern Great Plains, Colorado Plateau, Great Basin, and Mojave Desert mountains.

Canyon de Chelly National Monument. *Atriplex confertifolia* / *Pleuraphis jamesii* Shrubland was only sampled from two relevé locations within Canyon de Chelly National Monument. One is located south of the Canyon de Chelly campground, and the other is found southeast of the sand dunes that lay between Black Rock and the Tiis Ndiitsooi drainage.

Environmental summary:

Globally. This widespread association occurs in a variety of habitats and is found on two distinct substrates: coarse textured (rocky or sandy), non saline soils derived from sandstone or gravel, or deep fine textured, poorly drained, alkaline, often saline soils derived from shale or shale derived alluvium. Sites with coarse textured soils include gravel and cobble outcrops, mesa escarpments, mountain and hillslopes, ridges, and along toeslopes of river bluffs. Fine textured soil sites include alluvial flats, floodplains and basins. Stands with coarse textured soils can be on flat to moderately steep slopes, while stands with fine textured soils are typically on flat to gently sloping sites. The common trait of these different substrates is that they are very dry either because of low precipitation (15-23 cm annually) or because of high internal plant moisture stress from soil salinity. The unvegetated surface is composed largely of bare soil, gravel, and large or small rocks. Cryptogamic crusts and mosses are important in some stands.

Canyon de Chelly National Monument. This association occurs on sandy loam soils at the elevations of 1692 and 1744 m (5551 and 5722 feet). One relevé is found on a flat mesatop, and the other occurs on a colluvial slope with an incline of 21% at a southeastern aspect. Fine particulates and gravel each cover 25-50% of both relevés and one relevé has 10-25% cover of cobble.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by a sparse to open canopy (1-25% cover) of short shrubs dominated by *Atriplex confertifolia* with a sparse to moderate graminoid layer dominated by *Pleuraphis jamesii*. Some stands can be even more sparsely vegetated, and total vegetation cover is widely variable (1-70% in sampled stands). Associated shrubs include *Artemisia bigelovii*, *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, *Ephedra torreyana*, *Ericameria nauseosa*, *Grayia spinosa*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Opuntia polyacantha*, *Picrothamnus desertorum*, and *Suaeda moquinii* (= *Suaeda fruticosa*), depending on substrate, or *Amphipappus fremontii*, *Ambrosia dumosa*, and *Lycium pallidum* in the Mojave Desert. If other *Atriplex* species are present, they do not dominate the canopy. Other graminoids include *Achnatherum hymenoides*, *Sporobolus cryptandrus*, and *Elymus elymoides* on sandy sites and *Bouteloua gracilis* and *Sporobolus airoides* on fine textured soil. Forbs generally have low cover and may include *Calochortus nuttallii*, *Eriogonum inflatum*, *Lappula occidentalis*, *Plantago patagonica*, *Platyschkuhria integrifolia*, *Sphaeralcea coccinea*, *Sphaeralcea grossulariifolia*, and species of *Chaenactis*, *Phacelia*, and *Chenopodium*. Introduced species such as *Bromus tectorum* and *Salsola kali* are common on some sites.

Canyon de Chelly National Monument. Two relevés are classified as *Atriplex confertifolia* / *Pleuraphis jamesii* Shrubland. The total vegetation cover class for this association is moderate (10-25% and 25-50%). There is no tree stratum in either relevé. The shrub stratum covers 10-25% of both relevés, and the herbaceous stratum covers 10-25% of one relevé and 1-5% of the other. The species richness is 16 and 17 species, respectively. The shrub stratum has only one distinct layer that is 0.5-1 m tall and is dominated by *Atriplex confertifolia*, which has a cover class of 5-10% in both relevés. One relevé also contains 5-10% cover of *Artemisia bigelovii*. The herbaceous stratum is generally dominated by *Pleuraphis jamesii*, which has the cover class of 1-5% and 5-10%. *Bromus tectorum* is dominant in one relevé where it has the cover class of 10-25%, yet has only trace-1% occurrence in the other relevé. Other common species in the herbaceous stratum are *Achnatherum hymenoides*, *Chaetopappa ericoides*, and *Salsola kali*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Short shrub/ sapling	*Atriplex confertifolia, Gutierrezia sarothrae*	*Atriplex confertifolia, Artemisia bigelovii*
Herbaceous	*Pleuraphis jamesii*	*Pleuraphis jamesii, Bromus tectorum*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum	*Bromus tectorum, Salsola kali*

Authors:

Global descriptions. K.A. Schulz, mod. J. Drake and J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Annable 1985, Bourgeron and Engelking 1994, Branson and Owen 1970, Branson et al. 1976, CONHP unpubl. data 2003, Campbell 1977, Dastrup 1963, Driscoll et al. 1984, Graham 1937, Harper and Jaynes 1986, Ibrahim et al. 1972, Lusby et al. 1963, NVNHP 2003, Potter et al. 1985, Singh and West 1971, Soil Conservation Service 1978, Tuhy and MacMahon 1988, U.S. Bureau of Reclamation 1976, Von Loh 2000, Welsh 1957, West and Ibrahim 1968.

34. *Ericameria nauseosa / Bromus tectorum* Semi-natural Shrubland

NatureServe common name	Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland
NatureServe code	CEGL002937

Summary:

This shrubland association occurs in disturbed situations at moderate altitudes in the Colorado Plateau. It has been documented from sites in northwestern Colorado and southern and eastern Utah. Most stands are the result of fire burning sagebrush or other types of shrublands, but some derive from other forms of disturbance, including grazing. Elevations range from 1220 to 2085 m (4000-6840 feet), and sites occur on gentle to steep slopes. Soils are variable, but most stands occur on well drained sandy loams that are often rocky. Total vegetation cover is relatively sparse to moderately dense, depending primarily on the density of cheatgrass in any given year. The shrub canopy is open, consisting of *Ericameria nauseosa* with up to 40% cover. Scattered individuals of other shrub species such as *Artemisia tridentata*, *Rhus trilobata*, *Atriplex canescens*, and *Atriplex confertifolia* may be present. Although the herbaceous layer contains many species, *Bromus tectorum* overwhelmingly dominates. Relict native herbaceous grasses include *Elymus elymoides*, *Achnatherum hymenoides*, *Poa fendleriana*, and *Sporobolus cryptandrus*. Native herbaceous species are also common but contribute only sparse cover and may include *Cleome lutea*, *Eriogonum inflatum*, and *Heterotheca villosa*. Weedy forbs are more abundant in most stands, including *Descurainia pinnata*, *Lappula occidentalis*, and *Salsola tragus*.

Classification confidence: 2 - Moderate**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.4.	Microphyllous evergreen shrubland
Physiognomic subgroup	III.A.4.N.	Natural/Semi natural microphyllous evergreen shrubland
Formation name	III.A.4.N.a.	Lowland microphyllous evergreen shrubland
Alliance name		*Ericameria nauseosa* Shrubland Alliance (A.835) Rubber Rabbitbrush Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.821	Rocky Mountain Lower Montane Foothill Riparian Woodland and Shrubland
CES304.788	Inter Mountain Basins Semi Desert Shrub Steppe
CES304.781	Inter Mountain Basins Wash

NatureServe conservation status:

Global rank. GNA (ruderal) (14 Aug 2001).

Distribution:

Globally. This association has currently only been described from northwestern Colorado and southern and eastern Utah but is likely more widespread throughout the western U.S. in disturbed areas. It is also reported from northeastern Arizona.

Canyon de Chelly National Monument. *Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland was only sampled from two relevé locations within Canyon de Chelly National Monument. Both are non riparian wash areas in the canyon bottom of Canyon del Muerto.

Environmental summary:

Globally. This shrubland association occurs in disturbed situations at moderate altitudes in the Colorado Plateau. It has been documented from sites in northwestern Colorado and southern and eastern Utah. Elevations range from 1220 to 2085 m (4000-6840 feet), and sites occur on gentle to steep slopes that may be oriented to any aspect. Soils are variable, but most stands occur on sandy loams that are well drained and often rocky.

Canyon de Chelly National Monument. This association occurs on loam and clay loam soils at the elevations of 1900 and 1997 m (6234 and 6552 feet). Both relevés are found on riverine floodplains that experience seasonal or intermittent flooding. The slope of these relevés is generally flat.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. Total vegetation cover is relatively sparse to moderately dense, depending primarily on the density of cheatgrass in any given year. The shrub canopy is open, consisting of *Ericameria nauseosa* with up to 40% cover. Scattered individuals of other shrub species such as *Artemisia tridentata*, *Rhus trilobata*, *Atriplex canescens*, and *Atriplex confertifolia* may be present. The herbaceous layer contains many species but is overwhelmingly dominated by *Bromus tectorum*. Relict native herbaceous grasses include *Elymus elymoides*, *Achnatherum hymenoides*, *Poa fendleriana*, and *Sporobolus cryptandrus*. Native herbaceous species are also common but contribute only sparse cover and may include *Cleome lutea*, *Eriogonum inflatum*, and *Heterotheca villosa*. Weedy forbs are more abundant in most stands, including *Descurainia pinnata*, *Lappula occidentalis*, and *Salsola tragus*.

Canyon de Chelly National Monument. Two relevés are classified as *Ericameria nauseosa* / *Bromus tectorum* Semi natural Shrubland. The total vegetation cover class for this association is high (50-75% and 75-100%). The tree stratum is sparse, covering 5-10% in one relevé and 1-5% in the other. The shrub stratum is variable, having 5-10% cover in one relevé and 10-25% cover in the other. The herbaceous stratum is moderately dense, with 25-50% cover in both relevés. The species richness is high, with 28 and 39 species, respectively. The tree stratum is variable, with one relevé having 5-10% cover of *Elaeagnus angustifolia* and the other containing trace-1% amounts of *Juniperus osteosperma* (dbh of 14.4 cm), *Juniperus scopulorum* (drc of 7.6 cm and 13.5 cm), *Pinus edulis* (seedlings), and *Pseudotsuga menziesii* (dbh of 9.9 cm). The main canopy layer is 10-20 m in height, the subcanopy is 5-10 m, and seedling layer is 0.5-1 m tall. There is no emergent layer in either relevé, and the relevé containing *Elaeagnus angustifolia* also lacks the subcanopy and seedling layers.

The shrub stratum has two distinct layers. The tall shrub layer is 2-5 m in height, and the short shrub layer is 1-2 m tall. The dominant shrub is *Ericameria nauseosa*, which covers 1-5% of one relevé and 5-10% of the other. Both relevés also have 1-5% cover of *Rosa woodsii*. Occasionally the shrub stratum contains *Artemisia tridentata*, *Opuntia phaeacantha*, and *Rhus trilobata*. The herbaceous stratum is dominated by *Bromus tectorum*, which covers 10-25% of one relevé and 1-5% of the other. One relevé also has *Cirsium vulgare* and *Cynodon dactylon*, each with a 5-10% cover class. The herbaceous stratum has a diversity of other species, with the most common being *Heterotheca villosa*, *Muhlenbergia asperifolia*, *Poa compressa*, *Poa fendleriana*, and *Rumex crispus*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Short shrub/ sapling	*Ericameria nauseosa*	*Ericameria nauseosa*
Herbaceous	*Bromus tectorum*	*Cirsium vulgare, Bromus tectorum, Cynodon dactylon, Elaeagnus angustifolia*

Other noteworthy species:

Global species	Canyon de Chelly species
Descurainia pinnata, Lepidium latifolium, Salsola kali ssp. *tragus, Sonchus asper, Tamarix chinensis, Tragopogon dubius, Yucca elata* var. *utahensis*	*Data are not available.*

Authors:

Global descriptions. J. Coles.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Cogan et al. 2004.

35. *Fendlera rupicola* Talus Shrubland

NatureServe common name	Fendlerbush Talus Shrubland
NatureServe code	CEGL002765

Summary:

This tall shrub association occurs in patches on cool colluvial slopes in Colorado Plateau canyons. Slopes are moderate to very steep and are often oriented to the north or east. Elevations range from 1268 to 1638 m (4160-5375 feet). The high cover of rock on the ground surface concentrates runoff and acts as mulch to slow evaporation from the soil. Thus, relatively mesic species are able to persist on otherwise dry sites. Soils are sandy, skeletal, and derived from sandstones over shale. Stands commonly occur where Wingate sandstone colluvium has fallen onto Chinle shale slopes in canyons. Total vegetation cover ranges from 7 to 35% and is characterized by an open tall shrub canopy of *Fendlera rupicola* that provides 1 to 12% cover. *Juniperus osteosperma* is usually present as scattered seedlings and saplings. Associated shrubs vary from site to site, depending on the underlying substrate, and may include *Atriplex* spp., *Chrysothamnus viscidiflorus*, *Ephedra* spp., *Ericameria nauseosa*, *Cercocarpus montanus*, *Fraxinus anomala*, *Rhus trilobata*, and several species of *Opuntia*. The herbaceous layer is sparse in cover and may include *Leymus salinus*, *Pleuraphis jamesii*, *Achnatherum hymenoides*, and *Hesperostipa comata*. Forbs provide sparse cover with no one species providing more than 1% cover. Cryptogam cover is also restricted, rarely covering more than 5% of the ground surface.

Classification confidence: 2 - Moderate**.**

Classification comments:

Globally. *Fendlera rupicola* is an element, and sometimes codominant, of several shrub communities described from colluvial slopes, including *Amelanchier utahensis* Shrubland (CEGL001067). There is a great deal of uncertainty in the classification of these rocky slope shrublands in general, and assignments and concepts should be continually reviewed as new data become available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.2.	Temperate broad leaved evergreen shrubland
Physiognomic subgroup	III.A.2.N.	Natural/Semi natural temperate broad leaved evergreen shrubland
Formation name	III.A.2.N.c.	Sclerophyllous temperate broad leaved evergreen shrubland
Alliance name		*Fendlera rupicola* Shrubland Alliance (A.2656) Fendlerbush Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.765	Colorado Plateau Mixed Bedrock Canyon and Tableland

NatureServe conservation status:

Global rank. GNR (12 Apr 2005).

Distribution:

Globally. This association occurs on rocky canyon slopes in at least two areas of the northern

Colorado Plateau of Colorado and Utah. It may also occur in northeastern Arizona.

Canyon de Chelly National Monument. *Fendlera rupicola* Talus Shrubland was only sampled from two relevé locations within Canyon de Chelly National Monument. One is located in Black Rock Canyon, and the other is found in Canyon de Chelly proper near the confluence with Wild Cherry Canyon.

Environmental summary:

Globally. This tall shrub association occurs in patches on cool colluvial slopes in Colorado Plateau canyons. Slopes are moderate to very steep and are often oriented to the north or east. Elevations range from 1268 to 1638 m (4160-5375 feet). Rocks and litter cover most of the unvegetated ground surface. The high cover of rock on the ground surface concentrates runoff and acts as mulch to slow evaporation from the soil. Thus, relatively mesic species are able to persist on otherwise dry sites. Soils are sandy, skeletal, and derived from sandstones over shale. Stands commonly occur where Wingate sandstone colluvium has fallen onto Chinle shale slopes in canyons. The combination of sandy rock and soils overlying a substrate that is usually marine shale allows for both mesic and saline desert species to co-exist.

Canyon de Chelly National Monument. This association occurs on sandy loam soils at the elevations of 1810 and 1860 m (5938 and 6102 feet). One relevé is found on a canyon wall and has a slope of 23%, and the other occurs on a scree slope at an incline of 35%. Both relevés have a generally northeastern aspect and occur at the base of tall cliffs. Both relevés have 5-10% cover class for each of cobble, stones and boulders. One of the relevés also has 10-25% cover class for fine particles and gravel, plus 1-5% cover class for bedrock.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This shrubland association is rare, occurring in small stands on colluvial canyon slopes. The total vegetation cover ranges from 7 to 35% and is characterized by an open tall shrub canopy up to 3 m tall of *Fendlera rupicola* that provides 1 to 12% cover. *Juniperus osteosperma* is usually present as scattered seedlings and saplings. Associated shrubs vary from site to site, depending on the underlying substrate, and may include *Atriplex confertifolia*, *Atriplex canescens*, *Chrysothamnus viscidiflorus*, *Ephedra torreyana*, *Ephedra viridis*, *Ericameria nauseosa*, *Cercocarpus montanus*, *Fraxinus anomala*, *Rhus trilobata*, and several species of *Opuntia*. The herbaceous layer is moderate in terms of species composition but provides sparse cover. Common graminoids include *Leymus salinus*, *Pleuraphis jamesii*, *Achnatherum hymenoides*, and *Hesperostipa comata*. Forbs provide sparse cover with no one species providing more than 1% cover. Cryptogam cover is also restricted, rarely covering more than 5% of the ground surface.

Canyon de Chelly National Monument. Two relevés are classified as *Fendlera rupicola* Talus Shrubland. The total vegetation cover class for this association is 25-50% in one relevé and 50-75% in the other. The tree stratum is sparse, covering 1-5% in both relevés. The shrub stratum is variable, with the cover classes of 5-10% and 25-50%, and the herbaceous stratum covers 5-10% in one relevé and 10-25% in the other. The species richness is 17 and 24 species, respectively. The tree stratum is codominated by *Juniperus osteosperma* and *Pinus edulis*, each with trace-1% or 1-5% cover class. One *Pinus edulis* tree was measured for dbh at 11.3 cm. The tree stratum is composed of a main canopy layer that covers 1-5% of both relevés and a seedling layer of trace-1%. The canopy layer is 5-10 m in height, and seedling layer is 0.5-1 m tall. The shrub stratum has two distinct layers. The tall shrub layer is 5-10 m in height, and the short shrub layer is 2-5 m tall in one relevé and 1-2 m tall in the other. The tall shrub layer is the main layer and has the cover classes of 10-25% and 5-10%, and the short shrub layer covers trace-1% and 1-5%. The shrub stratum is dominated by *Fendlera rupicola*, which has a cover class of 5-10% in both relevés. Also present in the shrub stratum are *Amelanchier utahensis*, *Artemisia tridentata*, *Chrysothamnus greenei*, *Ephedra viridis*, and *Yucca angustissima*. The herbaceous stratum is dominated by *Poa fendleriana*, which has the cover classes of 1-5% and 5-10%, and by *Bromus tectorum*,

which covers 5-10% of one relevé. Other frequently encountered herbaceous species are *Artemisia ludoviciana* and *Stephanomeria minor* var. *minor*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tall shrub/sapling	*Fendlera rupicola*	*Fendlera rupicola*
Short shrub/ sapling	*Ericameria nauseosa*	*N/A*
Herbaceous	*Bromus tectorum*	*Bromus tectorum, Poa fendleriana*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum	*Bromus tectorum*

Authors:

Global descriptions. J. Coles, mod. K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

36. *Opuntia (fragilis, polyacantha, phaeacantha)* Shrubland

NatureServe common name	(Brittle Prickly pear, Panhandle Prickly pear, Tulip Prickly pear) Shrubland
NatureServe code	CEGL004009

Summary:

This succulent dominated dwarf shrubland is known only from Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau. It occurs in canyons on terraces and alluvial fans at the base of cliffs from 1755 to 1787 m (5758-5863 feet) elevation. Stands occur on gentle slopes (1-11%) with generally hot, south facing aspects. One stand is seasonally flooded. The soils are sandy loam in texture. There is moderate to high cover of bare ground. The vegetation is characterized by an open to moderately dense succulent dwarf shrub layer dominated by *Opuntia* species. *Opuntia phaeacantha*, *Opuntia polyacantha*, or *Opuntia whipplei* may dominate solely or in combination with the others. Other shrubs may be present, including *Artemisia filifolia*, *Artemisia tridentata*, and *Gutierrezia sarothrae*. The sparse to moderately dense herbaceous layer has a diversity of species. Common herbaceous species are *Astragalus lentiginosus*, *Bouteloua gracilis*, *Chaetopappa ericoides*, *Conyza canadensis*, *Croton texensis*, *Hesperostipa comata* ssp. *comata*, *Heterotheca villosa*, *Lappula occidentalis*, *Solanum elaeagnifolium*, and *Sphaeralcea fendleri*. The native annual forb *Plantago patagonica* may dominate after good spring precipitation. The annual exotic grass *Bromus tectorum* is generally abundant with 1-5% cover. Other exotic species include *Cynodon dactylon*, *Erodium cicutarium*, and *Salsola kali*.

Classification confidence: 2 - Moderate.

Classification comments:

Globally. One stand at Canyon de Chelly National Monument has an open tree layer 5 10 m in height, dominated by *Celtis laevigata* var. *reticulata*, which covers 10-25%, and with one dbh measurement at 44.2 cm. A "subcanopy" 2-5 m tall with <5% cover is dominated by *Juniperus osteosperma* and <1% cover of *Pinus edulis*. This stand (CACH 136) may be better classified as open canopy *Celtis laevigata* var. *reticulata* woodland.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A.	Evergreen shrubland
Physiognomic group	III.A.5.	Extremely xeromorphic evergreen shrubland
Physiognomic subgroup	III.A.5.N.	Natural/Semi natural extremely xeromorphic evergreen shrubland
Formation name	III.A.5.N.c.	Succulent extremely xeromorphic evergreen shrubland
Alliance name		*Opuntia* spp. Shrubland Alliance (A.2650) Prickly pear species Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.788	Inter Mountain Basins Semi Desert Shrub Steppe

NatureServe conservation status:

Global rank. GNR (20 Jul 2006).

Distribution:

Globally. This dwarf shrubland is known only from Canyon de Chelly National Monument in

northeastern Arizona in the southern Colorado Plateau.

Canyon de Chelly National Monument. *Opuntia* (*fragilis*, *polyacantha*, *phaeacantha*) Dwarf shrubland occurs on four relevés on terraces, canyons and toe-slopes within Canyon de Chelly National Monument. The relevés for this association were sampled from various locations in Canyon de Chelly proper, including Cave Ruins, Sliding Rock Ruins, and north of Spider Rock Lookout.

Environmental summary:

Globally. This succulent dominated dwarf shrubland is known only from Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau. It occurs in canyons on terraces and alluvial fans at the base of cliffs from 1755 to 1787 m (5758-5863 feet) elevation. Stands occur on gentle slopes (1-11%) with generally hot, south facing aspects. One stand is seasonally flooded. The soils are sandy loam in texture. There is moderate to high cover of bare ground.

Canyon de Chelly National Monument. This association occurs on sandy loam soils between the elevations of 1755 and 1787 m (5758-5863 feet) (average 1765 m [5791 feet]). The slope ranges from 1-11% (average 7%) at generally south facing aspects. Three of the relevés occur at cliff bases, and the fourth occurs on a seasonally flooded alluvial fan and contains buried Anasazi ruins. There is a moderately high coverage of fine particles that ranges from 5-10% to 50-75% (average cover class 26-46%), and a litter layer that varies between 5-10% and 25-50% (average cover class 13-28%).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation is characterized by an open to moderately dense succulent dwarf shrub layer dominated by *Opuntia* species. *Opuntia phaeacantha*, *Opuntia polyacantha*, or *Opuntia whipplei* may dominate solely or in combination with the others. Other shrubs may be present, including *Artemisia filifolia*, *Artemisia tridentata*, and *Gutierrezia sarothrae*. The sparse to moderately dense herbaceous layer has a diversity of species. Common herbaceous species are *Astragalus lentiginosus*, *Bouteloua gracilis*, *Chaetopappa ericoides*, *Conyza canadensis*, *Croton texensis*, *Hesperostipa comata* ssp. *comata*, *Heterotheca villosa*, *Lappula occidentalis*, *Solanum elaeagnifolium*, and *Sphaeralcea fendleri*. The native annual forb *Plantago patagonica* may dominate after good spring precipitation. The annual exotic grass *Bromus tectorum* is generally abundant with 1-5% cover. Other exotic species include *Cynodon dactylon*, *Erodium cicutarium*, and *Salsola kali.*

Canyon de Chelly National Monument. Four relevés are classified as *Opuntia* (*fragilis*, *polyacantha*, *phaeacantha*) Dwarf shrubland. The total vegetation cover class for this association ranges from 25-50% to 50-75% (average cover class 44-69%). The tree stratum is lacking in all but one of the relevés, where the tree stratum covers 10-25%. The shrub stratum has moderate cover, ranging between 10-25% and 25-50% (average cover class 21-44%). The herbaceous stratum is mostly moderate to low, ranging between 1-5% and 25-50% (average cover class 9-19%). The species richness ranges from 14-21 species (average of 17 species). The tree stratum (in the one relevé where it is present) consists of a main canopy that covers 10-25%, a subcanopy that covers 1-5%, and a seedling layer that covers trace-1%. The main canopy layer is 5-10 m in height, the subcanopy is 2-5 m, and the seedling layer is 0.5-1 m tall. The tree stratum is dominated by *Celtis laevigata* var. *reticulata* (= *Celtis reticulata*), which covers 10-25%, and with one dbh measurement at 44.2 cm. The subcanopy is dominated by 1-5% cover of *Juniperus osteosperma* and trace-1% cover of *Pinus edulis*.

The shrub stratum has only one distinct layer that is 0.05-1 m tall with the exception of one relevé where *Opuntia whipplei* covers 1-5% and forms a tall shrub layer of 2-5 m. The shrub stratum is dominated by *Opuntia phaeacantha*, which has 25-50% cover in two of the relevés, and by *Opuntia polyacantha*, which covers 25-50% in the remaining two relevés.

Opuntia whipplei is also present in three out of the four relevés but has a cover class <1%, except as mentioned above. The herbaceous stratum has a diversity of species. *Plantago patagonica* is dominant in one relevé, where it has a cover class of 5-10%, and *Bromus tectorum* is generally abundant with 1-5% cover in three out of the four relevés. Other common herbaceous species are *Astragalus lentiginosus*, *Bouteloua gracilis*, *Chaetopappa ericoides*, *Conyza canadensis*, *Croton texensis*, *Cynodon dactylon*, *Erodium cicutarium*, *Hesperostipa comata* ssp. *comata*, *Heterotheca villosa*, *Lappula occidentalis*, *Salsola kali*, *Solanum elaeagnifolium*, and *Sphaeralcea fendleri*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree	*N/A*	*Celtis laevigata* var. *reticulata*
Short shrub/ sapling	*Opuntia phaeacantha, Opuntia polyacantha*	*Opuntia phaeacantha, Opuntia polyacantha*
Herbaceous	*N/A*	*Plantago patagonica*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum, Conyza canadensis, Cynodon dactylon, Erodium cicutarium, Salsola kali	*Bromus tectorum, Conyza canadensis, Cynodon dactylon, Erodium cicutarium, Salsola kali*

Authors:

Global descriptions. K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

37. *Quercus gambelii / Fendlera rupicola* Shrubland [Provisional]

NatureServe common name	Gambel Oak / Fendlerbush Shrubland
NatureServe code	CEGL004010

Summary:

This tall shrubland is known from a single plot at Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau. It occurs in a west facing canyon bottom at 1631 m (5351 feet) elevation on a gentle slope (10%) at the base of a cliff. The soil is a sandy loam and there is high cover of litter on the ground surface. The vegetation is characterized by a moderately dense (50-75% cover), tall shrub (>10 m) canopy dominated by *Quercus gambelii* with *Fendlera rupicola* dominant in the moderate shrub layer (25-50% cover). The total vegetation cover class for this stand is 75-100%. Other shrubs (all with <1% cover) are *Ericameria nauseosa*, *Morus alba*, *Opuntia erinacea*, and *Yucca baccata*. The vine *Vitis arizonica* is abundant. The herbaceous stratum has a high diversity of species, each having <1% cover, except for *Thalictrum fendleri*, which has a cover class of 1-5%. Other herbaceous species include *Achillea millefolium*, *Arabis fendleri*, *Arenaria lanuginosa* ssp. *saxosa*, *Artemisia ludoviciana*, *Erigeron divergens*, *Heterotheca villosa*, *Hymenoxys richardsonii*, *Monarda fistulosa* var. *menthifolia*, *Penstemon barbatus*, and *Poa fendleriana*. Exotic species such as *Taraxacum officinale* and *Bromus tectorum* may be present.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. The diagnostic species both occur at Mesa Verde National Park; perhaps this association occurs there. More survey is needed to clarify the concept and extent of this provisional association.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.B.	Deciduous shrubland
Physiognomic group	III.B.2.	Cold deciduous shrubland
Physiognomic subgroup	III.B.2.N.	Natural/Semi natural cold deciduous shrubland
Formation name	III.B.2.N.a.	Temperate cold deciduous shrubland
Alliance name		*Quercus gambelii* Shrubland Alliance (A.920) Gambel Oak Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.818	Rocky Mountain Gambel Oak Mixed Montane Shrubland

NatureServe conservation status:

Global rank. GNR (20 Jul 2006).

Distribution:

Globally. This tall shrubland is known from a single plot at Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau. More survey work is needed in this region to assess its full extent.

Canyon de Chelly National Monument. *Quercus gambelii* / *Fendlera rupicola* Shrubland was only sampled from one relevé location in the bottom of Bat Canyon within Canyon de Chelly National Monument.

Environmental summary:

Globally. This tall shrubland is known from a single plot at Canyon de Chelly National Monument in northeastern Arizona in the southern Colorado Plateau. It occurs in a west facing canyon bottom at 1631 m (5351 feet) elevation on a gentle slope (10%) at the base of a cliff. The soil is a sandy loam and there is high cover of litter on the ground surface.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 1631 m (5351 feet). The relevé occurs on a west facing canyon bottom with an incline of 10% and is located at the base of a cliff. There is a dense litter layer (75-100% cover class).

USFWS wetland system: Not applicable.

Vegetation description:

Globally. The vegetation is characterized by a moderately dense (50-75% cover), tall shrub (>10 m) canopy dominated by *Quercus gambelii* with *Fendlera rupicola* dominant in the moderate shrub layer (25-50% cover). The total vegetation cover class for this stand is 75-100%. Other shrubs (all with <1% cover) are *Ericameria nauseosa*, *Morus alba*, *Opuntia erinacea*, and *Yucca baccata*. The vine *Vitis arizonica* is abundant. The herbaceous stratum has a high diversity of species, each having <1% cover, except for *Thalictrum fendleri*, which has a cover class of 1-5%. Other herbaceous species include *Achillea millefolium*, *Arabis fendleri*, *Arenaria lanuginosa* ssp. *saxosa*, *Artemisia ludoviciana*, *Erigeron divergens*, *Heterotheca villosa*, *Hymenoxys richardsonii*, *Monarda fistulosa* var. *menthifolia*, *Penstemon barbatus*, and *Poa fendleriana*. Exotic species such as *Taraxacum officinale* and *Bromus tectorum* may be present.

Canyon de Chelly National Monument. One relevé is classified as *Quercus gambelii* / *Fendlera rupicola* Shrubland. The total vegetation cover class for this association is 75-100%. The tree stratum is characterized by a total cover class of 50-75%, the shrub stratum covers 25-50%, and the herbaceous stratum covers 1-5%. The species richness is 29 species. The tree stratum is composed of *Quercus gambelii*, which has a cover class of 50-75% and a dbh that ranges from 5.1-21.0 cm (average dbh 13.5 cm). The main canopy has a height of 10-20 m and a cover class of 50-75%. The subcanopy is 5-10 m with 5-10% cover, and the seedling layer covers trace-1% and is 0.5-1 m tall. In addition to *Quercus gambelii*, the seedling layer contains *Pinus edulis* and *Pseudotsuga menziesii*, which are not present elsewhere in the tree stratum. The shrub stratum has two distinct layers. The tall shrub layer is 5-10 m tall, and the short shrub layer measures 2-5 m in height. Both layers are composed of *Fendlera rupicola*, which has a cover class of 10-25%. Other species in the shrub layer (all with <1% cover) are *Morus alba*, *Opuntia erinacea*, and *Yucca baccata*. The herbaceous stratum has a diversity of species, each having a cover class <1%, except for *Thalictrum fendleri*, which has a cover class of 1-5%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Quercus gambelii*	*Quercus gambelii*
Tall/short shrub/ sapling	*Fendlera rupicola*	*Fendlera rupicola*
Herbaceous	*N/A*	*Vitis arizonica*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Morus alba*

Authors:

Global descriptions. K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

38. *Quercus gambelii* Shrubland

NatureServe common name	Gambel Oak Shrubland
NatureServe code	CEGL002477

Summary:

This tall shrubland is known from northeastern Arizona and southwestern Colorado in the Colorado Plateau. Stands occur on southeastern to western aspects at 1884 to 2379 m (6181-7805 feet) elevation on gentle to moderately steep slopes (0-30%). Sites include canyons, mesas and a toeslope at the base of a cliff. The sandy soils have low cover of rock and moderate cover of litter on the ground surface. There is frequently evidence of past fires. The vegetation is characterized by an open to dense (25-75% cover), tall shrub (>10 m) canopy dominated by *Quercus gambelii*. Scattered *Pinus edulis* and *Juniperus osteosperma* trees may be present. Other shrubs (all with <1% cover) are *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Mahonia repens*, *Opuntia phaeacantha*, and *Purshia tridentata*. The herbaceous stratum is variable. *Artemisia ludoviciana* and *Elymus elymoides* are important species as is the exotic annual grass and forb species *Bromus tectorum* and *Erodium cicutarium*, respectively. The herbaceous stratum has a diversity of other species with low cover (<1%).

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. This association is intended for shrublands of oak with no other shrubs associated with mixed mountain shrublands (e.g., *Amelanchier* spp., *Symphoricarpos oreophilus*, *Prunus virginiana*, *Cercocarpus montanus*, etc.) or a distinctive herbaceous layer. Many stands are in unusual settings, such as recent burns (e.g., Mesa Verde National Park). It is likely to be a transitional phase that will eventually return to a more mixed shrub canopy understory or in some cases become dominated by exotic herbaceous species.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.B.	Deciduous shrubland
Physiognomic group	III.B.2.	Cold deciduous shrubland
Physiognomic subgroup	III.B.2.N.	Natural/Semi natural cold deciduous shrubland
Formation name	III.B.2.N.a.	Temperate cold deciduous shrubland
Alliance name		*Quercus gambelii* Shrubland Alliance (A.920) Gambel Oak Shrubland Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES306.818	Rocky Mountain Gambel Oak Mixed Montane Shrubland

NatureServe conservation status:

Global rank. GNR (29 Mar 2005).

Distribution:

Globally. This association has been reported from Mesa Verde National Park in southwestern Colorado and Canyon de Chelly National Monument in northeastern Arizona on the Colorado Plateau. It likely occurs elsewhere in the region, especially in areas relatively recently disturbed.

Canyon de Chelly National Monument. *Quercus gambelii* Shrubland was only sampled from one relevé location on the valley floor of Canyon del Muerto (in the vicinity of Massacre Cave) within Canyon de Chelly National Monument.

Environmental summary:

Globally. This tall shrubland is known from northeastern Arizona and southwestern Colorado in the Colorado Plateau. Stands occur on southeastern to western aspects at 1884 to 2379 m (6181-7805 feet) elevation on gentle to moderately steep slopes (0-30%). Sites include canyons, mesas and a toeslope at the base of a cliff. The sandy soils have low cover of rock and moderate cover of littler on the ground surface. There is frequently evidence of past fires.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 1884 m (6181 feet). The relevé occurs on a west facing toeslope with an incline of 18%. There is a litter layer having a 10-25% cover class and a 1-5% exposure of bedrock. The relevé is located at the base of a cliff and has evidence of fire history.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This tall shrubland is characterized by an open to dense (25-75% cover), tall shrub (>10 m) canopy dominated by *Quercus gambelii*. Scattered *Pinus edulis* and *Juniperus osteosperma* trees may be present. Other shrubs (all with <1% cover) are *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Mahonia repens*, *Opuntia phaeacantha*, and *Purshia tridentata*. The herbaceous stratum is variable. *Artemisia ludoviciana* and *Elymus elymoides* are important species as is the exotic annual grass and forb species *Bromus tectorum* and *Erodium cicutarium*, respectively. The herbaceous stratum has a diversity of other species with low cover (<1%). Other herbaceous species include *Achillea millefolium* var. *occidentalis*, *Achnatherum hymenoides*, *Artemisia ludoviciana*, *Balsamorhiza sagittata*, *Eriogonum racemosum*, *Elymus trachycaulus* ssp. *trachycaulus*, *Poa fendleriana* ssp. *longiligula*.

Canyon de Chelly National Monument. One relevé is classified as *Quercus gambelii* Shrubland. The total vegetation cover class for this association is 25-50%. The tree stratum is characterized by a total cover class of 25-50%, the shrub stratum covers 1-5%, and the herbaceous stratum covers 5-10%. The species richness is 28 species. The tree stratum is dominated by *Quercus gambelii*, which has a cover class of 10-25% and a dbh of 15.8-35.8 cm (average dbh 23.9 cm). Also present in the tree stratum is *Juniperus osteosperma*, which covers trace-1% (with one dbh measurement of 62.2 cm.), and *Pinus edulis*, which covers 1-5%. This relevé has a main canopy height of 10-20 m with a cover class of 25-50%, a subcanopy layer that covers 1-5% and is 2-5 m in height, and a trace seedling layer (<1% cover) that is 0.5-1 m tall. The shrub stratum has only one distinct layer that is 0.5-1 m tall. The dominant shrub species are *Gutierrezia sarothrae* and *Opuntia phaeacantha*, each of which cover 1-5%. The herbaceous stratum is dominated by *Bromus tectorum*, which has a cover class of 5-10%, and *Erodium cicutarium* with 1-5% cover. The herbaceous stratum has a diversity of other species, all having a cover class <1%.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*N/A*	*Quercus gambelii*
Tall/short shrub/ sapling	*Quercus gambelii*	*N/A*
Herbaceous	*N/A*	*Bromus tectorum*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum, Erodium cicutarium	*Bromus tectorum, Erodium cicutarium*

Authors:

Global descriptions. K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

None available.

39. *Tamarix* spp. Temporarily Flooded Semi-natural Shrubland

NatureServe common name	Salt-cedar species Temporarily Flooded Semi-natural Shrubland
NatureServe code	CEGL003114

Summary:

This broadly defined association is composed of shrublands which form moderately dense to dense thickets on banks of larger streams across the western Great Plains, interior and southwestern U.S. and northern Mexico. Stands are dominated by introduced species of *Tamarix*, including *Tamarix ramosissima*, *Tamarix chinensis*, *Tamarix gallica*, and *Tamarix parviflora*. *Tamarix* spp. were introduced from the Mediterranean and have become naturalized in various sites, including salt flats and other saline habitats, springs, and especially along streams and regulated rivers, where it replaces the native vegetation, such as shrublands dominated by species of *Salix* or *Prosopis* or woodlands of *Populus* spp. A remnant herbaceous layer may be present, depending on the age and density of the shrub layer, although in many cases this layer also consists of aggressive exotic species such as *Lepidium latifolium*. *Tamarix* species have become a critical nuisance along most large rivers in the semi-arid West and, because of permanent changes in flood regimes and the difficulty of removing trees, reflect irreversibly changed vegetation on many sites.

Classification confidence: 1 - Strong**.**

Classification comments:

Globally. This is a broadly defined plant association that is composed of many diverse *Tamarix* spp.-dominated vegetation communities from a wide variety of environments. Muldavin et al. (2000) described 8 community types that will be reviewed as possible USNVC associations.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	III	Shrubland
Physiognomic subclass	III.A	Evergreen shrubland
Physiognomic group	III.A.4	Microphyllous evergreen shrubland
Physiognomic subgroup	III.A.4.N	Natural/Semi natural microphyllous evergreen shrubland
Formation name	III.A.4.N.c	Temporarily flooded microphyllous shrubland
Alliance name		*Tamarix* spp. Semi-natural Temporarily Flooded Shrubland Alliance , Salt-cedar species Semi-natural Temporarily Flooded Shrubland Alliance (A.842)

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES302.748	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
CES302.753	North American Warm Desert Riparian Woodland and Shrubland
CES306.821	Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland

NatureServe conservation status:

Global rank. GNA (invasive) (24-Jul-2001).

Distribution:

Globally. This semi-natural shrubland is found along drainages in the semi-arid western Great Plains, interior and southwestern U.S. and northern Mexico, from central and eastern

Montana, south to Colorado, western Oklahoma and Texas, west to California.

Canyon de Chelly National Monument. This plant community was mainly found near or in the main riparian corridors at lower elevations.

Environmental summary:

Globally. These widespread shrublands are common along larger streams, rivers, and around playas in the western U.S. and Mexico. Elevation ranges from 75 m below sea level to 1860 m. *Tamarix* spp. have become naturalized in various sites including riverbanks, floodplains, basins, sandbars, side channels, springs, salt flats, and other saline habitats. Stands grow especially well along regulated rivers where flood-regenerated native species such as *Populus* are declining, and the absence of regular scouring floods allows *Tamarix* seedlings to become established. Substrates are commonly thin sandy loam soil over alluvial deposits of sand, gravel or cobbles.

Canyon de Chelly National Monument. The plant community was described on six accuracy assessment sites; environmental data was not collected.

USFWS wetland system: Palustrine.

Vegetation description:

Globally. This semi-natural shrubland occurs along streams, rivers, and playas where it forms a moderate to dense tall-shrub layer that is solely or strongly dominated by species of *Tamarix*, including *Tamarix ramosissima*, *Tamarix chinensis*, *Tamarix gallica*, and *Tamarix parviflora*. Other shrubs may include species of *Salix* (especially *Salix exigua*) and *Prosopis*, *Rhus trilobata*, and *Sarcobatus vermiculatus,* but with low cover (if shrub species are codominant, then the stand is classified as a natural shrubland). Scattered *Acer negundo*, *Salix amygdaloides*, *Populus* spp., or *Elaeagnus angustifolia* trees may also be present. Depending on stand age and density of the shrub layer, an herbaceous layer may be present. Associated native species include *Distichlis spicata* and *Sporobolus airoides*; introduced species include *Agrostis gigantea*, *Agrostis stolonifera*, and *Poa pratensis*. Introduced herbaceous species such as *Polypogon monspeliensis*, *Conyza canadensis*, *Lepidium latifolium*, and others have been reported from shrublands in this association.

Tamarix spp. are highly competitive shrubs that have invaded many riparian and wetland environments in the western U.S. Hansen et al. (1995) report that these shrubs are extremely drought- and salt-tolerant, produce prolific wind-dispersed seeds over much of the growing season, can resprout after burning or cutting, and, if kept moist, buried or broken, branches will develop adventitious roots and grow. Stands seem to favor disturbed and flow-regulated rivers, because the lack of annual overbank flooding and scouring allows seedlings to become established. However, *Tamarix* spp. will establish well in pristine areas, too, especially under drought conditions such as that experienced by the Colorado Plateau in 2002-2003. Under optimum conditions riparian areas can be converted to a dense thicket in less than 10 years (Hansen et al. 1995). Once established, stands are extremely difficult to eradicate, requiring cutting along with herbicide application on stumps to prevent resprouting (Smith 1989), as well as restoration of the original flooding and scouring regime. Many of the national parks in the western states have active programs of tamarisk removal and riparian restoration that have been moderately successful.

Canyon de Chelly National Monument. Six accuracy assessment observations were classified as *Tamarix* spp. Temporarily Flooded Semi-natural Shrubland. The species richness among all sites was 19 species. The tree stratum is composed of *Tamarix* species (predominantly *Tamarix chinensis*), which has a cover class of 5-75% with, one exception (plot 002 is more representative of barren cover than this plant community). One *Tamarix* plot was mixed with *Populus deltoides* (cover of 25-50%). *Elaeagnus angustifolia* occurred in two other plots (cover 1-10%). The shrub understory had a variety of shrubs with low cover (<5%); most frequent was *Ericamerica nauseosua* (cover <1 – 5%). The herbaceous stratum included traces of native grass species (*Sporobolus* spp. and *Achnatherum hymenoides*) with

cover less than 1%. The invasive non-native grass *Bromus tectorum* appeared in two plots with cover between 1 and 10%. The forb layer included the native species *Senecio flaccidus* var. *douglasii*, *Heterotheca villosa* and *Xanthium strumarium* var. *canadense* (all with cover less than 5%) as well as the invasive non-native *Acroptilon repens* (cover 10-25%).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tall/short shrub/ sapling	*Tamarix chinensis*	*Tamarix chinensis*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum, Lepidium latifolium, Poa pratensis	*Eleagnus angustifolia, Ericamerica nauseosus, Bromus tectorum*

Authors:

Global descriptions. K.A. Schulz, mod. J. Coles.

Local descriptions. K. Thomas.

References:

Baalman 1965, Carsey et al. 2003, Cogan et al. 2004, Cowardin et al. 1979, Hansen et al. 1995, Hansen et al. 2004b, Hoagland 2000, Holland 1986b, MTNHP 2002, Muldavin et al. 2000a, Nachlinger and Reese 1996, Ortenberger and Bird 1933, Paysen et al. 1980, Sawyer and Keeler Wolf 1995, Smith and Douglas 1989, Stevens and Shannon 1917, Szaro 1989, Ungar 1968, von Loh et al. 2002, Ware and Penfound 1949, Western Ecology Working Group n.d.

C.5 Herbaceous

40. *Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation

NatureServe common name	Indian Ricegrass Colorado Plateau Herbaceous Vegetation
NatureServe code	CEGL002343

Summary:

This herbaceous vegetation association usually occurs in small patches (<1 hectare) on upland eolian sand deposits, as well as on sandy alluvial terraces and point bars along intermittent washes in eastern Utah and northwestern Colorado. It is likely to occur in small patches throughout the Colorado Plateau. Disturbance is usually a factor; upland sites often have blowing sand, and wash sites are subject to periodic flooding. Sites are flat to gently sloping (not exceeding 10%) between 1220 and 1815 m elevation. The unvegetated surface has high cover by bare soil or sand, low cover by litter, and biological soil crusts may have up to 30% cover. Soils are rapidly drained sands or sandy loams derived from alluvium or eolian deposits. Total vegetation cover in upland sites with blowing sand is usually quite sparse, rarely exceeding 10%. Sites on sandy terraces and point bars may have up to 30% cover by vascular plants, with another 25% cover provided by biological soil crusts. *Achnatherum hymenoides* is the dominant species, ranging in cover between 3 and 15%. A scattering of shrubs may be present, with no species exceeding 1% cover and the total not exceeding 5% cover. Associated shrubs include *Amsonia tomentosa*, *Artemisia filifolia*, *Atriplex canescens*, *Ephedra torreyana*, *Ephedra viridis*, *Poliomintha incana*, *Vanclevea stylosa*, *Gutierrezia sarothrae*, and *Opuntia polyacantha*. Some stands may contain scattered *Juniperus osteosperma* trees or saplings. Associated graminoids include the short bunch grasses *Aristida purpurea*, *Sporobolus cryptandrus*, and *Pleuraphis jamesii*. Forbs present include *Abronia fragrans* and *Sphaeralcea parvifolia*.

Classification confidence: 2 - Moderate**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic subgroup	V.A.5.N.	Natural/Semi natural temperate or subpolar grassland
Formation name	V.A.5.N.d.	Medium tall bunch temperate or subpolar grassland
Alliance name		*Achnatherum hymenoides* Herbaceous Alliance (A.1262) Indian Ricegrass Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.787	Inter Mountain Basins Semi Desert Grassland

NatureServe conservation status:

Global rank. GNR (16 Mar 2005).

Distribution:

Globally. This association is documented from eastern Utah and northwestern Colorado. It is likely to occur in small stands, 0.1 to 1 ha in size, scattered throughout the Colorado Plateau.

Canyon de Chelly National Monument. *Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation was only sampled from one relevé location within Canyon de Chelly National Monument. It is found near the confluence of Black Rock Canyon and Canyon del Muerto in the vicinity of the Navajo Fortress ruins.

Environmental summary:

Globally. This herbaceous vegetation association occurs on upland eolian sand deposits, as well as on sandy alluvial terraces and point bars along intermittent washes in eastern Utah and northwestern Colorado. It is likely to occur in small patches throughout the Colorado Plateau. Sites are flat to gently sloping (not exceeding 10%) between 1220 and 1815 m elevation. The unvegetated surface has high cover by bare soil or sand, low cover by litter, and biological soil crusts may have up to 30% cover. Soils are rapidly drained sands or sandy loams derived from alluvium or eolian deposits.

Canyon de Chelly National Monument. This association occurs on sandy soil at an elevation of 1835 m (6020 feet). The relevé occurs on a valley floor at the base of a cliff and has a slope of 5% at a southwestern aspect. There is evidence of a fire event within the last few years.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. Small patches (usually less than 1 hectare) of this distinctive grassland type occur sporadically in the Colorado Plateau of southeastern Utah. Total vegetation cover in upland sites with blowing sand is usually quite sparse, rarely exceeding 10%. Sites on sandy terraces and point bars may have up to 30% cover by vascular plants, with another 25% cover provided by biological soil crusts. *Achnatherum hymenoides* is the dominant species, ranging in cover between 3 and 15%. A scattering of shrubs may be present, with no species exceeding 1% cover and the total not exceeding 5% cover. Associated shrubs include *Amsonia tomentosa*, *Artemisia filifolia*, *Atriplex canescens*, *Ephedra torreyana*, *Ephedra viridis*, *Gutierrezia sarothrae*, *Opuntia polyacantha*, *Poliomintha incana*, and *Vanclevea stylosa*. Some stands may contain scattered *Juniperus osteosperma* trees or saplings. Associated graminoids include the short bunch grasses *Aristida purpurea*, *Sporobolus cryptandrus*, and *Pleuraphis jamesii*. Forbs present include *Abronia fragrans* and *Sphaeralcea parvifolia*.

Canyon de Chelly National Monument. One relevé is classified as *Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation. The total vegetation cover class for this association is 25-50%. The tree stratum is absent from this association, the shrub stratum is sparse with 1-5% cover, and the herbaceous stratum covers 25-50%. The species richness is 19 species. The shrub stratum has two distinct layers. The tall shrub layer is 1-2 m tall, and the short shrub layer measures 0.5-1 m in height. The tall shrub layer is composed of *Atriplex canescens*, which has a cover class of 1-5%, and the short shrub layer contains mostly *Opuntia phaeacantha* and *Opuntia polyacantha*, each with a cover of <1%. The herbaceous stratum is dominated by *Achnatherum hymenoides*, which has a cover class of 5-10%. There are a diversity of other herbaceous species, with the most common being *Bromus tectorum*, *Sphaeralcea ambigua*, *Sphaeralcea fendleri*, and *Sporobolus airoides*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Herbaceous	*Achnatherum hymenoides*	*Achnatherum hymenoides*

Other noteworthy species:

Global species	Canyon de Chelly species
Bromus tectorum, Salsola kali ssp. *tragus*	*Bromus tectorum*

Authors:

Global descriptions. J. Coles.

Local descriptions. K. Thomas.

References:

None available.

41. *Agropyron desertorum* Semi-natural Herbaceous Vegetation [Park Special]

NatureServe common name	Crested Wheatgrass Semi-natural Herbaceous Vegetation [Park Special]
NatureServe code	Park Special

Summary:

This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. *Agropyron desertorum* (Syn = *Agropyron cristatum*).

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
	Not applicable.

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association is documented from eastern Utah and northwestern Colorado. It is likely to occur in small stands, 0.1 to 1 ha in size, scattered throughout the Colorado Plateau.

Canyon de Chelly National Monument. *Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation was only sampled from one relevé location within Canyon de Chelly National Monument. It is found near the confluence of Black Rock Canyon and Canyon del Muerto in the vicinity of the Navajo Fortress ruins.

Environmental summary:

Globally. This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. Environmental data was not collected at the five accuracy assessment sites.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. Trees on the two plots included four species with low cover (<10%) and was dominated by *Elaeagnus angustifolia*. Six species were found in the shrub stratum. Most species had low cover (<1%) but three had higher cover of *Sarcobatus vermiculatus* (>1-5%), *Tamarix* sp. (>5-10%), and an *Opuntia* species (>1-5%). The non-native grass *Agropyron desertorum* dominated the herbaceous layer with >25-50% cover in one plot and >5-10% cover in another. Other common herbs were *Solanum elaeagnifolium* (>1-5% cover), *Portulaca oleracea* (<5% cover), and *Brickellia californica* (<1% cover). There were at least 14 species within the two accuracy assessment sites.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Data are not available.*	*Eleagnus angustifolia*
Shrub/sapling	*Data are not available.*	*Sarcobatus vermiculatus, Tamarix sp.*
Herbaceous	*Data are not available.*	*Agropyron desertorum*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Opuntia spp., Solanum elaeagnifolium, Portulaca oleracea, and Brickellia californica*

Authors:

Local descriptions. K. Thomas.

References:

None available.

42. *Artemisia bigelovii / Bouteloua gracilis* Dwarf shrub Herbaceous Vegetation

NatureServe common name	Bigelow Sagebrush / Blue Grama Dwarf shrub Herbaceous Vegetation
NatureServe code	CEGL001742

Summary:

This dwarf shrub steppe is found near canyon rims and mesatops and along escarpments in southeastern Colorado and the Colorado Plateau in southern Arizona and south to the Oscura Mountains in northern portions of the Tula*Rosa* Basin of southern New Mexico. Stands often occur on shallow soil deposits surrounded by bedrock and cliff faces, but also are found on flat to gentle slopes on hillslopes and mesatops at 1545-1830 m (5100-6040 feet) elevation on all aspects. Soils are typically coarse textured loams derived from colluvium and residuum from sandstone and limestone or other parent materials. The vegetation is dominated by a moderately dense graminoid layer of the perennial shortgrass *Bouteloua gracilis* with an open (10-25% cover) dwarf shrub layer characterized by *Artemisia bigelovii*. *Gutierrezia sarothrae* is commonly present and may codominate some stands. An occasional *Pinus edulis* or *Juniperus* spp. tree may be present. Other dwarf shrubs and shrubs present with low cover may include *Atriplex confertifolia*, *Opuntia imbricata*, *Opuntia polyacantha* var. *polyacantha*, *Opuntia whipplei*, and *Yucca* glauca. Associated herbaceous species include grasses, such as *Achnatherum hymenoides*, *Aristida purpurea* var. *fendleriana* (= *Aristida fendleriana*), *Bouteloua curtipendula*, *Hesperostipa neomexicana*, *Muhlenbergia torreyi*, *Pleuraphis jamesii*, *Poa fendleriana*, *Sporobolus airoides*, *Sporobolus cryptandrus*, and the forbs *Arenaria hookeri*, *Astragalus lentiginosus*, *Chaetopappa ericoides*, *Eriogonum* jamesii, and *Petradoria pumila*.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. Additional classification work is needed to clarify differences between this shrub herbaceous association and similar shrubland associations in the *Artemisia bigelovii* Shrubland Alliance (A.1103).

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.8.	Temperate or subpolar grassland with a sparse dwarf shrub layer
Physiognomic subgroup	V.A.8.N.	Natural/Semi natural temperate or subpolar grassland with a sparse dwarf shrub layer
Formation name	V.A.8.N.a.	Short temperate or subpolar lowland grassland with a sparse needle leaved or microphyllous dwarf shrub layer
Alliance name		*Bouteloua gracilis* Dwarf Shrub Herbaceous Alliance (A.1571) Blue Grama Dwarf shrub Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.788	Inter Mountain Basins Semi Desert Shrub Steppe
CES304.762	Colorado Plateau Mixed Low Sagebrush Shrubland

NatureServe conservation status:

Global rank. GNR (23 Feb 1994).

Distribution:

Globally. This dwarf shrub association is found from canyon rims and mesatops in southeastern Colorado to the Colorado Plateau in northwestern New Mexico and northern Arizona, in southern Utah, and in the Oscura Mountains at the northern end of the Tula*Rosa* Basin of southern New Mexico.

Canyon de Chelly National Monument. *Artemisia bigelovii* / *Bouteloua gracilis* Dwarf shrub Herbaceous Vegetation was only sampled from one relevé location within Canyon de Chelly National Monument. It is found in Canyon de Chelly proper between White House ruin and Dog Rock.

Environmental summary:

Globally. This dwarf shrub steppe is found near canyon rims and mesatops and along escarpments in southeastern Colorado and the Colorado Plateau in southern Arizona and south to the Oscura Mountains in northern portions of the Tula*Rosa* Basin of southern New Mexico. Stands often occur on shallow soil deposits surrounded by bedrock and cliff faces, but also are found on flat to gentle slopes on hillslopes and mesatops at 1545-1830 m (5100-6040 feet) elevation on all aspects. Soils are typically coarse textured loams derived from colluvium and residuum from sandstone and limestone or other parent materials.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 1738 m (5702 feet). The relevé occurs on a soil outcrop surrounded by bedrock and cliff faces. The slope of the relevé is 9% at a northern aspect. Fine particles cover 25-50% of the soil surface, and there is 5-10% cover of cryptogamic soil crust.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. One relevé is classified as *Artemisia bigelovii* / *Bouteloua gracilis* Dwarf shrub Herbaceous Vegetation. The total vegetation cover class for this association is 25-50%. The tree stratum is characterized by a total cover class of 1-5%, the shrub stratum covers 10-25%, and the herbaceous stratum covers 25-50%. The species richness is 35 species. The tree stratum is composed of *Juniperus osteosperma*, which has a cover class of 1-5% and drc measurements of 25.0 cm and 82.5 cm (one dbh measurement at 25.3 cm). The tree stratum only has a canopy layer that measures 2-5 m in height. The shrub stratum has only one distinct layer that is 1-2 m tall. The dominant shrub species are *Gutierrezia sarothrae* with 5-10% cover and *Artemisia bigelovii*, which has a cover class of 1-5%. Other common shrubs include *Atriplex confertifolia*, *Opuntia polyacantha* var. *polyacantha*, and *Opuntia whipplei*. The herbaceous stratum is dominated by *Poa fendleriana* with 10-25% cover and *Bouteloua gracilis* with 5-10% cover. The herbaceous stratum has a diversity of other species, with the most common being *Achnatherum hymenoides*, *Astragalus lentiginosus* var. *diphysus*, *Chaetopappa ericoides*, *Petradoria pumila*, and *Sporobolus airoides*.

Canyon de Chelly National Monument. Trees on the two plots included four species with low cover (<10%) and was dominated by *Elaeagnus angustifolia*. Six species were found in the shrub stratum. Most species had low cover (<1%) but three had higher cover of *Sarcobatus vermiculatus* (>1-5%), *Tamarix* sp. (>5-10%), and an *Opuntia* species (>1-5%). The non-native grass *Agropyron desertorum* dominated the herbaceous layer with >25-50% cover in one plot and >5-10% cover in another. Other common herbs were *Solanum elaeagnifolium* (>1-5% cover), *Portulaca oleracea* (<5% cover), and *Brickellia californica* (<1% cover). There were at least 14 species within the two accuracy assessment sites.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Short shrub/ sapling	*Artemisia bigelovii*	*Artemisia bigelovii*

Herbaceous	*Bouteloua gracilis, Hesperostipa neomexicana*	*Gutierrezia sarothrae, Bouteloua gracilis, Poa fendleriana*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K.A. Schulz.

Local descriptions. M. Hansen, J. Donald, and K. Thomas.

References:

Bourgeron and Engelking 1994, Driscoll et al. 1984, Muldavin and Mehlhop 1992, Muldavin et al. 2000a, Shaw et al. 1989.

43. *Bouteloua gracilis* Herbaceous Vegetation

NatureServe common name	Blue Grama Herbaceous Vegetation
NatureServe code	CEGL001760

Summary:

This minor plant association is reported from Arizona, Colorado, New Mexico, Utah and Wyoming. Sites are flat to gently sloping and include plains, plateaus, and montane meadows. Substrates are variable and range from coarse textured soils derived from sand, gravel, granite, or cinder to silty clay loam prairie soils. The vegetation is characterized by a moderate to dense (25 80% cover) herbaceous layer that is strongly dominated by the warm season, perennial shortgrass *Bouteloua gracilis*. Associated grasses are *Bouteloua curtipendula*, *Elymus elymoides*, *Muhlenbergia* spp., *Pascopyrum smithii*, *Pleuraphis jamesii* (= *Hilaria jamesii*), *Sporobolus cryptandrus*, and the introduced annual grass *Bromus tectorum*. Forb cover is sparse. Scattered *Ericameria nauseosa* shrubs and an occasional *Pinus edulis*, *Juniperus* spp., or *Pinus ponderosa* tree (in montane stands) may be present.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. This is a low confidence association. There are many other associations in the *Bouteloua gracilis* Herbaceous Alliance (A.1282). This association often represents degraded montane grasslands and *Bouteloua gracilis* dominated grasslands that lack other diagnostic species. *Bouteloua gracilis* is often able to persist after other species are eliminated because it is an extremely drought and grazing tolerant species.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.A.	Perennial graminoid vegetation
Physiognomic group	V.A.5.	Temperate or subpolar grassland
Physiognomic subgroup	V.A.5.N.	Natural/Semi natural temperate or subpolar grassland
Formation name	V.A.5.N.e.	Short sod temperate or subpolar grassland
Alliance name		*Bouteloua gracilis* Herbaceous Alliance (A.1282) Blue Grama Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.787	Inter Mountain Basins Semi Desert Grassland

NatureServe conservation status:

Global rank. G4Q (23 Feb 1994).

Distribution:

Globally. This *minor* plant association occurs in Arizona, Colorado, New Mexico, Utah and Wyoming.

Canyon de Chelly National Monument. This association was the main grassland on the upland mesa and plateaus and also occurred in patches in the lower canyon.

Environmental summary:

Globally. This minor plant association is reported from Arizona, Colorado, New Mexico,

Utah and Wyoming. Elevation ranges from 1660-2705 m (5420-8875 feet). Sites are flat to moderately sloping and include plains, plateaus and montane meadows and parks. Substrates are variable and range from coarse textured soils derived from sand, gravel, granite or cinder to silty clay loam prairie soils. Montane *Bouteloua gracilis* dominated grasslands included in this association are typically the result of heavy grazing by wildlife and/or livestock that select out less grazing tolerant mid grasses.

Canyon de Chelly National Monument. This association was documented on 16 accuracy assessment sites; however, detailed environmental data was not collected during accuracy assessment.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association is characterized by a moderate to dense (10-80% cover) herbaceous layer that is strongly dominated by the warm season, perennial shortgrass *Bouteloua gracilis*. Associated grasses are *Achnatherum hymenoides*, *Bouteloua curtipendula*, *Elymus elymoides*, *Koeleria macrantha*, *Muhlenbergia montana*, *Muhlenbergia* richardsonis, *Muhlenbergia torreyi*, *Pascopyrum smithii*, *Pleuraphis jamesii* (= *Hilaria jamesii*), *Sporobolus cryptandrus*, and the introduced annual grass *Bromus tectorum*. Forb cover is sparse. Associated forbs include *Artemisia carruthii*, *Artemisia dracunculus*, *Eriogonum* spp., and *Sphaeralcea coccinea*. Scattered *Ericameria nauseosa* shrubs and an occasional *Juniperus* spp., *Pinus edulis*, or *Pinus ponderosa* tree (in montane stands) may be present.

Canyon de Chelly National Monument. The grasses *Bouteloua gracilis* and *Pleuraphis jamesii* (13 of 16 sites) typically are the dominant cover (>5-25% and >1-25% respectively) although in disturbed areas other grasses such as *Monroa squarrosa*, *Bromus tectorum*, and *Sporobolus airoides* may have high cover. *Opuntia* species, such as *O. polycarpa* and *O. whipplei*, are frequently found in the shrub stratum (8 of 16 sites) with cover ranging from >1 to 25%. Other common shrubs are *Gutierrezia sarothrae* (11 of 16 sites, cover <1-10%), *Ericameria nauseosa* (7 of 16 sites, cover <1-10%), *Ephedra viridis* (7 of 16 sites, <1 to 25%), *Chrysothamnus greenei* (9 of 16 sites, <1 to 5%). The most common tree species are *Juniperus osteosperma* (13 of 16 sites, <1-5%) and *Pinus edulis* (5 of 16 sites, <1 to 5%).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*Artemisia bigelovii*	*Juniperus osteosperma, Pinus edulis*
Shrub		*Gutierrezia sarothrae, Chrysothamnus greenei, Ericameria nauseosa, Ephedra viridis, Opuntia polycarpa and O. whipplei*
Herbaceous	*Bouteloua gracilis*	*Bouteloua gracilis, Pleuraphis jamesii*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. K.A. Schulz, mod. J. Coles

Local descriptions. K. Thomas.

References: Bourgeron and Engelking 1994, Bradley et al. 1992, CONHP unpubl. data 2003, Driscoll et al. 1984, Dwyer and Pieper 1967, Fisser 1970, Fisser et al. 1965, Hansen et al. 2004a, Hansen et al. 2004b, Muldavin et al. 2000a, Pieper 1968, Williams 1961, Zimmerman 1967.

44. *Brickellia californica* Shrubland [Park Special]

NatureServe common name	California Brickelbush Shrubland [Park Special]
NatureServe code	Park Special

Summary:

This *Brickellia californica* dominated association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 - Weak**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.788	Inter Mountain Basins Semi Desert Shrub Steppe

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. Brickellia californica Shrubland [Park Special] occurs on three relevés on canyon slopes within Canyon de Chelly National Monument. The relevés for this association were sampled from Canyon del Muerto and near the confluence of Canyon del Muerto with Black Rock Canyon in the area of the Navajo Fortress ruins.

Environmental summary:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This association occurs on sand and sandy loam soils between the elevations of 1774 and 1841 m (5820-6040 feet) (average 1807 m [5928 feet]). The slope ranges from 11-22% (average 17%) at west to northwest aspects. All three relevés are bordered to some degree by slickrock and cliff faces, and two of the relevés have significant exposures of bedrock (5-10% and 10-25% cover classes, respectively). One relevé is partially burned.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. Three relevés are classified as *Brickellia californica* Shrubland [Park Special]. The total vegetation cover class for this association ranges from 10-25% to 50-75% (average cover class 37-58%). The tree stratum is lacking in all but one of the relevés, where there is trace-1% coverage of *Pinus edulis* seedlings. The shrub stratum is sparse and ranges from trace-1% to 1-5% cover. The herbaceous stratum ranges in cover from 10-25% to 50-75% (average cover class 37-58%). The species richness ranges from 23-32 species (average of 28 species). The tree stratum (in the one relevé where it is present) consists of a trace-1% cover of *Pinus edulis* seedlings with a height class of 0.5-1 m.

The shrub stratum has two distinct layers. The tall-shrub layer is 0.5-1 m to 1-2 m in height, and the short-shrub layer (present in only one relevé) is 0.5-1 m tall. The shrub stratum is dominated by *Brickellia californica*, which ranges in cover from 1-5% to 10-25% (average cover class of 4-12%). Other common shrub species include *Brickellia microphylla* var. *scabra*, *Opuntia phaeacantha*, *Opuntia polyacantha* var. *polyacantha*, *Opuntia whipplei*, and *Yucca baccata*. The herbaceous stratum has a diversity of species, with *Artemisia ludoviciana*, *Bromus tectorum*, and *Heterotheca villosa* having the most significant coverage with 5-10% in one or more of the relevés. Less abundant but frequently found species include *Achnatherum hymenoides*, *Astragalus mollissimus*, *Bouteloua curtipendula*, *Conyza canadensis*, *Erigeron divergens*, *Hesperostipa comata* ssp. *comata*, *Ipomopsis aggregata* ssp. aggregata, *Melilotus officinalis* (= *Melilotus albus*), *Mirabilis multiflora*, *Penstemon barbatus*, *Physalis hederifolia*, and *Stephanomeria minor* var. *minor*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Herbaceous	*Data are not available.*	*Brickellia californica, Artemisia ludoviciana, Heterotheca villosa*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Achnatherum hymenoides, Astragalus mollissimus, Bouteloua curtipendula, Brickellia microphylla* var. *scabra, Bromus tectorum, Conyza canadensis, Erigeron divergens, Hesperostipa comata* ssp. *comata, Ipomopsis aggregata* ssp. *aggregata, Melilotus officinalis, Mirabilis multiflora, Opuntia phaeacantha, Opuntia polyacantha* var. *polyacantha, Opuntia whipplei, Penstemon barbatus, Physalis hederifolia, Stephanomeria minor* var. *minor*

Authors:

Local descriptions. M. Hansen.

References: None available.

45. *Bromus tectorum* Semi-natural Herbaceous Vegetation

NatureServe common name	Cheatgrass Annual Grassland
NatureServe code	CEGL003019

Summary:

This herbaceous vegetation type is found throughout much of western North America from the western Great Plains to the Intermountain West. It occurs most often after disturbance of a natural shrub or grass dominated community that results in the replacement of the natural vegetation by non native, annual grass species of *Bromus*. *Bromus tectorum* typically dominates the community with over 80-90% of the total vegetation cover, making it difficult to determine what natural community was formerly present. This vegetation also includes grasslands dominated or codominated by other Eurasian introduced annual *Bromus* species such as *Bromus hordeaceus*, *Bromus madritensis*, *Bromus japonicus*, *Bromus rigidus*, or *Bromus rubens*. It is distinct from the annual *Bromus* communities found along the Pacific Coast typical of the Mediterranean or maritime climates.

Classification confidence: 2 -Moderate**.**

Classification comments:

Globally. This alliance also includes grasslands dominated or codominated by other Eurasian introduced annual *Bromus* species. It is distinct from the annual *Bromus* communities found along the Pacific Coast with Mediterranean or maritime climates because it does not have the introduced annual oatgrass (*Avena barbata* and *Avena fatua*), or other species typical of the California annual grassland (Sawyer and Keeler Wolf 1995).

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	V	Herbaceous Vegetation
Physiognomic subclass	V.D.	Annual graminoid or forb vegetation
Physiognomic group	V.D.2.	Temperate or subpolar annual grasslands or forb vegetation
Physiognomic subgroup	V.D.2.N.	Natural/Semi natural temperate or subpolar annual grasslands or forb vegetation
Formation name	V.D.2.N.d.	Short temperate annual grassland
Alliance name		*Bromus tectorum* Semi-natural Herbaceous Alliance (A.1814) Cheatgrass Semi-natural Herbaceous Alliance

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.787	Inter Mountain Basins Semi Desert Grassland

NatureServe conservation status:

Global rank. GNA (invasive) (1 Dec 1997).

Distribution:

Globally. This alliance level herbaceous vegetation type is found throughout much of western North America from the western Great Plains to intermountain and southwestern U.S.

Canyon de Chelly National Monument. This association occurred in disturbed areas in the canyons and upper elevations.

Environmental summary:

Globally. This herbaceous vegetation type is found throughout much of western North America from the western Great Plains to the Intermountain and southwestern U.S. Elevation ranges from sea level to 2200 m. Stands occur after disturbance of a natural shrub or grass dominated community, resulting in the replacement of the natural vegetation by non native, annual grass species of *Bromus*, although invasion of undisturbed sites has also been reported (e.g., Evans et al. 2001). At Wind Cave National Park in South Dakota, weedy non native graminoid vegetation occurs on recently disturbed areas, most commonly along roads. Small stands also occur in prairie dog towns (H. Marriott pers. comm. 1999). In the Great Basin, *Bromus tectorum* grasslands have invaded large areas of burned over sagebrush steppe. *Bromus tectorum* increases the fire frequency of steppe communities, which eventually eliminates sagebrush (FEIS 2001).

Canyon de Chelly National Monument. The plant community was described on three accuracy assessment sites; environmental data was not collected.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This vegetation type is characterized by a sparse to dense, short, annual graminoid layer that is typically dominated by *Bromus tectorum* with over 80-90% of the total vegetation cover. Other Eurasian introduced annual species of *Bromus* which may alternatively dominate or codominate are *Bromus carinatus*, *Bromus hordeaceus*, *Bromus madritensis*, *Bromus japonicus*, *Bromus rigidus*, or *Bromus rubens*. Although there may be remnant species of the former native vegetation, the high cover of annual bromes makes it difficult to determine what natural community was formerly present. Weedy and exotic annual forbs may also have significant cover in some stands. At Wind Cave National Park in South Dakota, this weedy non native graminoid vegetation is usually dominated by several perennial and annual brome grasses, including *Bromus inermis*, *Bromus japonicus*, and *Bromus tectorum*. Cover is variable (H. Marriott pers. comm. 1999), and in drought years, *Bromus tectorum* may be sparse or absent.

Canyon de Chelly National Monument. *Bromus tectorum* was the dominant species (>25-50% cover) for one of the three sites identified as this association. The other two sites were highly disturbed and had only sparse *Bromus tectorum* or an unidentified grass. *Gutierrezia sarothrae* occurred on all three plots (<1-10% cover).

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Shrub	*N/A*	*Gutierrezia sarothrae*
Herbaceous	*Bromus hordeaceus, Bromus japonicus, Bromus madritensis, Bromus rigidus, Bromus rubens, Bromus tectorum*	*Bromus tectorum*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. D. Faber Langendoen, mod. K. Schulz and J. Coles.

Local descriptions. K. Thomas.

References:

Beatley 1976, Cogan et al. 2004, Daubenmire 1975, Englund 2004, Evans et al. 2001, FEIS 2001, Karl et al. 1999, Marriott pers. comm., Naumann pers. comm., Redente et al. 1992, Sawyer and Keeler Wolf 1995, Young and Evans 1973, Young and Evans 1978.

46. *Juniperus osteosperma* / *Ephedra viridis* / *Bromus tectorum* Wooded Herbaceous Vegetation [Park Special]

NatureServe common name	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation [Park Special]
NatureServe code	Park Special

Summary:

This *Juniperus osteosperma* wooded herbaceous association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 -Weak**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. Data are not available.

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
CES304.788	Inter Mountain Basins Semi Desert Shrub Steppe

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. Juniperus osteosperma / *Ephedra viridis* / *Bromus tectorum* Wooded Herbaceous Vegetation [Park Special] was only sampled from one relevé location within Canyon de Chelly National Monument. It is found in Canyon de Chelly proper near Dog Rock.

Environmental summary:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This association occurs on sandy loam soil at an elevation of 1854 m (6083 feet). The relevé occurs on a midslope with an incline of 1% at a northern aspect. Fine particles cover 25-50% of the soil surface, and the area appears to be covered by sandsheets that may be stabilized dunes.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This association has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. One relevé is classified as *Juniperus osteosperma* / *Ephedra viridis* / *Bromus tectorum* Wooded Herbaceous Vegetation [Park Special]. The total vegetation cover class for this association is 50-75%. The tree stratum is characterized by a total cover class of 1-5%, the shrub stratum covers 5-10%, and the herbaceous stratum covers 25-50%. The species richness is 12 species. The tree stratum is composed of *Juniperus osteosperma*, which has a cover class of 1-5% (one drc measurement at 47.5 cm), and *Pinus edulis* with trace-1% cover. The tree stratum only has a canopy layer that measures 5-10 m in height and a seedling layer of 0.5-1 m tall. The shrub stratum has only one distinct layer that is 0.5-1 m tall. The dominant shrub species is *Ephedra viridis*, which has 1-5% cover. Also present in the shrub stratum are *Chrysothamnus greenei*, *Opuntia polyacantha* var. *polyacantha*, and *Opuntia phaeacantha*. The herbaceous stratum is dominated by *Bromus tectorum*, which has a cover class of 25-50%. Other common herbaceous species are *Bouteloua gracilis*, *Chaetopappa ericoides*, and *Sphaeralcea coccinea*.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*N/A*	*Juniperus osteosperma*
Shrub	*N/A*	*Ephedra viridis*
Herbaceous	*N/A*	*Bromus tectorum*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Bouteloua gracilis, Chrysothamnus greenei*

Authors:

Global descriptions. Not applicable.

Local descriptions. M. Hansen.

References:

None available.

47. Mixed Riparian Herbaceous Vegetation [Park Special]

NatureServe code	Park Special

Summary:

This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 -Weak**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. This park special was mapped as Mixed Riparian Herbaceous.

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
None	Not Applicable

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This association was observed adjacent to surface water in lower and upper canyons.

Environmental summary:

Globally. This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This association has been observed at Canyon de Chelly National Monument on 17 accuracy assessment observation sites that had an exact match to the mapped area; however, environmental descriptors were not obtained during accuracy assessment field work. It is often intermittently flooded.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. Trees were infrequently present (7 of 17 sites) and with low cover except for *Elaeagnus angustifolia* which could have up to 25% cover. Other trees present were *Tamarix chinensis*, *Populus deltoides*, *Pinus edulis*, *Acer negundo*, *Juniperus osteosperma*, and *Juniperus scopulorum*. Shrubs were also infrequently present (9 of 17 sites). *Salix exigua* occurred in five sites with cover ranging from greater than 1 to 25 %. Other frequent shrubs were *Ericameria nauseosa* (4 sites, cover <1 to 5%) and *Gutierrezia sarothrae* (5 sites, cover <1 -10%). Thirteen other shrubs occurred once at the 17 sites. The presence of herbaceous species, particularly weedy species, characterized these sites. Common forbs were *Xanthium strumarium* (5 sites, cover <1-25%), *Machaeranthera canescens* (5 sites, cover >1 – 5%), and *Achillea millefolium* (5 sites, cover <1 to 50%); while many other forbs occurred in 2-3 plots. Grasses were often abundant; *Poa pratensis* occurred with more than 50% cover in three sites, *Pascopyrum* sp. in 2 sites, and *Agropyron repens* at one site. A mix of native forbs, grasses, and shrubs may occur. Many species are riparian obligates, and may include the shrub *Salix exigua*. This map class often occurs in areas adjacent to surface water and is often intermittently flooded.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Tree canopy	*N/A*	*Elaeagnus angustifolia*
Shrub/sapling	*N/A*	*Salix exigua*
Herbaceous	*N/A*	*Xanthium strumarium, Machaeranthera canescens, Achillea millefolium*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

Authors:

Global descriptions. Not applicable.

Local descriptions. K. Thomas.

References:

None available.

48. Mixed Weedy Herbaceous Vegetation [Park Special]

NatureServe code	Park Special

Summary:

This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Classification confidence: 3 -Weak**.**

Classification comments:

Globally. Data are not available.

Canyon de Chelly National Monument. This park special was mapped as Mixed Weedy Herbaceous.

Vegetation hierarchy:

Physiognomic class	Not Applicable
Physiognomic subclass	Not Applicable
Physiognomic group	Not Applicable
Physiognomic subgroup	Not Applicable
Formation name	Not Applicable
Alliance name	Not Applicable

Ecological systems placement:

Ecological system unique ID	Ecological system name
None	Not Applicable

NatureServe conservation status:

Global rank. Data are not available.

Distribution:

Globally. This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This park special was observed in the lower canyon and in Canyon del Muerto.

Environmental summary:

Globally. This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. This park special has been observed at Canyon de Chelly National Monument on 22 accuracy assessment observation sites that had an exact match to the mapped area; however, environmental descriptors were not obtained during accuracy assessment field work. It generally occurred in upland disturbed sites.

USFWS wetland system: Not applicable.

Vegetation description:

Globally. This vegetation type has only been described from Canyon de Chelly National Monument. When additional data for the association is collected from other locations, a global description can be developed.

Canyon de Chelly National Monument. Trees were infrequently present (10 of 22 sites) and with low cover except for *Populus deltoides* and *Ulmus pumila* which could have up to 25% cover. Shrubs were present in a little over half the sites (13 of 22 sites). *Gutierrezia sarothrae* occurred in seven sites with cover ranging from less than 1 to 50 %. Other frequent shrubs were *Atriplex canescens* (4 sites, cover <1 to 10%), and *Ericameria nauseosa* (4 sites, cover <1 to 50%). The presence of herbaceous species, particularly weedy species, characterized these sites. Common forbs were *Amaranthus retroflexus* (11 sites, cover <1 to 25%), *Erodium cicutarium* (7 sites, >1-75%), *Helianthus* sp. (6 sites, cover <1 to 10%), *Portulaca oleracea* (6 sites, <1 to 25% cover), *Salsola kali* (6 sites, cover >1 to 25%). In two plots the *Bromus tectorum* had cover up to 50%, although this non-native grass was observed in only 5 sites. *Poa pratensis* occurred with >25 to >75% cover in two sites.

Most abundant species:

Stratum	Global species	Canyon de Chelly species
Shrub/sapling	*N/A*	*Gutierrezia sarothrae*
Herbaceous	*N/A*	*Amaranthus retroflexus, Poa pratensis*

Other noteworthy species:

Global species	Canyon de Chelly species
Data are not available.	*Data are not available.*

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Global descriptions. Not applicable.

Local descriptions. K. Thomas.

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None available.

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Appendix D: Plant Species List

The species list was compiled from plants observed on classification relevés, photointerpreter's observations, and accuracy assessment observation sites at CACH during the Canyon de Chelly National Monument vegetation mapping project. Locations for each plant are recorded in the respective databases for these field efforts.

In some cases the taxonomy of the species has changed since the original field work. We have kept the taxonomy used in the database, but have annotated this list to indicate where there have been updates in the International Taxonomic Information System (ITIS, http://www.itis.gov) as of July 2008.

404 species were collectively found during the field events, representing 68 families. Asteraceae was represented by the most species (88), followed by Poaceae (70 species), and Fabaceae (21 species). Forty-five non-native species were noted.

The fields in the following table and their contents and sources are:

- Family and Scientific name: The taxonomic name for the plant according to the Integrated Taxonomic Information System (ITIS, http://www.itis.gov) at the time of the field work.
- Common name: The common name for the plant according to ITIS. In some cases the ITIS common name is not the common name used regionally or by NatureServe. Where that is the case, we have included other regional common names.
- TSN code: The ITIS Taxonomic Serial Number (TSN), accessed July 2008.
- Synonym: The taxonomic name for the plant current to July 2008, if the taxonomy for the plant has changed since the field work.
- Non-native: Plants that are listed as non-native by the USDA PLANTS Database (http://plants.usda.gov/) are indicated.

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Abronia elliptica	fragrant white sand verbena	Nyctaginaceae		19556	
Abronia sp.	sand verbena	Nyctaginaceae		19550	
Acer negundo	ashleaf maple	Aceraceae		28749	
Achillea millefolium	bloodwort, yarrow	Asteraceae		35423	
Achnatherum hymenoides	Indian ricegrass	Poaceae		507943	
Achnatherum lettermanii	Letterman needlegrass	Poaceae		507946	
Acroptilon repens	hardheads	Asteraceae		36459	
Adiantum capillus-veneris	common maidenhair	Pteridaceae		17308	
Agropyron cristatum	crested wheatgrass	Poaceae		40371	
Agropyron desertorum	clustered wheat grass	Poaceae		40372	Yes
Agropyron repens	couchgrass	Poaceae	*Elymus repens*	40382	
Agropyron sp.	wheatgrass	Poaceae		40353	
Agrostis exarata	spike bentgrass	Poaceae		40412	
Aletes macdougalii	MacDougal's aletes	Apiaceae		29575	
Allium cernuum	nodding onion	Liliaceae		42721	
Allium cernuum var. *obtusum*	nodding onion	Liliaceae		182643	
Amaranthus blitoides	mat amaranth	Amaranthaceae		20723	Yes
Amaranthus palmeri	carelessweed	Amaranthaceae		20740	
Amaranthus retroflexus	careless weed, redroot amaranth	Amaranthaceae		20745	Yes
Amaranthus sp.	pigweed	Amaranthaceae		20715	
Ambrosia sp.	bursage, ragweed	Asteraceae		36495	
Ambrosia acanthicarpa	annual bursage	Asteraceae		36497	
Ambrosia artemisiifolia	annual ragweed	Asteraceae		36496	
Ambrosia trifida	horseweed	Asteraceae		36521	
Amelanchier sp.	serviceberry	Rosaceae		25108	
Amelanchier utahensis	serviceberry (Utah)	Rosaceae		25121	
Andropogon gerardii	bluejoint, big bluestem	Poaceae		40462	
Androsace septentrionalis	northern rockjasmine	Primulaceae		23935	
Anemopsis californica	yerba mansa	Saururaceae		18223	
Antennaria marginata	whitemargin pussytoes	Asteraceae		36739	
Antennaria parvifolia	little-leaf pussytoes	Asteraceae		36749	
Antennaria sp.	pussytoes	Asteraceae		36716	
Arabis fendleri	fendler rockcress	Brassicaceae		22690	
Arceuthobium divaricatum	pinyon dwarf mistletoe	Viscaceae		27891	
Arenaria eastwoodiae	Eastwood sandwort	Caryophyllaceae		20244	
Arenaria lanuginosa ssp. *saxosa*	spreading sandwort	Caryophyllaceae		20260	
Aristida purpurea var. *fendleriana*	Fendler threeawn	Poaceae		531154	
Aristida purpurea var. *longiseta*	Fendler threeawn	Poaceae		185314	
Aristida schiedeana var. *orcuttiana*	Orcutt's threeawn	Poaceae		531420	
Aristida sp.	threeawn	Poaceae		41400	
Artemisia biennis	biennial sagewort	Asteraceae		35451	
Artemisia bigelovii	Bigelow sage	Asteraceae		35452	
Artemisia dracunculus	false tarragon	Asteraceae		35462	
Artemisia filifolia	sand sagebrush	Asteraceae		35463	

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Artemisia frigida	fringed sagebrush	Asteraceae		35465	
Artemisia ludoviciana	cudweed sagewort	Asteraceae		35474	
Artemisia nova	black sagebrush	Asteraceae		500971	
Artemisia sp.	sagebrush	Asteraceae		35431	
Artemisia tridentata	big sagebrush	Asteraceae		35498	
Asclepias sp.	milkweed	Asclepiadaceae		30240	
Asclepias asperula	Antelope horns	Asclepiadaceae		30247	
Asparagus officinalis	asparagus	Liliaceae		42784	Yes
Asteraceae sp.	sunflower family	Asteraceae		35420	
Astragalus amphioxys var. *modestus*	crescent milkvetch	Fabaceae		192347	
Astragalus kentrophyta	spiny milk-vetch	Fabaceae		25553	
Astragalus lentiginosus	freckled milkvetch	Fabaceae		25559	
Astragalus lentiginosus var. *diphysus*	freckled milkvetch	Fabaceae		192557	
Astragalus mollissimus	purple locoweed	Fabaceae		25589	
Astragalus mollissimus var. *thompsoniae*	Thompson woolly milkvetch	Fabaceae		192649	
Astragalus sp.	locoweed	Fabaceae		25392	
Atriplex canescens	fourwing saltbush	Chenopodiaceae		20518	
Atriplex confertifolia	shadscale	Chenopodiaceae		20519	
Bahia dissecta	ragleaf bahia	Asteraceae		36794	
Besseya arizonica	Arizona coraldrops	Scrophulariaceae		33496	
Betula occidentalis	water birch	Betulaceae		19488	
Blepharoneuron tricholepis	pine dropseed	Poaceae		41475	
Boerhavia spicata	creeping spiderling	Nyctaginaceae		19678	
Bothriochloa sp.	beardgrass	Poaceae		41476	
Bouteloua barbata	sixweeks grama	Poaceae		41498	
Bouteloua curtipendula	sideoats grama	Poaceae		41500	
Bouteloua eriopoda	black grama	Poaceae		41501	
Bouteloua gracilis	blue grama	Poaceae		41493	
Bouteloua sp.	grama	Poaceae		41491	
Brassicaceae sp.	mustard	Brassicaceae		22669	
Brickellia brachyphylla	Brach brickellbush, plumed brickellbush	Asteraceae		36865	
Brickellia californica	California brickellbush	Asteraceae		36866	
Brickellia grandiflora	mountain brickellbush	Asteraceae		36878	
Brickellia microphylla	littleleaf brickellbush	Astereacae		36886	
Brickellia microphylla var. *scabra*	rough brickellbush	Asteraceae		526984	
Brickellia oblongifolia	Mohave brickellbush	Asteraceae		36891	
Brickellia sp.	brickellbush	Asteraceae		36859	
Bromus anomalus	nodding brome	Poaceae		565860	
Bromus carinatus	California brome	Poaceae		40481	
Bromus japonicus	Japanese brome	Poaceae		40479	Yes
Bromus racemosus	bald brome	Poaceae		40516	Yes
Bromus rigidus	ripgut brome	Poaceae		565030	Yes
Bromus rubens	foxtail brome	Poaceae		40518	Yes

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Bromus sp.	brome	Poaceae		40478	
Bromus tectorum	cheat grass	Poaceae		40524	Yes
Calochortus nuttallii	sego lily	Liliaceae		42863	
Carduus nutans	chardon penche	Asteraceae		35787	Yes
Carex foenea var. *foenea*	silvertop sedge	Cyperaceae		527095	
Carex geophila	White Mountain sedge	Cyperaceae		39612	
Carex sp.	sedge	Cyperaceae		39369	
Castilleja integra	squawfeather	Scrophulariaceae		33131	
Castilleja linariifolia	Wyoming Indian paintbrush	Scrophulariaceae		33138	
Castilleja sp.	Indian paintbrush	Scrophulariaceae		33049	
Celtis laevigata var. *reticulata*	netleaf hackberry	Ulmaceae		527226	
Celtis reticulata	netleaf hackberry	Ulmaceae	*Celtis laevigata* var. *reticulata*	19045	
Cenchrus spinifex	coastal sandbur	Poaceae		565054	
Centaurea pratensis	knapweed	Asteraceae	*Centaurea debeauxii* ssp. *thuillieri*	510529	
Cercocarpus intricatus	littleleaf mountain mahogany	Rosaceae		25133	
Cercocarpus ledifolius	Curl-leaf mountain mahogany	Rosaceae		25134	
Cercocarpus montanus	alderleaf cercocarpus, mountain mahogany	Rosaceae		25136	
Cercocarpus sp.	cercocarpus	Rosaceae		25131	
Chaetopappa ericoides	rose heath	Asteraceae		501376	
Chamaesyce fendleri	Fendler's sandmat	Euphorbiaceae		501419	
Chamaesyce maculata	large spurge	Euphorbiaceae		565061	
Chamaesyce sp.	sandmat	Euphorbiaceae		28244	
Cheilanthes feei	Fee lipfern	Pteridaceae		17441	
Chenopodium album	common lambsquarters	Chenopodiaceae		20592	
Chenopodium berlandieri	netseed lambsquarters	Chenopodiaceae		20594	
Chenopodium fremontii	Fremont goosefoot	Chenopodiaceae		20607	
Chenopodium glaucum	oak-leaf goosefoot	Chenopodiaceae		20610	Yes
Chenopodium leptophyllum	narrowleaf goosefoot	Chenopodiaceae		20616	
Chrysothamnus sp.	rabbitbrush	Asteraceae		37048	
Chrysothamnus depressus	dwarf rabbitbrush	Asteraceae		37051	
Chrysothamnus greenei	Greene rabbitbrush	Asteraceae		37052	
Chrysothamnus nauseosus	gray rabbitbrush	Asteraceae	*Ericameria nauseosa* var. *nauseosa*	37055	
Chrysothamnus viscidiflorus	Douglas rabbitbrush	Asteraceae		37090	
Cirsium arvense	field thistle	Asteraceae		36335	
Cirsium chellyense	queen thistle	Asteraceae		501535	
Cirsium sp.	thistle	Asteraceae		36334	
Cirsium vulgare	bull thistle	Asteraceae		36428	Yes
Citrullus sp.	citrullus	Cucurbitaceae		22355	
Clematis ligusticifolia	virgin'sbower	Ranunculaceae		18702	
Clematis sp.	Clematis	Ranunculaceae		18685	
Cleome serrulata	bee spiderflower	Capparaceae		22626	

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Convolvulus arvensis	creeping jenny, bindweed	Convolvulaceae		30705	Yes
Conyza canadensis	Canada horseweed	Asteraceae		37113	
Cordylanthus wrightii	Wright bird's-beak	Scrophulariaceae		33577	
Corydalis sp.	Corydalis	Fumariaceae		18998	
Croton texensis	croton	Euphorbiaceae		28291	
Cryptantha bakeri	Baker catseye	Boraginaceae		31786	
Cryptantha cinerea	bownut cryptantha	Boraginaceae		501822	
Cucurbita sp.	gourd	Cucurbitaceae		22365	
Cynodon dactylon	Bermudagrass	Poaceae		41619	Yes
Datura wrightii	sacred datura	Solanaceae		30521	
Distichlis spicata	desert saltgrass	Poaceae		40662	
Draba cuneifolia	wedgeleaf draba	Brassicaceae		22874	
Echinocereus fendleri	fendler cactus	Cactaceae		19809	
Echinocereus triglochidiatus	claretcup hedgehog	Cactaceae		19815	
Elaeagnus angustifolia	oleaster	Elaeagnaceae		27770	Yes
Elymus canadensis	Canada wildrye	Poaceae		40683	
Elymus elymoides	bottlebrush squirreltail	Poaceae		502264	
Elymus trachycaulus	slender wheatgrass	Poaceae		502282	
Ephedra torreyana	torrey ephedra	Ephedraceae		502318	
Ephedra viridis	green ephedra	Ephedraceae		502319	
Equisetum arvense	field horsetail	Equisetaceae		17152	
Equisetum hyemale	horsetail	Equisetaceae		17154	
Equisetum laevigatum	horsetail	Equisetaceae		17156	
Equisetum sp.	horsetail	Equisetaceae		17148	
Eragrostis sp.	lovegrass	Poaceae		40716	
Ericameria nauseosa	Goldenbush, gray rabbitbush	Asteraceae		507594	
Ericameria parryi[1]	Parry's rabbitbrush	Asteraceae		507596	
Erigeron concinnus var. *concinnus*	Navajo daisy	Asteraceae		527928	
Erigeron divergens	spreading daisy	Asteraceae		35852	
Erigeron flagellaris	trailing daisy	Asteraceae		35865	
Erigeron formosissimus var. *formosissimus*	beautiful fleabane	Asteraceae		527942	
Erigeron speciosus var. *speciosus*	aspen daisy	Asteraceae		527964	
Eriogonum alatum	wind wildbuckwheat	Polygonaceae		21057	
Eriogonum microthecum	slender buckwheat	Polygonaceae		21192	
Eriogonum racemosum	redroot buckwheat	Polygonaceae		21230	
Eriogonum sp.	buckwheat	Polygonaceae		21054	
Eriogonum umbellatum var. *cognatum*	sulphur-flower buckwheat	Polygonaceae		195601	
Erioneuron pilosum	hairy tridens	Poaceae		41731	
Erodium cicutarium	alfilaree	Geraniaceae		29147	Yes
Erysimum capitatum	coast wallflower	Brassicaceae		22932	
Escobaria vivipara var. *arizonica*	Arizona pincushion cactus	Cactaceae		528092	
Escobaria vivipara var. *vivipara*	pink pincushioncactus	Cactaceae		528100	
Fabaceae sp.		Fabaceae		500059	

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Fendlera rupicola	cliff fendlerbush	Hydrangeaceae		24331	
Festuca arizonica	Arizona fescue	Poaceae		40809	
Forestiera neomexicana	New Mexico forestiera, New Mexico olive	Oleaceae	*Forestiera pubescens* var. *pubescens*	32995	
Forestiera pubescens var. *pubescens*	New Mexico forestiera, New Mexico olive	Oleaceae		528175	
Fraxinus anomala	singleleaf ash	Oleaceae		32937	
Galium sp.	bedstraw	Rubiaceae		34796	
Galium stellatum	starry bedstraw	Rubiaceae		34927	
Galium wrightii	slenderbranch bedstraw	Rubiaceae		34940	
Geranium richardsonii	Richardson geranium	Geraniaceae		29118	
Grindelia sp.	gumweed	Asteraceae		37439	
Grindelia squarrosa	Curleycup gumweed	Asteraceae		37472	
Grindelia squarrosa var. *serrulata*	curly-cup gumweed	Asteraceae		528288	
Gutierrezia microcephala	threadleaf snakeweed	Asteraceae		37482	
Gutierrezia sarothrae	broom snakeweed	Asteraceae		37483	
Hedeoma drummondii	Drummond falsepennyroyal	Lamiaceae		32512	
Hedeoma oblongifolia	oblongleaf false pennyroyal	Lamiaceae		502894	
Hedysarum boreale	boreal sweet-vetch	Fabaceae		26724	
Helianthella microcephala	purpledisk helianthella	Asteraceae		37595	
Helianthus annuus	annual sunflower	Asteraceae		36616	
Helianthus petiolaris	prairie sunflower	Asteraceae		36671	
Helianthus sp.	sunflower	Asteraceae		36611	
Heliomeris multiflora	showy goldeneye	Asteraceae		37603	
Hesperostipa comata	Hesperostipa	Poaceae		507974	
Hesperostipa comata ssp. *comata*	needle and thread	Poaceae		525116	
Hesperostipa neomexicana	New Mexico feathergrass	Poaceae		507976	
Heterotheca villosa	hairy false goldaster	Asteraceae		37689	
Heuchera rubescens var. *versicolor*	pink alumroot	Saxifragaceae		528432	
Hilaria jamesii	James' galleta	Poaceae	*Pleuraphis jamesii*	41768	
Hordeum jubatum	foxtail barley	Poaceae		40871	
Hodium murinum	bulbous barley	Poaceae		40881	Yes
Hordeum murinum ssp. *glaucum*	smooth barley	Poaceae		524160	Yes
Hymenopappus filifolius	cutleaf	Asteraceae		37766	
Hymenopappus filifolius var. *lugens*	Idaho hymenopappus	Asteraceae		528521	
Hymenoxys acaulis	stemless actinea	Asteraceae	*Tetraneuris acaulis* var. *acaulis*	514991	
Hymenoxys richardsonii	Colorado rubberweed	Asteraceae		37785	
Hymenoxys richardsonii var. *floribunda*	Colorado rubberweed	Asteraceae		528536	
Ipomopsis aggregata	skyrocket gilia	Polemoniaceae		31192	
Ipomopsis aggregata ssp. *aggregata*	scarlet gilia	Polemoniaceae		31193	
Ipomopsis longiflora	flaxflowered gilia	Polemoniaceae		31198	
Ipomopsis multiflora	many-flower gilia	Polemoniaceae		503187	

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Juglans major	Arizona black walnut	Juglandaceae		19252	
Juncus balticus var. *montanus*	mountain rush	Juncaceae		528598	
Juncus sp.	rush	Juncaceae		39220	
Juniperus monosperma	oneseed juniper	Cupressaceae		194853	
Juniperus osteosperma	Utah juniper	Cupressaceae		194859	
Juniperus scopulorum	Enebro riparío	Cupressaceae		194872	
Juniperus sp.	juniper	Cupressaceae		18047	
Kallstroemia californica	California caltrop	Zygophyllaceae		29043	
Kochia scoparia	common kochia	Chenopodiaceae		20696	Yes
Krascheninnikovia lanata	winterfat	Chenopodiaceae		503290	
Lamiaceae sp.	mint	Lamiaceae		32251	
Lappula occidentalis	flat-spine sheepburr	Boraginaceae		503329	
Lappula occidentalis var. *occidentalis*	desert stickseed	Boraginaceae		528678	
Lepidium densiflorum	common pepperweed	Brassicaceae		22960	
Lesquerella fendleri	Fendler's bladderpod	Brassicaceae		23180	
Lesquerella intermedia	Santa Fe bladderpod	Brassicaceae		23193	
Lesquerella rectipes	straight bladderpod	Brassicaceae		23224	
Linum aristatum	bristle flax	Linaceae		29231	
Linum australe	southern flax	Linaceae		29232	
Linum neomexicanum	New Mexico yellow flas	Boraginaceae		29216	
Lithospermum incisum	fringed gromwell	Boraginaceae		31940	
Lotus plebeius	common birdsfoot trefoil	Fabaceae		503560	
Lotus wrightii	Wright deervetch	Fabaceae		26411	
Lupinus caudatus ssp. *cutleri*	Cutler's spurred lupine	Fabaceae		25984	
Lycium pallidum	pale desert-thorn	Solanaceae		30544	
Machaeranthera canescens	hoary aster	Asteraceae		37984	
Machaeranthera grindelioides	Nuttall tarweed	Asteraceae		37992	
Machaeranthera sp.	goldenweed	Asteraceae		37970	
Mahonia repens	creeping barberry	Berberidaceae		195045	
Malus pumila	paradise apple	Rosaceae		25262	Yes
Malus sp.	apple	Rosaceae		25254	
Malva sp.	cheeseweed	Malvaceae		21832	
Malva neglecta	buttonweed	Malvaceae		21836	Yes
Marrubium sp.	marrubium	Lamiaceae		32560	Yes
Marrubium vulgare	horehound	Lamiaceae		32561	Yes
Medicago lupulina	black medic	Fabaceae		503721	Yes
Medicago sativa	alfalfa	Fabaceae		183623	Yes
Medicago sp.	alfalfa, medicago	Fabaceae		183622	Yes
Melilotus alba	white sweetclover	Fabaceae		26149	Yes
Melilotus officinalis	yellow sweet-clover	Fabaceae		26150	Yes
Menodora scabra	rough menodora	Oleaceae		32985	
Mentzelia multiflora	Adonis blazingstar	Loasaceae		503788	
Mirabilis linearis	linearleaf four-o'clock	Nyctaginaceae		19651	
Mirabilis multiflora	Colorado four o'clock	Nyctaginaceae		19654	

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Mirabilis sp.	four o' clock	Nyctaginaceae		19624	
Monarda fistulosa var. *menthifolia*	wild bergamot	Lamiaceae		566738	
Monroa squarrosa	false buffalo grass	Poaceae		41882	
Morus alba	mulberry	Moraceae		19066	Yes
Muhlenbergia andina	foxtail muhly	Poaceae		41884	
Muhlenbergia arsenei	Navajo muhly	Poaceae		41898	
Muhlenbergia asperifolia	alkali muhly	Poaceae		41899	
Muhlenbergia montana	mountain muhly	Poaceae		41927	
Muhlenbergia pauciflora	New Mexico muhly	Poaceae		41930	
Muhlenbergia porteri	bush muhly	Poaceae		41933	
Muhlenbergia pungens	sandhill muhly	Poaceae		41934	
Muhlenbergia sp.	muhly	Poaceae		41883	
Muhlenbergia torreyi	ring muhly	Poaceae		503886	
Oenothera albicaulis	halfshrub sundrop	Onagraceae		27373	
Oenothera caespitosa ssp. *caespitosa*	tufted evening-primrose	Onagraceae		566058	
Oenothera caespitosa ssp. *marginata*	tufted evening-primrose	Onagraceae		566061	
Oenothera sp.	evening primrose	Onagraceae		27367	
Opuntia erinacea	grizzlybear pricklypear	Cactaceae		19705	
Opuntia fragilis	brittle cactus	Cactaceae		19707	
Opuntia phaeacantha	brownspine pricklypear	Cactaceae		19724	
Opuntia polyacantha	plains pricklypear	Cactaceae		19726	
Opuntia polyacantha var. *polyacantha*	hair-spine prickly-pear, plains prickly-pear	Cactaceae		195296	
Opuntia sp.	pricklypear	Cactaceae		19686	
Opuntia whipplei	Whipple cholla	Cactaceae		19745	
Packera multilobata	lobeleaf groundsel	Asteraceae		518150	
Parietaria pensylvanica	Pennsylvania pellitory	Urticaceae		19169	
Parthenocissus vitacea	thicket creeper	Vitaceae		28605	
Pascopyrum smithii	pubescent wheatgrass	Poaceae		504124	
Pascopyrum sp.	wheatgrass	Poaceae		500464	
Pedicularis centranthera	dwarf lousewort	Scrophulariaceae		33367	
Penstemon barbatus	beardlip penstemon	Scrophulariaceae		33825	
Penstemon barbatus ssp. *trichander*	beardlip penstemon	Scrophulariaceae		524441	
Penstemon linarioides	creeping penstemon	Scrophulariaceae		33937	
Penstemon sp.	beard tongue	Scrophulariaceae		33665	
Petradoria pumila	rock goldenrod	Asteraceae		38233	
Petradoria pumila ssp. *graminea*	giant rockgoldenrod	Asteraceae		38235	
Phaseolus sp.	Bean	Fabaceae		203844	
Philadelphus microphyllus	littleleaf mock orange	Hydrangeaceae		24437	
Philadelphus sp.	mock orange	Hydrangeaceae		24418	
Phlox austromontana	desert mountain phlox	Polemoniaceae		30913	
Phlox gracilis	slender phlox	Polemoniaceae		504316	
Phoradendron juniperinum	juniper mistletoe	Viscaceae		27866	
Phragmites australis	common reed	Poaceae		41072	

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Phragmites communis	common reed	Poaceae	*Phragmites australis*	41073	
Physalis hederifolia	ivyleaf ground cherry	Solanaceae		30600	
Physalis longifolia	longleaf groundcherry	Solanaceae		30603	
Physalis sp.	ground cherry	Solanaceae		30587	
Physalis virginiana	ground cherry	Solanaceae		30612	
Picea pungens	blue spruce	Pinaceae		183307	
Pinus edulis	colorado pinyon	Pinaceae		183336	
Pinus ponderosa	blackjack pine, ponderosa pine	Pinaceae		183365	
Plantago argyraea	salt-meadow plantain	Plantaginaceae		32898	
Plantago lanceolata	buckhorn plantain	Plantaginaceae		32874	Yes
Plantago major	broadleaf plantain	Plantaginaceae		32887	
Plantago patagonica	woolly Indianwheat	Plantaginaceae		32907	
Plantago sp.	plantain	Plantaginaceae		32870	
Pleuraphis jamesii	galleta	Poaceae		507993	
Poa compressa	Canada bluegrass	Poaceae		41082	Yes
Poa fendleriana	mutton grass	Poaceae		504467	
Poa pratensis	Kentucky bluegrass	Poaceae		41088	
Poa sp.	bluegrass	Poaceae		41074	
Poaceae sp.	grasses	Poaceae		40351	
Polygonum aviculare	prostrate knotweed	Polygonaceae		20876	Yes
Polypogon monspeliensis	annual rabbit's-foot grass	Poaceae		41171	Yes
Populus angustifolia	narrowleaf cottonwood	Salicaceae		22452	
Populus deltoides ssp. *wislizeni*	Rio Grande cottonwood	Salicaceae		524563	
Populus fremontii	cottonwood	Salicaceae		22459	
Populus sp.	cottonwood	Salicaeae		22444	
Populus tremuloides	quaking aspen	Salicaceae		195773	
Portulaca oleracea	akulikuli-kula, purslane	Portulacaceae		20422	
Proboscidea parviflora	devilsclaw	Pedaliaceae		504615	
Prunus armeniaca	apricot	Rosaceae		24769	Yes
Prunus persica	peach	Rosaceae		24765	Yes
Prunus sp.	plum	Rosaceae		24762	
Pseudocymopterus montanus	alpine false springparsley	Apiaceae		29837	
Pseudotsuga menziesii	douglas fir	Pinaceae		183424	
Purshia stansburiana	Stansbury Cliff-rose	Rosaceae		195901	
Purshia tridentata	antelope bitterbrush	Rosaceae		25290	
Pyrus communis	pear	Rosaceae		25295	
Quercus gambelii	Gambel oak	Fagaceae		19337	
Quercus x pauciloba	wavyleaf oak	Fagaceae		19395	
Quercus turbinella	scrub oak	Fagaceae		19440	
Rhus aromatica	fragrant sumac	Anacardiaceae		28779	
Rhus trilobata	skunkbush	Anacardiaceae		28791	
Ribes pinetorum		Grossulariaceae			
Ribes sp.	currant	Grossulariaceae		24448	
Robinia pseudo-acacia	black locust	Fabaceae		26185	

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Rosa woodsii	Wood's rose	Rosaceae		24847	
Rumex crispus	curly dock,	Polygonaceae		20937	Yes
Rumex sp.	dock	Polygonaceae		20933	
Salix bebbiana	Bebb willow	Salicaceae		22507	
Salix exigua	coyote willow	Salicaceae		22529	
Salix gooddingii	Goodding's willow	Salicaceae		22539	
Salix lasiolepis	arroyo willow	Salicaceae		22551	
Salix sp.	willow	Salicaeae		22476	
Salsola kali	prickly Russian thistle	Chenopodiaceae		20655	Yes
Salsola sp.	Russian thistle	Chenopodiaceae		20654	Yes
Salsola tragus	prickly Russian thistle	Chenopodiaceae		520950	Yes
Sarcobatus vermiculatus	black greasewood	Chenopodiaceae		20707	
Schizachyrium scoparium	little bluestem	Poaceae		42076	
Senecio sp.	groundsel	Asteraceae		36084	
Senecio flaccidus	Douglas Senecio	Asteraceae		505126	
Senecio flaccidus var. *douglasii*	Douglas groundsel	Asteraceae		530312	
Senecio flaccidus var. *flaccidus*	threadleaf groundsel	Asteraceae		530313	
Senecio multilobatus	lobeleaf groundsel	Asteraceae	*Packera multilobata*	36161	
Senecio neomexicanus	New Mexico groundsel	Asteraceae	*Packera neomexicana* var. *neomexicana*	36162	
Senecio spartioides var. *multicapitatus*	broomlike ragwort	Asteraceae		531525	
Senecio spartioides var. *spartioides*	broomlike ragwort	Asteraceae		531235	
Senecio wootonii	Wooton ragwort	Asteraceae		36196	
Sisymbrium altissimum	Jim Hill mustard	Brassicaceae		23312	Yes
Solanum elaeagnifolium	silverleaf nightshade	Solanaceae		30429	
Solanum rostratum	buffalobur	Solanaceae		30454	
Solanum sp.	nightshade	Solanaceae		36521	
Solidago sp.	goldenrod	Asteraceae		36223	
Solidago sparsiflora	sparse goldenrod	Asteraceae	*Solidago velutina*	36306	
Solidago velutina	sparse goldenrod, threenerve goldenrod	Asteraceae		505290	
Sonchus asper	perennial sowthistle	Asteraceae		38424	Yes
Sphaeralcea sp.	Globemallow	Malvaceae		21909	
Sphaeralcea ambigua	desert globemallow	Malvaceae		21910	
Sphaeralcea coccinea	copper mallow, scarlet mallow	Malvaceae		21920	
Sphaeralcea fendleri	Fendler's globemallow	Malvaceae		21933	
Sphaeralcea hastulata	spear globemallow	Malvaceae		21942	
Sphaeralcea incana	gray globemallow	Malvaceae		21943	
Sphaeralcea leptophylla	scaly globemallow	Malvaceae		21947	
Sphaeralcea parvifolia	smallflower globemallow	Malvaceae		21953	
Sphaeralcea sp.	globemallow	Malvaceae		21909	
Sporobolus airoides	alkali sacaton	Poaceae		42128	
Sporobolus contractus	spike dropseed	Poaceae		42131	
Sporobolus cryptandrus	sand dropseed	Poaceae		42132	
Sporobolus sp.	dropseed	Poaceae		42115	

Scientific name	Common name	Family name	Synonym	TSN code	Non-native
Stephanomeria minor	lesser wirelettuce	Asteraceae		565544	
Stephanomeria minor var. *minor*	narrowleaf wirelettuce	Asteraceae		566323	
Stephanomeria sp.	wire lettuce	Asteraceae		38442	
Stephanomeria tenuifolia	narrowleaf wirelettuce	Asteraceae	*Stephanomeria minor* var. *minor*	38455	
Streptanthella longirostris	longbeak fiddle mustard	Brassicaceae		23333	
Streptanthus cordatus	heartleaf twistflower	Brassicaceae		23348	
Symphoricarpos oreophilus	mountain snowberry	Caprifoliaceae		35338	
Symphyotrichum falcatum var. *falcatum*	white prairie aster	Asteraceae		566331	
Symphyotrichum lanceolatum var. *hesperium*	white panicle aster	Asteraceae		566829	
Symphyotrichum sp.	aster	Asteraceae		564906	
Sisymbrium sp.	hedge mustard	Brassicaceae		23311	
Tamarix chinensis	China tamarisk	Tamaricaceae		22308	Yes
Tamarix sp.	saltcedar	Tamaricaceae		22303	Yes
Taraxacum officinale	blowball, common dandelion	Asteraceae		36213	Yes
Taraxacum sp.	dandelion	Asteraceae		36199	
Tetradymia canescens	gray horsebrush	Asteraceae		38494	
Tetraneuris ivesiana	Ives' four-nerve-daisy	Asteraceae		38512	
Thalictrum fendleri	Fendler meadowrue	Ranunculaceae		18670	
Thalictrum sp.	meadowrue	Ranunculaceae		18658	
Thelesperma megapotamicum	green threads	Asteraceae		38525	
Townsendia incana	hoary Townsend daisy	Asteraceae		38549	
Toxicodendron rydbergii	western poison-ivy	Anacardiaceae		28822	
Tradescantia occidentalis	prairie spiderwort	Commelinaceae		39168	
Tragia ramosa	branched noseburn	Euphorbiaceae		28433	
Tragopogon dubius	common salsify	Asteraceae		38564	Yes
Tribulus terrestris	bullhead	Zygophyllaceae		29057	Yes
Trifolium repens	Dutch clover	Fabaceae		26206	Yes
Typha sp.	Cattail	Typhaceae		42324	
Ulmus pumila	Chinese elm, Siberian elm	Ulmaceae		19057	Yes
Valeriana acutiloba	cordilleran valerian	Valerianaceae		35352	
Vicia americana	American deervetch	Fabaceae		26331	
Vitis arizonica	canyon grape	Vitaceae		28612	
Vulpia octoflora	eight-flower six-weeks grass	Poaceae		42264	
Vulpia octoflora var. *hirtella*	sixweeks fescue	Poaceae		530862	
Xanthium strumarium var. *canadense*	Canada cocklebur	Asteraceae		530872	
Yucca angustissima	narrowleaf yucca	Agavaceae		43131	
Yucca baccata	banana yucca	Agavaceae		43134	
Yucca sp.	yucca	Agavaceae		43116	
Zea mays	corn	Poaceae		42269	Domesticated

[1] *Ericameria parryi* is recorded as its older synonym *Chrysothamnus parryi* in the accompanying species database, cachdata.mdb.

Appendix E: Plant Community and Map Class Key

The plant community and map class key, developed to identify plant communities (NVC associations, alliances and park specials) and map classes (base, group, and management) was used in the field during accuracy assessment of the CACH vegetation mapping project. It can be used at CACH in areas of at least 0.5 ha in size (e.g. a circle with a 40-m radius). Most base map classes key to one plant community, but some are aggregations of more than one plant community and may appear in several places in the dichotomous key.

Because the group and management map classes are aggregations of base map classes, they also appear multiple times in the key. The group map classes represent aggregations of the base map classes to the group level of the National Vegetation Classification Standard (NVCS), Version 2 (2008). Terrestrial ecological systems, as described by NatureServe, were used as a first approximation of the group level. The management map classes were developed in consultation with park staff, with the intent of preserving the highest map accuracy possible while maintaining base map classes that are of importance to park managers.

The key begins with a lifeform key that separates the observed vegetation or land cover into one of four lifeform types, each with a subkey. The subkeys consist of decision couplets within which the vegetation characteristics and typical geomorphic setting are described. Vegetation with the same species may be separated into different associations or even lifeforms due to differences in cover and/or habitat. Because of this, both parts of the couplet should be considered before proceeding through the key. As is the case with a botanical key, often it is important to follow the key a few couplets beyond the point where you believe you may have correctly identified a map label or association because you may find a better fit in subsequent steps or you may gain increased confidence that your initial choice was correct.

Some map labels are based on geology, such as Sandstone Rock, where any existing vegetation is very sparse. However, the distinction between sparse landform classes and other sparsely vegetated areas is sometimes difficult. If you use the sparse vegetation subkey and get to a landform-based map class you may want to also continue in the key to the next most representative vegetation lifeform and see if there is a better description of the plant community there. Each of the subkeys has plant communities that are sparse (<10% generally and sometimes <15% cover) and may better characterize the site than the sparse landform-based map class.

Lifeform Key

1a. Site is either barren (non-vegetated), sparsely vegetated (<5% vegetation), or characterized by an anthropogenic landuse with up to 15% vegetation cover. The site may be characterized by a barren geomorphic feature such as bedrock, canyon bottom, sand dunes, and lakes, or a sparsely vegetated to vegetated anthropogenic landuse, i.e. urban development and agriculture. SPARSE VEGETATION AND BARREN (Key A, go to 4)

1b. Site with >5% vegetation and not characterized by an anthropogenic landuse. (2a)

2a. Site characterized by tree and/or shrub cover. If tree or shrub cover is greater than 15% cover; grasses and forbs may have higher cover. If tree or shrub cover is less than 15%, grasses and forbs, if present, have less cover than either trees or shrubs. (3a)

2b. Site characterized by grasses and forbs; trees or shrubs may be present with less than 15% cover and with less cover than grasses and forbs. HERBACEOUS VEGETATION (Key B, go to 9a)

3a. Site characterized by trees, including evergreen and deciduous species. WOODLANDS AND FORESTS (Key C, go to 17a)

3b. Site characterized by shrubs. SHRUBLANDS (Key D, go to 43a)

Key A: Sparse Vegetation

Cover of vascular plants is low to none, often with less than 5% total vegetation cover. In some cases, the total vegetation cover may be as high as 15% cover; however, the geomorphic feature or anthropogenic land use is the dominant feature.

4a. Site characterized by a geomorphic feature. (5a)

4b. Site characterized by anthropogenic land use. (8a)

5a. Site characterized by a large reservoir/lake.
- Base Map Class: Tsaile Lake.
- Group Map Class: Water.
- Management Map Class: Tsaile Lake.

5b. Site not characterized by the feature listed above (6a)

6a. Site is either permanently flooded or is subject to intermediate flooding, limiting vegetation establishment. This map class mainly occurs in the canyon bottoms of Canyon de Chelly and Canyon del Muerto.
- Base Map Class: Barren Wash Bottom.
- Group Map Class: Barren.
- Management Map Class: Barren Wash Bottom.

6b. Site characterized by surface rocks or sand. (7a)

7a. Substrate is dominated by sandstone bedrock. This map class ranges from flat surfaces to steep vertical cliff faces.
- Base Map Class: Sandstone Rock.
- Group Map Class: Barren.
- Management Map Class: Sandstone Rock.

7b. Substrate is unvegetated sand dunes.
- Base Map Class: Sand Dunes.
- Group Map Class: Barren.
- Management Map Class: Sand Dunes.

8a. Site characterized by one of the following land uses:

a. Artificial Catchment – These are generally small raised catchments that will fill with water depending on seasonal rainfall, developed for ranching or agricultural purposes.
- Base Map Class: Artificial catchment.
- Group Map Class: Agriculture.
- Management Map Class: Artificial catchment.

b. Mixed Urban Chinle – Chinle, Arizona is located adjacent to Canyon de Chelly National Monument. This map class represents the urban development outside the park boundary within the five km buffer within the project boundary. This area consists of various urban uses, including roads, buildings, yards, parks, and parking lots.
- Base Map Class: Mixed Urban Chinle.
- Group Map Class: Residential.
- Management Map Class: Mixed Urban Chinle.

c. Mixed Urban Monument – The city of Chinle, Arizona extends within the Canyon de Chelly National Monument boundary. This map class represents the urban development with the park boundary. This area also consists of various urban uses, including roads, buildings, yards, parks, and parking lots.
- Base Map Class: Mixed Urban Monument.
- Group Map Class: Residential.
- Management Map Class: Mixed Monument and Rim Rural Residential.

d. Major Roads – This map class consists only of the major paved roads.
- Base Map Class: Major Roads.
- Group Map Class: Transportation.
- Management Map Class: Major Roads.

e. Rim Agriculture – This map class only occurs on the mesas and plateaus on top of Canyon de Chelly and Canyon del Muerto. It consists of large-scale and small-scale agricultural use, including farming and livestock activities.
- Base Map Class: Rim Agriculture.
- Group Map Class: Agriculture.
- Management Map Class: Mixed Monument and Rim Rural Residential.

f. Traditional Community-Use Agriculture (Canyon del Muerto) – This map class is limited to small-scale traditional agricultural activities, including farming and ranching on the canyon floor of Canyon del Muerto.
- Base Map Class: Traditional Community-Use Agriculture (Canyon del Muerto).
- Group Map Class: Agriculture.
- Management Map Class: Traditional Community-Use Agriculture (Canyon del Muerto)

g. Traditional Community-Use Agriculture (Canyon de Chelly) – This map class is limited to small-scale traditional agricultural activities, including farming and ranching on the canyon floor of Canyon de Chelly.
- Base Map Class: Traditional Community-Use Agriculture (Canyon de Chelly.
- Group Map Class: Agriculture.
- Management Map Class: Traditional Community-Use Agriculture (Canyon de Chelly).

8b. Site not characterized as above. If vegetated, but with low cover (<15% cover), go back to the lifeform key and continue to use the key to select the appropriate lifeform.

Key B: Herbaceous Vegetation

Total vegetation cover is generally greater than 15% cover; in particularly dry sites vegetation cover can be as low as 5%. Tree and shrub cover must be less than 15% cover. In sites that have low total vegetation cover, the tree cover must be less than the total herbaceous cover. If tree cover is more, continue to Key C: Woodlands and Forests. Grasses and forbs are the dominant lifeform.

9a. Herbaceous cover is dominated by native grasses and forbs. (10a)

9b. Herbaceous cover is dominated by non-native grasses and forbs. (14a)

10a. *Artemisia bigelovii*, a dwarf-shrub, is the dominant shrub and covers over half of the total herbaceous cover.
- Base Map Class: Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation.
- Group Map Class: Colorado Plateau Mixed Bedrock and Tableland.
- Management Map Class: Rubber Rabbitbrush - Prickly Pear Shrubland.
- Association: *Artemisia bigelovii* / *Bouteloua gracilis* Dwarf-Shrub Herbaceous Vegetation.

10b. Dominant shrub cover not as above. (11a)

11a. Herbaceous cover is dominated by the native bunch grass, *Achnatherum hymenoides*. This map class often occurs on sandy soils and may have a low cover of native shrubs.
- Base Map Class: Indian Ricegrass Colorado Plateau Herbaceous Vegetation.
- Group Map Class: Inter-Mountain Basins Semi-Desert Grassland.
- Management Map Class: Mixed Upland Herbaceous Vegetation.
- Association: *Achnatherum hymenoides* Herbaceous Vegetation.

11b. Dominant herbaceous cover not as above. (12a)

12a. *Agropyron desertorum*, a non-native grass, is the dominant species. This association/map class is likely a result of re-seeding efforts and has been documented at only one location.
- Base Map Class: Desert Wheatgrass Herbaceous Vegetation.
- Group Map Class: Inter-Mountain Basins Semi-Desert Grassland.
- Management Map Class: Mixed Upland Herbaceous Vegetation.
- Association: *Agropyron desertorum* Herbaceous Vegetation.

12b. Dominant herbaceous cover not as above. (13a)

13a. A mix of native forbs, grasses, and shrubs may occur. Many species are riparian obligates, and may include the shrub *Salix exigua*. This map class often occurs in areas adjacent to surface water and is often intermittently flooded.
- Base Map Class: Mixed Riparian Herbaceous.
- Group Map Class: Colorado Plateau Riparian Woodland and Shrubland.
- Management Map Class: Mixed Riparian Herbaceous Vegetation.
- Park Special: Mixed Riparian Herbaceous Vegetation.

13b. *Bouteloua gracilis* is often the dominant species in the uplands, however in some disturbed areas forbs and other grasses can co-dominate. This is the main grassland that occurs in the large expanses in the uplands on mesas and plateaus.
- Base Map Class: Blue Grama Herbaceous Vegetation.
- Group Map Class: Inter-Mountain Basins Semi-Desert Grassland.
- Management Map Class: Blue Grama Herbaceous Vegetation.
- Association: *Bouteloua gracilis* Herbaceous Vegetation.

14a. *Bromus tectorum*, a non-native annual invasive species, can be the dominant herbaceous species; however, it varies with cover each growing season. *Bouteloua gracilis*, a native herbaceous species, may co-dominate or dominate the herbaceous cover. *Juniperus osteosperma* and *Ephedra viridis* both occur and together cover over half of the total herbaceous cover. This association commonly occurs on sandy soils and is restricted to the canyon rims.

- Base Map Class: Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation.
- Group Map Class: Inter-Mountain Basins Semi-Desert Shrub-Steppe.
- Management Map Class: Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation.
- Association: *Juniperus osteosperma* / *Ephedra viridis* / *Bromus tectorum* Wooded Herbaceous Vegetation.

14b. *Juniperus osteosperma* or *Ephedra viridis* cover is less than half of the total herbaceous cover. (15a)

15a. The non-native invasive species, *Bromus tectorum*, covers over half of the total herbaceous cover. This map class often occurs in disturbed areas and in the broad expanses of the canyon bottom.

- Base Map Class: Cheatgrass Herbaceous Vegetation.
- Group Map Class: Inter-Mountain Basins Semi-Desert Grassland.
- Management Map Class: Mixed Upland Herbaceous Vegetation.
- Association: *Bromus tectorum* Semi-natural Herbaceous Vegetation.

15b. The dominant grass species is not as above. (16a)

16a. Non-native species may include, but are not limited to, *Acroptilon repens*, *Bromus rigidus*, *Bromus tectorum*, and *Cynodon dactylon*. This map class occurs in flood plains or in areas with temporary flooding. Non-native herbaceous species composition and density vary depending on the area and infestation rates.

- Base Map Class: Mixed Riparian Herbaceous.
- Group Map Class: Colorado Plateau Riparian Woodland and Shrubland.
- Management Map Class: Mixed Riparian Herbaceous Vegetation.
- Park Special: Mixed Riparian Herbaceous Vegetation.

16b. This map class contains a mixture of non-native herbaceous species that often occur in upland disturbed sites. This map class contains various species and ranges in composition and density, depending on site infestation rates. Non-native species may include, but are not limited to, *Bromus tectorum*, *Cirsium vulgare*, *Hordeum murinum* ssp. *glaucum*, and *Melilotus alba*.

- Base Map Class: Mixed Weedy Herbaceous.
- Group Map Class: Inter-Mountain Basins Semi-Desert Grassland.
- Management Map Class: Mixed Upland Herbaceous Vegetation.
- Park Special: Mixed Weedy Herbaceous Vegetation.

Key C: Woodlands and Forests

Total vegetation cover is generally greater than 15% cover, except in dry sites where vegetation cover can be as low as 5% cover. Trees dominate the woodland and forest communities and generally have over 15% canopy cover. If shrub cover is more than tree cover, then chose Key D: Shrubs. In some areas, canopy cover is dense (> 75% cover) and these communities are often classified as forests.

17a. Tree species are dominated or co-dominated by *Pseudotsuga menziesii*. (18a)

17b. Tree species not as above. (21a)

18a. The canopy is co-dominated by *Populus deltoides*. This vegetation community mainly occurs in the transition zone between cooler side canyon slopes and the riparian canyon

floor. It most commonly occurs in streambeds in narrow side canyons.

- Base Map Class: Douglas-fir / Rio Grande Cottonwood Forest.
- Group Map Class: Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland.
- Management Map Class: Douglas-fir Mixed Forest.
- Association: *Pseudotsuga menziesii* / *Populus deltoides* Forest.

18b. Canopy is not co-dominated with *Populus deltoides*. *Pseudotsuga menziesii* commonly has dense cover in the cooler side canyons and on north-facing slopes. (19a)

19a. The understory consists of *Quercus gambelii* and often contains *Amelanchier utahensis*.

- Base Map Class: Douglas-fir / Gambel Oak Forest.
- Group Map Class: Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland
- Management Map Class: Douglas-fir Mixed Forest.
- Association: *Pseudotsuga menziesii* / *Quercus gambelii* Forest.

19b. Understory species not as above and sites often occur on steep scree slopes. (20a)

20a. Understory species are mostly comprised of graminoids. *Poa fendleriana* typically is the main herbaceous species. This map class typically occurs on steep scree slopes.

- Base Map Class: Douglas-fir / Muttongrass Woodland.
- Group Map Class: Southern Rocky Mountain Montane Mixed Conifer Forest.
- Management Map Class: Douglas-fir Mixed Forest.
- Association: *Pseudotsuga menziesii* / *Poa fendleriana* Woodland.

20b. Understory species are sparse (<5% cover). This map class is restricted to steep scree slopes.

- Base Map Class: Douglas-fir Scree Woodland.
- Group Map Class: Southern Rocky Mountain Montane Mixed Conifer Forest.
- Management Map Class: Douglas-fir Mixed Forest.
- Association: *Pseudotsuga menziesii* Scree Woodland.

21a. Dominant tree species are deciduous trees. (22a)

21b. Dominant tree species are evergreens. (27a)

22a. Dominant species are *Populus deltoides*, *Elaeagnus angustifolia*, and/or *Tamarix* sp. Vegetation communities mainly occur in the floodplain where vegetation persists in areas with high water tables or temporary flooding occurs, scouring the surface. (23a)

22b. Dominant species include *Populus tremuloides*, *Acer negundo*, *Celtis reticulata*, and/or *Quercus gambelii*. Vegetation communities are not restricted to the floodplain. (24a)

23a. The canopy consists of a mix of *Populus deltoides*, *Elaeagnus angustifolia*, and *Tamarix* sp.

- Base Map Class: Rio Grande Cottonwood / Russian Olive Semi-natural Woodland.
- Group Map Class: Colorado Plateau Riparian Woodland and Shrubland.
- Management Map Class: Rio Grande Cottonwood / Russian Olive Semi-natural Woodland.
- Association: *Populus deltoides* ssp. *wislizeni* Disturbed Understory Woodland.

23b. The canopy is entirely dominated by *Elaeagnus angustifolia* and typically occurs in dense monocultures.

- Base Map Class: Russian Olive Woodland.
- Group Map Class: Colorado Plateau Riparian Woodland and Shrubland.
- Management Map Class: Russian Olive - Saltcedar Woodland and Shrubland.
- Association: *Elaeagnus angustifolia* Semi-natural Woodland.

24a. The canopy is dominated by *Populus tremuloides*. This vegetation community was only

identified from one location in a side canyon. The main understory species identified is the shrub, *Rhus trilobata*.

- Base Map Class: Quaking Aspen / Three-leaf Sumac Forest.
- Group Map Class: Rocky Mountain Aspen Forest and Woodland.
- Management Map Class: Quaking Aspen / Three-leaf Sumac Forest.
- Association: *Populus tremuloides* / *Rhus trilobata* Forest.

24b. The canopy is not as above. (25a)

25a. The canopy is dominated by *Quercus gambelii*. In the understory, a sparse to moderate shrub layer may be present. This association is known from talus slopes, on the canyon floor, and at the base of talus slopes.

- Base Map Class: Gambel Oak Woodland.
- Group Map Class: Rocky Mountain Gambel Oak-Mixed Montane Shrubland.
- Management Map Class: Mixed Conifer Gambel Oak Woodland.
- Association: *Quercus gambelii* Shrubland.

25b. The canopy is not as above. (26a)

26a. *Acer negundo* or *Celtis reticulata* dominate the canopy. *Artemisia tridentata* may also be present in the understory. This vegetation community has been found in moist, cool areas on the canyon floor and on canyon walls. This vegetation occurs in areas with relatively low disturbance; if disturbance is present, see 26b.

- Base Map Class: Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland.
- Group Map Class: Colorado Plateau Riparian Woodland and Shrubland.
- Management Map Class: Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland.
- Association: *Acer negundo* / *Artemisia tridentata* Woodland.

26b. *Acer negundo* entirely dominates the canopy. The vegetation commonly occurs in disturbed areas, including areas that are impacted by agriculture, residence development, and roads. Herbaceous and shrub cover may include non-native species that are common to areas with high disturbance.

- Base Map Class: Boxelder / Disturbed Understory Woodland.
- Group Map Class: Colorado Plateau Riparian Woodland and Shrubland.
- Management Map Class: Rubber Rabbitbrush - Prickly Pear Shrubland.
- Association: *Acer negundo* / Disturbed Understory Woodland.

27a. The canopy is either dominated or co-dominated by *Pinus edulis*, *Juniperus osteosperma*, or *Juniperus scopulorum*. *Pinus edulis/Juniperus osteosperma* woodlands are the most common wooded vegetation communities in the project area. (28a)

27b. The canopy is dominated or co-dominated with *Pinus ponderosa*. These vegetation communities are typically found at higher elevations in the central/eastern area of Canyon de Chelly National Monument and its environs. (41a)

28a. The understory is either sparsely vegetated or consists of a medium to tall shrub species, including *Amelanchier utahensis*, *Cercocarpus intricatus*, *Cercocarpus montanus*, *Fendlera rupicola*, *Purshia stansburiana*, *Quercus gambelii*, or *Quercus turbinella*. The vegetation community occurs on canyon walls and slopes, the canyon bottom, and the canyon rim. If not in this environment, check 28b before choosing. (29a)

28b. The understory is either sparsely vegetated or the dominant species in the understory may include the dwarf-shrub *Artemisia nova*, tall shrubs *Artemisia tridentata* or *Quercus gambelii*, and native and non-native grasses, including *Bouteloua gracilis*. The vegetation community occurs in upland environments. (36a)

29a. The understory is very sparse (<5% cover). The vegetation often occurs on dry, rocky areas in the canyon bottom, along canyon rims, and on steep talus slopes.

- Base Map Class: Two-needle Pinyon - Utah Juniper / Sparse Understory Wood-

land.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland.
- Association: *Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland.

29b. The understory is not sparse (>5% cover). (30a)

30a. *Amelanchier utahensis* occurs as an indicator species in the understory. The vegetation occurs on the walls and slopes of the canyon, on the cooler north and east-facing canyon rims. The understory can vary from sparse on steep slopes to dense on wetter side canyons.
- Base Map Class: Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Mixed Conifer Gambel Oak Woodland.
- Association: *Pinus edulis - Juniperus osteosperma* / *Amelanchier utahensis* Woodland.

30b. The understory does not include *Amelanchier utahensis*. (31a)

31a. *Cercocarpus intricatus* is an indicator species for this vegetation. The vegetation is often patchy, commonly occurs on dry exposed sandstone, and tends to grow between rock crevices.
- Base Map Class: Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland.
- Association: *Pinus edulis - Juniperus osteosperma* / *Cercocarpus intricatus* Woodland.

31b. The understory does not include *Cercocarpus intricatus*. (32a)

32a. The understory tends to be sparse with *Cercocarpus montanus* either dominating or co-dominating the shrub layer. Other shrubs may also co-occur in the understory including, *Quercus gambelii* and *Purshia stansburiana*. The vegetation commonly occurs on the canyon rims and on dry, sunny, and warm exposures on talus slopes.
- Base Map Class: Two-needle Pinyon - Juniper species / Mountain-mahogany Mixed Shrubs Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Two-needle Pinyon - Juniper species / Mountain-mahogany - Stansbury Cliff-rose Shrub Woodland.
- Association: *Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* Mixed Shrub Woodland.

32b. The shrub layer is not dominated or co-dominated by *Cercocarpus montanus*. (33a)

33a. *Fendlera rupicola* either dominates or co-dominates the shrub layer. It often occurs adjacent to stands of *Pseudotsuga menziesii* and/or *Quercus gambelii*. This vegetation occurs on steep canyon walls and slopes.
- Base Map Class: Two-needle Pinyon - Utah Juniper / Cliff Fendlerbush Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland.
- Association: *Pinus edulis - Juniperus osteosperma* / *Fendlera rupicola* Woodland.

33b. The shrub layer is not dominated or co-dominated by *Fendlera rupicola*. (34a)

34a. *Purshia stansburiana* dominates or co-dominates the shrub layer and *Poa fendleriana* often occurs as the dominant grass in the herbaceous layer. Some of the stands may have

a higher cover of *Poa fendleriana* than the *Purshia stansburiana* cover. The vegetation typically occurs on canyon rims and talus slopes and often occurs adjacent to *Pseudotsuga menziesii* stands in cooler habitat.

- Base Map Class: Two-needle Pinyon - Utah Juniper / Stansbury Cliff-rose Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Two-needle Pinyon - Juniper species / Mountain-mahogany - Stansbury Cliff-rose Shrub Woodland.
- Association: *Pinus edulis - Juniperus osteosperma* / *Purshia stansburiana* Woodland or *Pinus edulis - Juniperus osteosperma* / *Poa fendleriana* Woodland.

34b. The shrub layer is not dominated or co-dominated by *Purshia stansburiana*. (35a)

35a. *Juniperus scopulorum* may occur and occasionally can dominate the canopy. *Quercus gambelii* dominates the shrub layer and can also occur as a short tree in the canopy. *Quercus gambelii* often forms little clonal stands and can appear patchy in the understory. The vegetation occurs in cooler side canyons, north and east-facing talus slopes, on canyon rims, as well as in the uplands at higher elevations.

- Base Map Class: Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Mixed Conifer Gambel Oak Woodland.
- Association: *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland

35b. *Quercus turbinella* always occurs in the shrub layer and can occur in large patches. In areas with low vegetation cover, *Quercus turbinella* is the indicator. *Pinus edulis* and/or *Juniperus osteosperma* can vary between low to moderate cover. This vegetation almost always occurs on dry west or south-facing talus slopes or on large exposed sandstone bedrock flats near or on the canyon rim. This association is most often found at lower elevations.

- Base Map Class: Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland.
- Association: *Pinus edulis - Juniperus osteosperma* / *Quercus turbinella* Woodland.

36a. The understory is very sparse (<5% cover). Many of these areas have been previously impacted and have poor soil development.

- Base Map Class: Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland.
- Association: *Pinus edulis - Juniperus osteosperma* / Sparse Understory Woodland.

36b. The understory is not sparse (>5% cover). (37a)

37a. The dwarf-shrub *Artemisia nova* is the dominant understory species. This vegetation primarily is known from the eastern and southern end of the project area.

- Base Map Class: Two-needle Pinyon - Utah Juniper / Black Sagebrush Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Mixed Conifer Sagebrush Woodland.
- Association: *Pinus edulis - Juniperus* spp. / *Artemisia nova* Woodland.

37b. The dominant understory species is not as above. (38a)

38a. The shrub *Artemisia tridentata* is the dominant understory species.

- Base Map Class: Two-needle Pinyon - Juniper spp. / Big Sagebrush Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Mixed Conifer Sagebrush Woodland.

- Association: *Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland.

38b. The dominant understory species is not as above. (39a)

39a. The tall shrub or small tree, *Quercus gambelii* is the main species in the understory. *Quercus gambelii* often forms little clonal stands and can appear patchy in the understory.
- Base Map Class: Two-needle Pinyon - Juniper species / Gambel Oak Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Mixed Conifer Gambel Oak Woodland.
- Association: *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland.

39b. The dominant understory species is not as above. (40a)

40a. Grasses comprise the main understory component. The native grass, *Bouteloua gracilis*, is often the dominant species. Other grasses can also dominate the understory, such as *Bromus tectorum*, *Achnatherum hymenoides*, *Elymus elymoides*, and *Pleuraphis jamesii*. Shrubs, including *Ericameria nauseosa* and *Atriplex confertifolia*, can also occur in the understory. The tree cover varies between a savanna structure to dense woodland. This vegetation frequently occurs in lower elevations in the western half of the mapping area.
- Base Map Class: Two-needle Pinyon - Utah Juniper / Blue Grama Woodland.
- Group Map Class: Colorado Plateau Pinyon Juniper Woodland.
- Management Map Class: Two-needle Pinyon - Utah Juniper / Blue Grama Woodland.
- Association: *Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland.

40b. The main shrub is *Chrysothamnus greenei*. This vegetation tends to occur in disturbed areas. This association was not mappable and was included into the adjacent polygons. Association: *Pinus edulis - Juniperus osteosperma* / *Chrysothamnus greenei* Woodland. Continue with key to adjacent vegetation for vegetation identification. (41a)

41a. The understory is sparse (<5% cover) or is dominated by herbaceous vegetation. *Bouteloua gracilis* is the most common herbaceous species. However, *Bouteloua gracilis* does not need to be present in order to be included in this map class.
- Base Map Class: Ponderosa Pine / Blue Grama Woodland.
- Group Map Class: Southern Rocky Mountain Ponderosa Pine Woodland.
- Management Map Class: Mixed Conifer Sagebrush Woodland.
- Association: *Pinus ponderosa* / *Bouteloua gracilis* Woodland.

41b. The dominant understory species is not as above. (42a)

42a. The understory is either dominated or co-dominated by the dwarf-shrub *Artemisia nova* or the shrub *Artemisia tridentata*.
- Base Map Class: Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland.
- Group Map Class: Southern Rocky Mountain Ponderosa Pine Woodland.
- Management Map Class: Mixed Conifer Sagebrush Woodland.
- Association: *Pinus ponderosa* / *Artemisia nova* Woodland.

42b. *Quercus gambelii* occurs as a large shrub in the understory or as a small tree in the canopy. *Quercus gambelii* often grows in clonal patches. *Juniperus scopulorum* may occur in the canopy and occasionally can dominate the canopy.
- Base Map Class: Ponderosa Pine / Gambel Oak Woodland.
- Group Map Class: Southern Rocky Mountain Ponderosa Pine Woodland.
- Management Map Class: Mixed Conifer Gambel Oak Woodland.
- Association: *Pinus ponderosa* / *Quercus gambelii* Woodland.

Key D: Shrublands

Total vegetation cover is generally greater than 15% cover; in particularly dry sites vegetation cover can be as low as 5% cover. Tree cover is less than the total shrub cover and less than 15% cover, if tree cover is more than shrub cover then use Key C: Woodlands and Forests. The herbaceous cover is either equal to or less than the total shrub cover; if more, use Key B: Herbaceous. The dominant lifeform is shrubs.

43a. Shrublands occur on the canyon walls, canyon slopes, canyon floor, and in side canyons. (44a)

43b. Shrublands occur on the level areas in the uplands on mesas and plateaus and/or in the canyon bottom. (48a)

44a. The herbaceous shrub, *Brickellia californica*, occurs in dense patches on the canyon floor. Other herbaceous shrubs may also co-dominate or dominate this vegetation and may include *Artemisia ludoviciana*, *Brickellia californica*, and *Heterotheca villosa*.
- Base Map Class: California Brickelbush Shrubland.
- Group Map Class: Inter-Mountain Basins Semi-desert Shrub-steppe.
- Management Map Class: California Brickelbush Shrubland.
- Association: *Brickellia californica* Shrubland.

44b. Herbaceous shrubs do not occur in dense patches on the canyon floor. (45a)

45a. *Fendlera rupicola* co-dominates or dominates the shrub layer. Many other shrubs can occur in this map class, including *Amelanchier utahensis* and *Artemisia tridentata*. This map class generally occurs on talus slopes at the base of canyon walls and in cooler side canyons. It typically occurs on cooler north and east facing slopes.
- Base Map Class: Utah Serviceberry - Cliff Fendlerbush Shrubland.
- Group Map Class: Rocky Mountain Gambel Oak-Mixed Montane Shrubland.
- Management Map Class: Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland.
- Association: *Fendlera rupicola* Talus Shrubland.

45b. Dominant or co-dominant species not as above. (46a)

46a. *Amelanchier utahensis* co-dominates or dominates the shrub layer. Many other shrubs can occur in this map class, including *Artemisia tridentata* and *Chrysothamnus greenei*. This map class generally occurs on talus slopes at the base of canyon walls and in cooler side canyons. It typically occurs on cooler north and east facing slopes.
- Base Map Class: Utah Serviceberry - Cliff Fendlerbush Shrubland.
- Group Map Class: Rocky Mountain Gambel Oak-Mixed Montane Shrubland.
- Management Map Class: Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland.
- Association: *Amelanchier utahensis* Shrubland.

46b. *Quercus gambelii* occurs as a tall shrub or short tree and co-dominates or dominates the shrub layer. (47a)

47a. *Quercus gambelii* occurs in large clones and forms thick dense patches of vegetation. It is not co-dominated by other tall shrubs, however smaller shrubs and herbaceous species may occur in low cover (<10%) in the understory.
- Base Map Class: Gambel Oak Woodland.
- Group Map Class: Rocky Mountain Gambel Oak-Mixed Montane Shrubland.
- Management Map Class: Mixed Conifer Gambel Oak Woodland.
- Association: *Quercus gambelii* Shrubland.

47b. *Quercus gambelii* occurs as moderate to dense patches of trees or tall shrubs. A moderate shrub and herbaceous layer are present (>10%). *Fendlera rupicola* may dominate or co-dominate the shrub layer.

- Base Map Class: Gambel Oak / Cliff Fendlerbush Shrubland.
- Group Map Class: Rocky Mountain Gambel Oak-Mixed Montane Shrubland.
- Management Map Class: Mixed Conifer Gambel Oak Woodland.
- Association: *Quercus gambelii* / *Fendlera rupicola* Shrubland.

48a. *Artemisia tridentata* dominates or co-dominates the shrub layer. (49a)

48b. Dominant or co-dominant species not as above. Dominant species are *Ericameria nauseosa*, *Atriplex confertifolia*, *Opuntia* sp., or *Tamarix* sp. (51a)

49a. *Artemisia nova* dominates or co-dominates the shrub layer with *Artemisia tridentata*. *Pinus edulis*, *Juniperus osteosperma*, and *Pinus ponderosa* trees can occasionally occur in this vegetation; however, they generally occur with less than 10% cover. This map class typically occurs at higher elevations in the mapping area.

- Base Map Class: Big Sagebrush / Black Sagebrush Shrubland.
- Group Map Class: Inter Mountain Basins Big Sagebrush Shrubland.
- Management Map Class: Big Sagebrush / Natural and Semi-natural Understory Shrubland.
- Association: *Artemisia tridentata* ssp. *wyomingensis* / *Artemisia nova* Shrubland.

49b. *Artemisia nova* does not dominate or co-dominate the shrub layer. (50a)

50a. Native herbaceous species occur in the understory. *Bouteloua gracilis* is typically the main herbaceous species; however, in some areas other native grass and forbs may dominate the understory community.

- Base Map Class: Big Sagebrush / Blue Grama Shrubland.
- Group Map Class: Inter Mountain Basins Big Sagebrush Shrubland.
- Management Map Class: Big Sagebrush / Natural and Semi-natural Understory Shrubland.
- Association: *Artemisia tridentata* ssp. *wyomingensis* / *Bouteloua gracilis* Shrubland.

50b. Non-native species and disturbance-thriving native species dominate the herbaceous layer, including, but not limited to *Bromus tectorum* and *Erodium cicutarium*. This community often occurs adjacent to areas of disturbance, such as roads, streambeds, and agricultural areas.

- Base Map Class: Big Sagebrush / Disturbed Understory Semi-natural Shrubland.
- Group Map Class: Inter Mountain Basins Big Sagebrush Shrubland.
- Management Map Class: Big Sagebrush / Natural and Semi-natural Understory Shrubland.
- Association: *Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland.

51a. *Atriplex confertifolia*, a dwarf-shrub, is the dominant species. The vegetation generally has low total vegetation cover and commonly occurs on Chinle shale in the western half of the project area. If an herbaceous layer is present, the native grass *Pleuraphis jamesii* commonly occurs. If the vegetation occurs in a disturbed area, other non-native or disturbance-thriving herbaceous species such as *Bromus tectorum* may dominate the herbaceous layer.

- Base Map Class: Shadscale / Galleta Shrubland.
- Group Map Class: Inter-Mountain Basins Mixed Salt Desert Scrub.
- Management Map Class: Shadscale / Galleta Shrubland.
- Association: *Atriplex confertifolia* / *Pleuraphis jamesii* Shrubland.

51b. *Atriplex confertifolia* does not dominate the shrub layer. (52a)

52a. *Opuntia* sp., often in the form of a sprawling dwarf-shrub, dominates the shrub layer. It commonly occurs in flat broad expanses on the canyon bottom. Commonly, a low cover of disturbance-thriving herbaceous species may occur between the cacti interspaces. These herbaceous species may include *Bromus tectorum*, *Croton texensis*, *Erodium*

cicutarium, *Salsola kali*, and *Solanum elaeagnifolium*.

- Base Map Class: Prickly-pear Dwarf-shrubland.
- Group Map Class: Inter-Mountain Basins Semi-Desert Shrub-Steppe.
- Management Map Class: Rubber Rabbitbrush - Prickly Pear Shrubland.
- Association: *Opuntia* (*fragilis*, *polyacantha*, *phaeacantha*) Shrubland.

52b. *Opuntia* sp. does not dominate the shrub layer. (53a)

53a. *Ericameria nauseosa* typically dominates the shrub layer. Occasionally, shrubs such as Sarcobatus vermiculatus or Atriplex canescens dominate the shrub layer. The vegetation most commonly occurs in the flat expanses on the canyon bottom. The understory typically is covered with non-native herbaceous species, and may include *Bromus tectorum*, *Cirsium vulgare*, and *Cynodon dactylon*.

- Base Map Class: Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland.
- Group Map Class: Inter Mountain Basins Semi-desert Shrub Steppe.
- Management Map Class: Rubber Rabbitbrush - Prickly Pear Shrubland.
- Association: *Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland.

53b. *Ericameria nauseosa* does not typically dominate the shrub layer.

54a. *Tamarix* sp. dominates the shrub layer. This species often occurs as a tall shrub or a short tree and forms dense monocultures. This community generally occurs in riparian areas or in areas with a high water table, such as in washes or near stock tanks. *Tamarix* sp. is commonly associated with *Populus deltoides* and *Elaeagnus angustifolia*; however, only areas where *Populus deltoides* or *Elaeagnus angustifolia* were absent and *Tamarix* sp. dominated the shrub layer, were mapped as this vegetation type.

- Base Map Class: Saltcedar Temporarily Flooded Shrubland.
- Group Map Class: Colorado Plateau Riparian Woodland and Shrubland.
- Management Map Class: Russian Olive - Saltcedar Woodland and Shrubland.
- Association: *Tamarix* spp. Temporarily Flooded Semi-natural Shrubland.

54b. *Salix exigua* dominates the shrub layer. This species often occurs in areas with surface water or periodic flooding. *Salix exigua* generally occurs in dense patches and is associated with a mixed herbaceous vegetation community.

- Base Map Class: Mixed Riparian Herbaceous.
- Group Map Class: Colorado Plateau Riparian Woodland and Shrubland.
- Management Map Class: Mixed Riparian Herbaceous Vegetation.
- Park Special: Mixed Riparian Herbaceous Vegetation.

Appendix F: Plant Community and Map Class Crosswalk

The table below provides a crosswalk among the plant communities (associations and park specials) of Canyon de Chelly National Monument and their base, group, and management map classes to which they were assigned in this project. Each plant community is in only one map class for each schema, but each map class may contain more than one plant community. The CEGL code is the community element code assigned to the associations currently registered in the NatureServe Explorer database (http://www.natureserve.org/explorer).

Three plant communities observed in the field (*Juniperus scopulorum - Quercus gambelii* Woodland, *Pinus edulis - Juniperus osteosperma / Chrysothamnus greenei* Woodland, and *Pinus edulis - Juniperus osteosperma / Ephedra viridis* Woodland) occurred in small patches that were indistinguishable on aerial photography. They occur as inclusions within the particular polygons which surrounded them.

	Plant communities (associations) and park specials	CEGL Code	Base map class		Group map class		Management map class	
FOREST								
1	*Populus tremuloides* / *Rhus trilobata* Forest	None	B3	Quaking Aspen / Three-leaf Sumac Forest	G11	Rocky Mountain Aspen Forest and Woodland	M15	Quaking Aspen / Three-leaf Sumac Forest
2	*Pseudotsuga menziesii* / *Populus deltoides* Forest	None	B2	Douglas-fir / Rio Grande Cottonwood Forest	G13	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland	M7	Douglas-fir Mixed Forest
3	*Pseudotsuga menziesii* / *Quercus gambelii* Forest	CEGL000452	B1	Douglas-fir / Gambel Oak Forest	G13	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland	M7	Douglas-fir Mixed Forest
WOODLAND								
4	*Acer negundo* / *Artemisia tridentata* Woodland	None	B4	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland	G5	Colorado Plateau Riparian Woodland and Shrubland	M5	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland
5	*Acer negundo* / Disturbed Understory Woodland	CEGL002693	B5	Boxelder / Disturbed Understory Woodland	G5	Colorado Plateau Riparian Woodland and Shrubland	M17	Rubber Rabbitbrush - Prickly Pear Shrubland
6	*Elaeagnus angustifolia* Semi-natural Woodland	CEGL005269	B12	Russian Olive Woodland	G5	Colorado Plateau Riparian Woodland and Shrubland	M18	Russian Olive - Saltcedar Woodland and Shrubland
7	*Juniperus scopulorum* - *Quercus gambelii* Woodland [Provisional]	CEGL002967		Occur as inclusions within surrounding polygons		Occur as inclusions within surrounding polygons		Occur as inclusions within surrounding polygons
8	*Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland	CEGL000778	B17	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland	G4	Colorado Plateau Pinyon Juniper Woodland	M26	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland
9	*Pinus edulis* - *Juniperus osteosperma* / *Amelanchier utahensis* Woodland	CEGL002329	B23	Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland	G4	Colorado Plateau Pinyon Juniper Woodland	M9	Mixed Conifer Gambel Oak Woodland
10	*Pinus edulis* - *Juniperus osteosperma* / *Artemisia nova* Woodland	CEGL002331	B16	Two-needle Pinyon - Utah Juniper / Black Sagebrush Woodland	G4	Colorado Plateau Pinyon Juniper Woodland	M10	Mixed Conifer Sagebrush Woodland
11	*Pinus edulis* - *Juniperus osteosperma* / *Cercocarpus intricatus* Woodland	CEGL000779	B19	Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland	G4	Colorado Plateau Pinyon Juniper Woodland	M27	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland
12	*Pinus edulis* - *Juniperus osteosperma* / *Chrysothamnus greenei* Woodland	None		Occur as inclusions within surrounding polygons		Occur as inclusions within surrounding polygons		Occur as inclusions within surrounding polygons
13	*Pinus edulis* - *Juniperus osteosperma* / *Ephedra viridis* Woodland	CEGL002370		Occur as inclusions within surrounding polygons		Occur as inclusions within surrounding polygons		Occur as inclusions within surrounding polygons
14	*Pinus edulis* - *Juniperus osteosperma* / *Fendlera rupicola* Woodland	CEGL004005	B18	Two-needle Pinyon - Utah Juniper / Cliff Fendlerbush Woodland	G4	Colorado Plateau Pinyon Juniper Woodland	M27	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland
15	*Pinus edulis* - *Juniperus osteosperma* / *Purshia stansburiana* Woodland	CEGL000782	B22	Two-needle Pinyon - Utah Juniper / Stansbury Cliffrose Woodland	G4	Colorado Plateau Pinyon Juniper Woodland	M25	Two-needle Pinyon - Juniper spp. / Mountain-mahogany - Stansbury Cliffrose Shrub Woodland
16	*Pinus edulis* - *Juniperus osteosperma* / *Quercus turbinella* Woodland	CEGL004007	B20	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland	G4	Colorado Plateau Pinyon Juniper Woodland	M27	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland
17	*Pinus edulis* - *Juniperus osteosperma* / Sparse Understory Woodland	CEGL002148	B21	Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland	G4	Colorado Plateau Pinyon Juniper Woodland	M27	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland

Plant communities (associations) and park specials	CEGL Code	Base map class	Group map class	Management map class
18 *Pinus edulis - Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland	CEGL000776	B13 Two-needle Pinyon - Juniper spp. / Big Sagebrush Woodland	G4 Colorado Plateau Pinyon Juniper Woodland	M10 Mixed Conifer Sagebrush Woodland
19 *Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* Mixed Shrubs Woodland	CEGL000780	B15 Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland	G4 Colorado Plateau Pinyon Juniper Woodland	M25 Two-needle Pinyon - Juniper spp. / Mountain-mahogany - Stansbury Cliffrose Shrub Woodland
20 *Pinus edulis - Juniperus* spp. / *Poa fendleriana* Woodland	CEGL000787	B22 Two-needle Pinyon - Utah Juniper / Stansbury Cliffrose Woodland	G4 Colorado Plateau Pinyon Juniper Woodland	M25 Two-needle Pinyon - Juniper spp. / Mountain-mahogany - Stansbury Cliffrose Shrub Woodland
21 *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland	CEGL000791	B14 Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland	G4 Colorado Plateau Pinyon Juniper Woodland	M9 Mixed Conifer Gambel Oak Woodland
22 *Pinus ponderosa* / *Artemisia nova* Woodland	CEGL000846	B8 Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland	G14 Southern Rocky Mountain Ponderosa Pine Woodland	M10 Mixed Conifer Sagebrush Woodland
23 *Pinus ponderosa* / *Artemisia tridentata* ssp. *vaseyana* Woodland	CEGL002794	B8 Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland	G14 Southern Rocky Mountain Ponderosa Pine Woodland	M10 Mixed Conifer Sagebrush Woodland
24 *Pinus ponderosa* / *Bouteloua gracilis* Woodland	CEGL000848	B9 Ponderosa Pine / Blue Grama Woodland	G14 Southern Rocky Mountain Ponderosa Pine Woodland	M10 Mixed Conifer Sagebrush Woodland
25 *Pinus ponderosa* / *Quercus gambelii* Woodland	CEGL000870	B10 Ponderosa Pine / Gambel Oak Woodland	G14 Southern Rocky Mountain Ponderosa Pine Woodland	M9 Mixed Conifer Gambel Oak Woodland
26 *Populus deltoides* ssp. wislizeni / Disturbed Understory Woodland	CEGL003810	B11 Rio Grande Cottonwood / Russian Olive Semi-natural Woodland	G5 Colorado Plateau Riparian Woodland and Shrubland	M16 Rio Grande Cottonwood / Russian Olive Semi-natural Woodland
27 *Pseudotsuga menziesii* / *Poa fendleriana* Woodland	CEGL002809	B6 Douglas-fir / Muttongrass Woodland	G13 Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland	M7 Douglas-fir Mixed Forest
28 *Pseudotsuga menziesii* Scree Woodland	CEGL000911	B7 Douglas-fir Scree Woodland	G13 Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland	M7 Douglas-fir Mixed Forest
SHRUBLAND				
29 *Amelanchier utahensis* Shrubland	CEGL001067	B33 Utah Serviceberry - Cliff Fendlerbush Shrubland	G12 Rocky Mountain Gambel Oak-Mixed Montane Shrubland	M27 Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland
30 *Artemisia tridentata* ssp. *wyomingensis* / *Artemisia nova*		B24 Big Sagebrush / Black Sagebrush Shrubland	G6 Inter-Mountain Basins Big Sagebrush Shrubland	M3 Big Sagebrush / Natural and Semi-natural Understory Shrubland
31 *Artemisia tridentata* ssp. *wyomingensis* / *Bouteloua gracilis* Shrubland	CEGL001041	B25 Big Sagebrush / Blue Grama Shrubland	G6 Inter-Mountain Basins Big Sagebrush Shrubland	M3 Big Sagebrush / Natural and Semi-natural Understory Shrubland
32 *Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland	CEGL002083	B26 Big Sagebrush / Disturbed Understory Semi-natural Shrubland	G6 Inter-Mountain Basins Big Sagebrush Shrubland	M3 Big Sagebrush / Natural and Semi-natural Understory Shrubland
33 *Atriplex confertifolia* / *Pleuraphis jamesii* Shrubland	CEGL001304	B32 Shadscale / Galleta Shrubland	G7 Inter-Mountain Basins Mixed Salt Desert Scrub	M21 Shadscale / Galleta Shrubland
34 *Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland	CEGL002937	B30 Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland	G9 Inter-Mountain Basins Semi-desert Shrub-Steppe	M17 Rubber Rabbitbrush - Prickly Pear Shrubland

Plant communities (associations) and park specials	CEGL Code	Base map class	Group map class	Management map class
35 *Fendlera rupicola* Talus Shrubland	CEGL002765	B33 Utah Serviceberry - Cliff Fendlerbush Shrubland	G12 Rocky Mountain Gambel Oak-Mixed Montane Shrubland	M27 Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland
36 *Opuntia* (*fragilis*, *polyacantha*, *phaeacantha*) Shrubland	CEGL004009	B29 Prickly-pear Dwarf-shrubland	G9 Inter-Mountain Basins Semi-desert Shrub-Steppe	M17 Rubber Rabbitbrush - Prickly Pear Shrubland
37 *Quercus gambelii* / *Fendlera rupicola* Shrubland	CEGL004010	B27 Gambel Oak / Cliff Fendlerbush Shrubland	G12 Rocky Mountain Gambel Oak-Mixed Montane Shrubland	M9 Mixed Conifer Gambel Oak Woodland
38 *Quercus gambelii* Shrubland	CEGL002477	B28 Gambel Oak Woodland	G12 Rocky Mountain Gambel Oak-Mixed Montane Shrubland	M9 Mixed Conifer Gambel Oak Woodland
39 *Tamarix* spp. Temporarily Flooded Semi-natural Shrubland		B31 Saltcedar Temporily Flooded Shrubland	G5 Colorado Plateau Riparian Woodland and Shrubland	M18 Russian Olive - Saltcedar Woodland and Shrubland
HERBACEOUS				
40 *Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation	CEGL002343	B39 Indian Ricegrass Colorado Plateau Herbaceous Vegetation	G8 Inter-Mountain Basins Semi-desert Grassland	M13 Mixed Upland Herbaceous Vegetation
41 *Agropyron desertorum* Semi-natural Herbaceous Vegetation	None	B38 Desert Wheatgrass Herbaceous Vegetation	G8 Inter-Mountain Basins Semi-desert Grassland	M13 Mixed Upland Herbaceous Vegetation
42 *Artemisia bigelovii* / *Bouteloua gracilis* Dwarf-shrub Herbaceous Vegetation	CEGL001742	B34 Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation	G3 Colorado Plateau Mixed Bedrock and Tableland	M17 Rubber Rabbitbrush - Prickly Pear Shrubland
43 *Bouteloua gracilis* Herbaceous Vegetation	CEGL001760	B35 Blue Grama Herbaceous Vegetation	G8 Inter-Mountain Basins Semi-desert Grassland	M4 Blue Grama Herbaceous Vegetation
44 *Brickellia californica* Shrubland	None	B36 California Brickelbush Shrubland	G9 Inter-Mountain Basins Semi-desert Shrub-Steppe	M6 California Brickelbush Shrubland
45 *Bromus tectorum* Semi-natural Herbaceous Vegetation	CEGL003019	B37 Cheatgrass Herbaceous Vegetation	G8 Inter-Mountain Basins Semi-desert Grassland	M13 Mixed Upland Herbaceous Vegetation
46 *Juniperus osteosperma* / *Ephedra viridis* / *Bromus tectorum* Wooded Herbaceous Vegetation	None	B42 Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation	G9 Inter-Mountain Basins Semi-desert Shrub-Steppe	M28 Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation
47 Mixed Riparian Herbaceous Vegetation	None	B40 Mixed Riparian Herbaceous	G5 Colorado Plateau Riparian Woodland and Shrubland	M12 Mixed Riparian Herbaceous Vegetation
48 Mixed Weedy Herbaceous Vegetation	None	B41 Mixed Weedy Herbaceous	G8 Inter-Mountain Basins Semi-desert Grassland	M13 Mixed Upland Herbaceous Vegetation
LAND USE/LANDFORMS				
	None	B43 Artificial Catchment	G1 Agriculture	M1 Artificial Catchment
	None	B44 Barren Wash Bottom	G2 Barren	M2 Barren Wash Bottom
	None	B45 Major Roads	G15 Transportation	M8 Major Roads
	None	B46 Mixed Urban Chinle	G10 Residential	M14 Mixed Urban Chinle
	None	B47 Mixed Urban Monument	G10 Residential	M11 Mixed Monument and Rim Rural Residential
	None	B48 Rim Agriculture	G1 Agriculture	M11 Mixed Monument and Rim Rural Residential

Plant communities (associations) and park specials	CEGL Code	Base map class	Group map class	Management map class
	None	B49 Sand Dunes	G2 Barren	M19 Sand Dunes
	None	B50 Sandstone Rock	G2 Barren	M20 Sandstone Rock
	None	B51 Traditional Community-Use Agriculture (Canyon del Chelly)	G1 Agriculture	M22 Traditional Community-Use Agriculture (Canyon de Chelly)
	None	B52 Traditional Community-Use Agriculture (Canyon del Muerto)	G1 Agriculture	M23 Traditional Community-Use Agriculture (Canyon del Muerto)
	None	B53 Tsaile Lake	G16 Water	M24 Tsaile Lake

Appendix G: Base Map Class Summaries

These map class summaries provide statistics for each base map class, list the group and management classes for each base map class, and show accuracy results for all three map-class levels. The photointerpreter provided examples of the base map-class photosignature and comments on the aerial photo interpretation of the base map class. A field photograph of a characteristic view of most, but not all, base map classes is also provided. Field photographs are the top photo in each summary; photosignature images are the bottom image.

* **Please note** that while the number labels on the aerial photographs in Appendix G do indicate the base map class photosignature being described, the numbers themselves have no other meaning or correspondence to map class numbers.

B1 Douglas-fir / Gambel Oak Forest



Figure G1. Ground photo for map class B1, Douglas-fir / Gamble Oak Forest.



Figure G2. Photosignature for map class B1, Douglas-fir / Gamble Oak Forest.

Location: The Douglas-fir / Gambel Oak Forest map class typically occurs on north-facing, cool slopes. It also often occurs in side canyons with steep slopes.

Photosignature: *Pseudotsuga menziesii* trees are tall and conical with pointed canopies and a deep, 'forest' green coloring. *Amelanchier utahensis* often occurs as a major understory component and may be more prevalent than *Quercus gambelii*. *Quercus gambelii* fills in the canopy gaps and generally grows as dense solid green stands among the tall spikes of *Pseudotsuga menziesii*.

Plant communities	*Pseudotsuga menziesii* / *Quercus gambelii* Forest
Group map class	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland (1 of 4)
Management map class	Douglas-fir Mixed Forest (1 of 4)
Number of map units in park & environs	137
Number of map units in park	133
Number of map units less than 0.5 ha	17 (0.3% of total map class area)
Area of map class in park	1598.3 ha / 3949.6 ac
Area of map class in park & environs	1614.0 ha / 3988.2 ac
Proportion of map class in park	4.3%
Proportion of map class in project environs	1.0%
Base map class accuracy	user 60.0 (35.2 - 80.6), producer 85.7 (54.8 - 96.7)
Group map class accuracy	user 62.5 (42.2 - 79.2), producer 90.9 (67.7 - 97.9)
Management map class accuracy	user 62.5 (42.2 - 79.2), producer 90.9 (67.7 - 97.9)
Documentation for base map class	8 2004 relèves, 1 2001/02 plot

B2 Douglas-fir / Rio Grande Cottonwood Forest



Figure G3. Ground photo for map class B2, Douglas-fir / Rio Grande Cottonwood Forest.



Figure G4. Photosignature for map class B2, Douglas-fir / Rio Grande Cottonwood Forest.

Location: This community is found in the eastern extents of the canyons, in sheltered narrow side canyons along the streambeds. This community commonly occurs in the transition zone between the cool side canyon communities and the riparian communities. It is also found against the talus slopes, where the boundaries of *Pseudotsuga menziesii* and *Populus deltoides* mix.

Photosignature: This community occurs as a mix of the dark green conical *Pseudotsuga menziesii* canopy and the broad, lighter green, fluffy-texture of *Populus deltoides*.

Plant communities	*Pseudotsuga menziesii* / *Populus deltoides* Forest
Group map class	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland (1 of 4)
Management map class	Douglas-fir Mixed Forest (1 of 4)
Number of map units in park & environs	5
Number of map units in park	5
Number of map units less than 0.5 ha	3 (41.7% of total map class area)
Area of map class in park	3.1 ha / 7.6 ac
Area of map class in park & environs	3.1 ha / 7.6 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 66.7 (25.4 - 92.2), producer 66.7 (25.4 - 92.2)
Group map class accuracy	user 62.5 (42.2 - 79.2), producer 90.9 (67.7 - 97.9)
Management map class accuracy	user 62.5 (42.2 - 79.2), producer 90.9 (67.7 - 97.9)
Documentation for base map class	1 2004 relève, 0 2001/02 plots,

B3 Quaking Aspen / Three-leaf Sumac Forest



Figure G5. Ground photo for map class B3, Quaking Aspen / Three-leaf Sumac Forest.



Figure G6. Photosignature for map class B3, Quaking Aspen / Three-leaf Sumac Forest.

Location: This map class is known from one location in the eastern end of the monument, not far from Sonsela Buttes at the upstream end of a side canyon. It intergrades with the *Pinus edulis* and *Juniperus osteosperma* dominated map classes downstream.

Photosignature: The color is a bit lighter and grayer than the adjacent *Pinus edulis* and *Juniperus osteosperma* map classes. The texture of the canopy is obviously coarse. Individual tree canopies are quite small with various heights. This gives the texture of the photosignature a coarser look than a more uniform canopy. The canopy is dense and appears to cover the entire surface. An example polygon is shown within the yellow outline in the image.

Plant communities	*Populus tremuloides* / *Rhus trilobata* Forest
Group map class	Rocky Mountain Aspen Forest and Woodland (1 of 1)
Management map class	Quaking Aspen / Three-leaf Sumac Forest (1 of 1)
Number of map units in park & environs	1
Number of map units in park	1
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	1.0 ha / 2.4 ac
Area of map class in park & environs	1.0 ha / 2.4 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Group map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Management map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Documentation for base map class	1 2004 relève, 0 2001/02 plots

B4 Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland



Figure G7. Ground photo for map class B4, Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland.



Figure G8. Photosignature for map class B4, Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland.

Location: This map class is typically identified by the presence of boxelder (*Acer negundo*). *Acer negundo* typically occurs in moist areas along the canyon floor and on canyon walls. This community occurs in sheltered areas often adjacent to the canyon walls, in small fairly isolated stands on deeper soils within a talus slope, or on the edge of a side canyon in small linear strips.

Photosignature: *Acer negundo* communities often occur as a very light, bright green patch. This canopy is easy to identify, since it contrasts greatly with the other vegetation in the area. The *Artemisia tridentata* understory is difficult to identify under the canopy. This map class by default is catch-all for all undisturbed *Acer negundo* communities. This community often has a co-occurrence of *Celtis reticulata* in the canopy. An example polygon (labeled 4) is shown in the image.

Plant communities	*Acer negundo* / *Artemisia tridentata* Woodland
Group map class	Colorado Plateau Riparian Woodland and Shrubland (1 of 5)
Management map class	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland (1 of 1)
Number of map units in park & environs	11
Number of map units in park	11
Number of map units less than 0.5 ha	7 (22.1% of total map class area)
Area of map class in park	9.2 ha / 22.7 ac
Area of map class in park & environs	9.2 ha / 22.7 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 0.0 (NA), producer NS (NS)
Group map class accuracy	user 86.9 (78.2 - 92.4), producer 76.8 (67.5 - 84.1)
Management map class accuracy	user 0.0 (NA), producer NS (NS)
Documentation for base map class	1 2004 relève, 0 2001/02 plots

B5 Boxelder / Disturbed Understory Woodland



Figure G9. Ground photo for map class B5, Boxelder / Disturbed Understory Woodland.



Figure G10. Photosignature for map class B5, Boxelder / Disturbed Understory Woodland.

Location: This community is also identified by the presence of boxelder (*Acer negundo*). *Acer negundo* generally occurs in moist, cool areas. It often occurs in narrow strips in side canyon or as small patches in the deeper soils on the canyon walls. The difference between this map class and the Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland community is that this community has a disturbed understory community. This map class often occurs adjacent to areas that have been modified through various land use activities, including agriculture, residences, and transportation corridors.

Photosignature: This photosignature occurs as a light green canopy with a mixture of spotted understory striations, indicative of land use disturbance.

Plant communities	*Acer negundo* / Disturbed Understory Woodland
Group map class	Colorado Plateau Riparian Woodland and Shrubland (1 of 5)
Management map class	Rubber Rabbitbrush - Prickly Pear Shrubland (1 of 4)
Number of map units in park & environs	1
Number of map units in park	0
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	0 ha / 0 ac
Area of map class in park & environs	0.9 ha / 2.3 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	100.0%
Base map class accuracy	user NS (NS), producer 0.0 (NA)
Group map class accuracy	user 86.9 (78.2 - 92.4), producer 76.8 (67.5 - 84.1)
Management map class accuracy	user 77.6 (66.5 - 85.8), producer 74.5 (63.4 - 83.1)
Documentation for base map class	1 2004 relève, 0 2001/02 plots

B6 Douglas-fir / Muttongrass Woodland



Figure G11. Ground photo for map class B6, Douglas-fir / Muttongrass Woodland.



Figure G12. Photosignature for map class B6, Douglas-fir / Muttongrass Woodland.

Location: This map class typically occurs on steep cooler scree slopes in central to eastern areas of the monument. In the main canyons this map class tends to occur on the north and east-facing slopes. It is also found on the steep canyon walls of the side canyons that have less sun exposure. In the eastern section of the monument, this map class grades into the *Pinus ponderosa* map classes on top of the canyon rim and into the *Pseudotsuga menziesii* communities with a dense *Quercus gambelii* understory community on the canyon bottom.

Photosignature: *Pseudotsuga menziesii* occurs as a tall, dark green, conical shape tree. The *Poa fendleriana* understory occurs as a homogenous light blue-green color. The understory is often difficult to discern when the map class is identified on the steep scree slopes. This photosignature can be distinguished from the other *Pseudotsuga menziesii* map classes by the absence of the dark green, blob-like texture of the *Quercus gambelii* and the presence of the pale, blue-green ground cover of *Poa fendleriana* in the understory.

Plant communities	*Pseudotsuga menziesii / Poa fendleriana* Woodland
Group map class	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland (1 of 4)
Management map class	Douglas-fir Mixed Forest (1 of 4)
Number of map units in park & environs	13
Number of map units in park	13
Number of map units less than 0.5 ha	1 (0.8% of total map class area)
Area of map class in park	59.3 ha / 146.5 ac
Area of map class in park & environs	59.3 ha / 146.5 ac
Proportion of map class in park	0.2%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 33.3 (7.8 - 74.6), producer 100.0 (27.0 - 100.0)
Group map class accuracy	user 62.5 (42.2 - 79.2), producer 90.9 (67.7 - 97.9)
Management map class accuracy	user 62.5 (42.2 - 79.2), producer 90.9 (67.7 - 97.9)
Documentation for base map class	2 2004 relèves, 1 2001/02 plots

B7 Douglas-fir Scree Woodland



Figure G13. Ground photo for map class B7, Douglas-fir Scree Woodland.



Figure G14. Photosignature for map class B7, Douglas-fir Scree Woodland.

Location: This map class occurs on very steep scree slopes in the central to eastern areas of the monument. The scree slopes tend to be steep, with shallow soils, preventing the establishment of understory communities. The understory communities are sparse to absent. This map class generally occurs on the north and east-facing slopes. It also occurs on the steep shady side canyon walls. This map class is transitional to the *Pinus ponderosa* map classes on the top of the canyon rim in the eastern section of the monument and into the *Pseudotsuga menziesii / Quercus gambelii* map class in the canyon bottom.

Photosignature: *Pseudotsuga menziesii* canopy occurs as a tall, conical shape with a dark green color. This map class is distinguished from the other *Pseudotsuga menziesii* map classes by the absence of the dark, blotchy *Quercus gambelii* in the understory and absence of the pale, blue-green ground cover of *Poa fendleriana*. Examples are shown in the polygons labeled 7 on the image.

Plant communities	*Pseudotsuga menziesii* Scree Woodland
Group map class	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland (1 of 4)
Management map class	Douglas-fir Mixed Forest (1 of 4)
Number of map units in park & environs	12
Number of map units in park	12
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	48.3 ha / 119.4 ac
Area of map class in park & environs	48.3 ha / 119.4 ac
Proportion of map class in park	0.1%
Proportion of map class in project environs	0.0%
Base map class accuracy	Not accuracy assessed.
Group map class accuracy	user 62.5 (42.2 - 79.2), producer 90.9 (67.7 - 97.9)
Management map class accuracy	user 62.5 (42.2 - 79.2), producer 90.9 (67.7 - 97.9)
Documentation for base map class	1 2004 relève, 1 2001/02 plots

B8 Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland



Figure G15. Ground photo for map class B8, Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland.



Figure G16. Photosignature for map class B8, Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland.

Location: This map class occurs in the eastern area of the monument on the canyon top, above the rim. The *Pinus ponderosa* woodlands are transitional to the *Pinus edulis / Juniperus osteosperma* woodlands and typically occur at higher elevation in the monument. It is particularly common downstream of Tsaile Lake.

Photosignature: *Pinus ponderosa* typically occurs as an open canopy with dark green conical trees. The understory community is a medium green color. *Artemisia nova* was not distinguishable on the aerial photos from the *Artemisia tridentata* shrubs. These two species are likely to co-occur in some of the polygons in this map class and in some cases *Artemisia tridentata* may be more the dominant shrub in the understory community. Based on field data, we determined *Artemisia nova* is the major shrub component under *Pinus ponderosa* in the eastern section of the monument. The polygon labeled 11 in the image illustrates the photosignature of this map class.

Plant communities	*Pinus ponderosa / Artemisia nova* Woodland; *Pinus ponderosa / Artemisia tridentata* ssp. *vaseyana* Woodland
Group map class	Southern Rocky Mountain Ponderosa Pine Woodland (1 of 3)
Management map class	Mixed Conifer Sagebrush Woodland (1 of 4)
Number of map units in park & environs	69
Number of map units in park	33
Number of map units less than 0.5 ha	16 (0.6% of total map class area)
Area of map class in park	280.6 ha / 693.3 ac
Area of map class in park & environs	682.9 ha / 1687.4 ac
Proportion of map class in park	0.7%
Proportion of map class in project environs	58.9%
Base map class accuracy	user 25.0 (13.5 - 41.5), producer 46.2 (26.1 - 67.5)
Group map class accuracy	user 68.8 (58.6 - 77.4), producer 89.8 (80.5 - 94.9)
Management map class accuracy	user 75.3 (67.4 - 81.7), producer 77.7 (69.9 - 83.9)
Documentation for base map class	2 2004 relèves, 1 2001/02 plots

B9 Ponderosa Pine / Blue Grama Woodland



Figure G17. Ground photo for map class B9, Ponderosa Pine / Blue Grama Woodland.

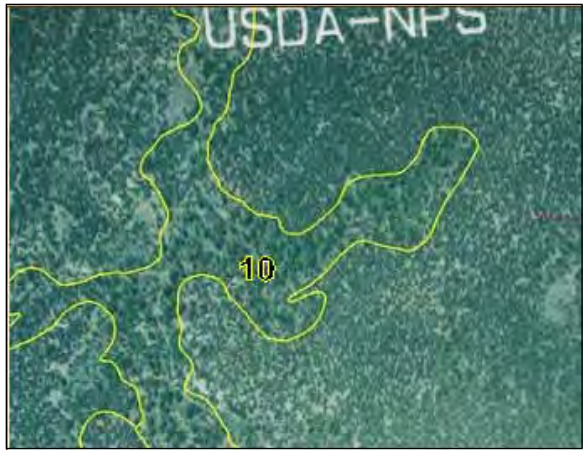


Figure G18. Photosignature for map class B9, Ponderosa Pine / Blue Grama Woodland.

Location: This class commonly occurs in the central and eastern areas of the monument on the upland areas above the canyon. It is transitional to the *Pinus edulis* / *Juniperus osteosperma* woodlands and gradates into this map class at higher elevations.

Photosignature: *Pinus ponderosa*'s canopy tends to be darker, denser, and more of a conical shape than the adjacent *Pinus edulis* canopy. The *Bouteloua gracilis* understory shows up as a light green to light brown color. This understory community was not distinguishable from other grass species and sparse vegetation. This map class was delineated as the general category for *Pinus ponderosa* woodlands with a grass or sparse understory. See polygon 10 in the image.

Plant communities	*Pinus ponderosa* / *Bouteloua gracilis* Woodland
Group map class	Southern Rocky Mountain Ponderosa Pine Woodland (1 of 3)
Management map class	Mixed Conifer Sagebrush Woodland (1 of 4)
Number of map units in park & environs	157
Number of map units in park	113
Number of map units less than 0.5 ha	13 (0.3% of total map class area)
Area of map class in park	810.9 ha / 2003.7 ac
Area of map class in park & environs	1508.8 ha / 3728.3 ac
Proportion of map class in park	2.2%
Proportion of map class in project environs	46.3%
Base map class accuracy	user 20.0 (9.3 - 37.8), producer 57.1 (28.9 - 81.4)
Group map class accuracy	user 68.8 (58.6 - 77.4), producer 89.8 (80.5 - 94.9)
Management map class accuracy	user 75.3 (67.4 - 81.7), producer 77.7 (69.9 - 83.9)
Documentation for base map class	0 2004 relèves, 2 2001/02 plots

B10 Ponderosa Pine / Gambel Oak Woodland



Figure G19. Ground photo for map class B10, Ponderosa Pine / Gambel Oak Woodland.



Figure G20. Photosignature for map class B10, Ponderosa Pine / Gambel Oak Woodland.

Location: This map class occurs mainly in the eastern section of the monument at higher elevations on top of the canyon. This map class is transitional from the lower elevation *Pinus edulis / Juniperus osteosperma* woodlands.

Photosignature: *Pinus ponderosa* is identified by its tall height and broad, rounded canopy, and dark green open canopy. Intermixed with the *Pinus ponderosa* trees is a fluffy, dark understory of *Quercus gambelii*. This map class appears rather dense and dark on the photos, as illustrated in polygon 12 on the image.

Plant communities	*Pinus ponderosa / Quercus gambelii* Woodland
Group map class	Southern Rocky Mountain Ponderosa Pine Woodland (1 of 3)
Management map class	Mixed Conifer Gambel Oak Woodland (1 of 5)
Number of map units in park & environs	95
Number of map units in park	88
Number of map units less than 0.5 ha	11 (0.1% of total map class area)
Area of map class in park	1578.9 ha / 3901.7 ac
Area of map class in park & environs	3226.2 ha / 7972.2 ac
Proportion of map class in park	4.2%
Proportion of map class in project environs	51.1%
Base map class accuracy	user 45.0 (28.4 - 62.8), producer 45.0 (28.4 - 62.8)
Group map class accuracy	user 68.8 (58.6 - 77.4), producer 89.8 (80.5 - 94.9)
Management map class accuracy	user 52.4 (42.1 - 62.4), producer 62.3 (51.0 - 71.4)
Documentation for base map class	5 2004 relèves, 2 2001/02 plots

B11 Rio Grande Cottonwood / Russian Olive Semi-natural Woodland



Figure G21. Ground photo for map class B11, Rio Grande Cottonwood / Russian Olive Semi-natural Woodland.



Figure G22. Photosignature for map class B11, Rio Grande Cottonwood / Russian Olive Semi-natural Woodland.



Figure G23. Aerial photo for map class B11, Rio Grande Cottonwood / Russian Olive Semi-natural Woodland.

Location: This is a riparian map class and is mainly found in the canyon bottoms along the stream banks. It occasionally occurs in upland areas around springs or in areas with a high water table.

Photosignature: *Populus deltoides* (PODE) occurs as tall light green trees with a large round canopy. The canopy is often intermixed with *Elaeagnus angustifolia* (ELAN), a medium gray green to silvery smaller tree. Both trees have a soft, clumpy texture. Tamarisk species occasionally occur in this map class as a dark green smooth textured shrub, especially at the junction of Canyon de Chelly and Canyon del Muerto.

Plant communities	*Populus deltoides* ssp. *wislizeni* / Disturbed Understory Woodland
Group map class	Colorado Plateau Riparian Woodland and Shrubland (1 of 5)
Management map class	Rio Grande Cottonwood / Russian Olive Semi-Natural Woodland (1 of 1)
Number of map units in park & environs	121
Number of map units in park	104
Number of map units less than 0.5 ha	34 (1.2% of total map class area)
Area of map class in park	806.7 ha / 1993.3 ac
Area of map class in park & environs	863.2 ha / 2133.1 ac
Proportion of map class in park	2.2%
Proportion of map class in project environs	6.6%
Base map class accuracy	user 69.2 (53.1 - 81.7), producer 85.7 (69.1 - 94.1)
Group map class accuracy	user 86.9 (78.2 - 92.4), producer 76.8 (67.5 - 84.1)
Management map class accuracy	user 69.2 (53.1 - 81.7), producer 85.7 (69.1 - 94.1)
Documentation for base map class	1 2004 relève, 1 2001/02 plots

B12 Russian Olive Woodland



Figure G24. Ground photo for map class B12, Russian Olive Woodland.

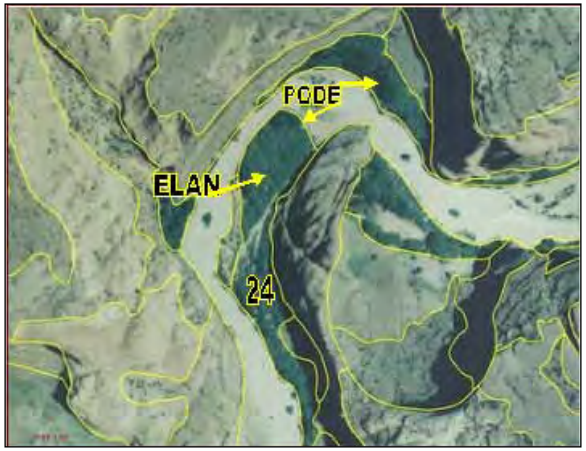


Figure G25. Photosignature for map class B12, Russian Olive Woodland.

Location: This map class commonly occurs along the canyon bottom and in wetland areas above the canyon rim. This map class is common along the river corridor near Chinle.

Photosignature: *Elaeagnus angustifolia* occurs in large dense patches or gray-green to silver color. The canopy height is a medium height. It is illustrated within the polygon labeled 24 in the image.

Plant communities	*Elaeagnus angustifolia* Semi-natural Woodland
Group map class	Colorado Plateau Riparian Woodland and Shrubland (1 of 5)
Management map class	Russian Olive - Saltcedar Woodland and Shrubland (1 of 2)
Number of map units in park & environs	9
Number of map units in park	4
Number of map units less than 0.5 ha	2 (.2.6% of total map class area)
Area of map class in park	11.2 ha / 27.6 ac
Area of map class in park & environs	25.9 ha / 64.0 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	56.9%
Base map class accuracy	user 62.5 (45.8 - 76.7), producer 53.6 (38.4 - 68.1)
Group map class accuracy	user 86.9 (78.2 - 92.4), producer 76.8 (67.5 - 84.1)
Management map class accuracy	user 27.3 (11.5 - 52.0), producer 27.3 (11.5 - 52.0)
Documentation for base map class	1 2004 relève, 1 2001/02 plots

B13 Two-needle Pinyon – Juniper spp. / Big Sagebrush Woodland



Figure G26. Ground photo for map class B13, Two-needle Pinyon – Juniper spp. / Big Sagebrush Woodland.

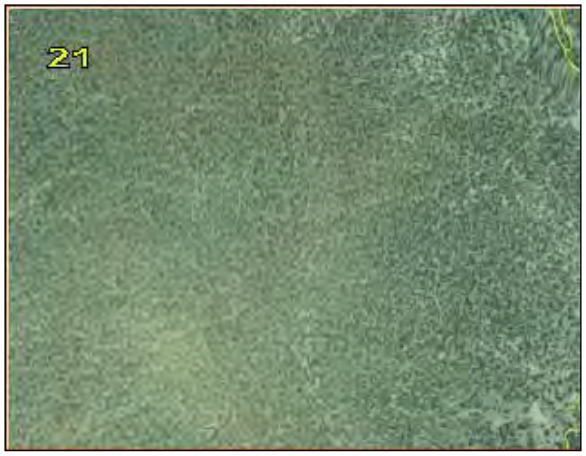


Figure G27. Photosignature for map class B13, Two-needle Pinyon – Juniper spp. / Big Sagebrush Woodland.

Location: This map class was identified throughout monument. This map class commonly occurs on top of the rim and is the main rim-top community in the eastern section of the monument. This class was the mostly commonly used map class, both in terms of total numbers of polygons as well as total area.

Photosignature: The canopy consists of *Pinus edulis* and *Juniperus osteosperma* which both have rounded canopy and a short-stature in the imagery. *Artemisia tridentata* appears as dark speckled shrubs. In dense canopy, *Artemisia tridentata* is difficult to identify but is assumed to be the main understory species under the canopy. This map class often inter-fingers larger patches of *Artemisia tridentata* shrublands.

Plant communities	*Pinus edulis* - *Juniperus* spp. / *Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana*) Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Mixed Conifer Sagebrush Woodland (1 of 4)
Number of map units in park & environs	631
Number of map units in park	428
Number of map units less than 0.5 ha	166 (0.2% of total map class area)
Area of map class in park	13654.0 ha / 33739.9 ac
Area of map class in park & environs	23521.2 ha / 58122.2 ac
Proportion of map class in park	36.5%
Proportion of map class in project environs	42.0%
Base map class accuracy	user 70.8 (54.1 - 83.3), producer 34.7 (24.6 - 46.4)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 75.3 (67.4 - 81.7), producer 77.7 (69.9 - 83.9)
Documentation for base map class	15 2004 relèves, 15 2001/02 plots,

B14 Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland



Figure G28. Ground photo for map class B14, Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland.



Figure G29. Photosignature for map class B14, Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland.

Location: This map class most commonly occurs in the cooler side canyons, north and east-facing talus slopes, and on top of the canyon rim in the higher elevations of the eastern sections of the monument.

Photosignature: This canopy is dominated by *Pinus edulis* and *Juniperus osteosperma*. Canopy height varies from short-statured trees to medium-height trees in wetter areas. *Quercus gambelii* appears as a medium green, smooth, tall shrub or short tree. *Quercus gambelii* is often clonal and is easily identified by the dense patches of medium green shrubs co-dominating the *Pinus edulis* and *Juniperus osteosperma* canopy. Polygon 22 illustrates this vegetation in the image.

Plant communities	*Pinus edulis* - *Juniperus* spp. / *Quercus gambelii* Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Mixed Conifer Gambel Oak Woodland (1 of 5)
Number of map units in park & environs	52
Number of map units in park	44
Number of map units less than 0.5 ha	3 (0.3% of total map class area)
Area of map class in park	184.8 ha / 456.7 ac
Area of map class in park & environs	295.3 ha / 729.6 ac
Proportion of map class in park	0.5%
Proportion of map class in project environs	37.4%
Base map class accuracy	user 23.5 (11.0 - 43.3), producer 33.3 (15.9 - 56.9)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 52.4 (42.1 - 62.4), producer 62.3 (51.0 - 71.4)
Documentation for base map class	5 2004 relèves, 0 2001/02 plots

B15 Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland



Figure G30. Ground photo for map class B15, Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland.



Figure G31. Photosignature for map class B15, Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland.

Location: This map class is mostly found along the canyon rims and on dry, warm, sunny exposures on talus slopes.

Photosignature: The *Pinus edulis* / *Juniperus osteosperma* communities are identified by their gray-green, open-canopy, woodland appearance. This community is the most common woodland community in the monument. *Cercocarpus montanus* shrubs are too small to positively identify on the aerial photos. Based on field data we identified that *Cercocarpus montanus* is the main understory species in the *Pinus edulis* / *Juniperus osteosperma* woodlands on the canyon rims. These communities are often sparse, dry, rocky areas. They sometimes occur on slickrock, but mostly occur in slightly deeper soils. Usually the soil is a washed out gray color on the rocky canyon rims. They are illustrated by polygon 9 in the imagery.

Plant communities	*Pinus edulis* - *Juniperus* spp. / *Cercocarpus montanus* Mixed Shrubs Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Two-needle Pinyon - Juniper species / Mountain-mahogany - Stansbury Cliff-rose Shrub Woodland (1 of 2)
Number of map units in park & environs	88
Number of map units in park	87
Number of map units less than 0.5 ha	7 (0.2% of total map class area)
Area of map class in park	1279.5 ha / 3161.8 ac
Area of map class in park & environs	1285.9 ha / 3177.5 ac
Proportion of map class in park	3.4%
Proportion of map class in project environs	0.5%
Base map class accuracy	user 35.3 (19.5 - 55.1), producer 33.3 (18.3 - 52.7)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 55.6 (42.0 - 68.3), producer 45.5 (33.7 - 57.7)
Documentation for base map class	8 2004 relèves, 7 2001/02 plots

B16 Two-needle Pinyon – Utah Juniper / Black Sagebrush Woodland



Figure G32. Ground photo for map class B16 Two-needle Pinyon – Utah Juniper / Black Sagebrush Woodland.



Figure G33. Photosignature for map class B16 Two-needle Pinyon – Utah Juniper / Black Sagebrush Woodland.

Location: This map class mainly occurs in the eastern end of the monument. It is primarily known to occur in the eastern and southern end of Middle Mesa and downstream of Tsaile Lake.

Photosignature: This vegetation is transitional between the *Pinus ponderosa – Artemisia nova* woodlands. The *Pinus edulis* and *Juniperus osteosperma* trees occur as a more rounded canopy, smaller tree size, and a lighter green color. *Artemisia nova* often occurs in areas with a reddish-brown soil apparent within the homogenous texture of the gray-green shrubs. In this map class *Artemisia tridentata* may co-dominate the understory and the imagery may show small, dark-green speckling from these shrubs. Polygon 8 in the imagery illustrates the photosignature.

Plant communities	*Pinus edulis - Juniperus osteosperma / Artemisia nova* Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Mixed Conifer Sagebrush Woodland (1 of 4)
Number of map units in park & environs	94
Number of map units in park	30
Number of map units less than 0.5 ha	17 (0.7% of total map class area)
Area of map class in park	149.6 ha / 369.8 ac
Area of map class in park & environs	557.0 ha / 1378.7 ac
Proportion of map class in park	0.4%
Proportion of map class in project environs	73.2%
Base map class accuracy	user 44.8 (30.7 - 59.8), producer 56.5 (39.7 - 71.9)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 75.3 (67.4 - 81.7), producer 77.7 (69.9 - 83.9)
Documentation for base map class	5 2004 relèves, 0 2001/02 plots

B17 Two-needle Pinyon – Utah Juniper / Blue Grama Woodland



Figure G34. Ground photo for map class B17 Two-needle Pinyon – Utah Juniper / Blue Grama Woodland.



Figure G35. Photosignature for map class B17 Two-needle Pinyon – Utah Juniper / Blue Grama Woodland.

Location: This map class is known throughout the study area but is predominant in the drier lower elevations in the western half of the monument. It most commonly occurs on top of mesas in drier, sandy soils. It also occurs in the canyon bottoms, in dry areas with shallow soils.

Photosignature: The photosignature for this map class is inconsistent. The open canopy of small trees is typical of the *Pinus edulis* / *Juniperus osteosperma* woodland. Canopy density is variable and often ranges between an open meadow-like stand to denser woodland. The understory color does vary from a very light tan or beige into an almost consistent light leaf green color. This map class may periodically include *Ericameria nauseosa* and *Atriplex confertifolia* shrubs in the understory. These shrubs are not easily distinguished from the grasses and often appear to have the same color and washed out texture as the grasses. This map class is often adjacent to *Pinus edulis* / *Juniperus osteosperma* woodlands with an *Artemisia tridentata* understory and can be distinguished from it under magnification by a consistent cover of tiny black specks. See polygon 13 in the image.

Plant communities	*Pinus edulis* - (*Juniperus osteosperma*) / *Bouteloua gracilis* Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Two-needle Pinyon - (Utah Juniper) / Blue Grama Woodland (1 of 1)
Number of map units in park & environs	86
Number of map units in park	73
Number of map units less than 0.5 ha	13 (0.1% of total map class area)
Area of map class in park	1612.6 ha / 3984.9 ac
Area of map class in park & environs	2545.9 ha / 6291.2 ac
Proportion of map class in park	4.3%
Proportion of map class in project environs	36.7%
Base map class accuracy	user 62.5 (45.8 - 76.7), producer 53.6 (38.4 - 68.1)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 62.5 (45.8 - 76.7), producer 60.0 (43.7 - 74.4)
Documentation for base map class	10 2004 relèves, 8 2001/02 plots

B18 Two-needle Pinyon – Utah Juniper / Cliff Fendlerbush Woodland



Figure G36. Ground photo for map class B18 Two-needle Pinyon – Utah Juniper / Cliff Fendlerbush Woodland.



Figure G37. Photosignature for map class B18 Two-needle Pinyon – Utah Juniper / Cliff Fendlerbush Woodland.

Location: This map class occurs on steep talus slopes on the canyon walls. It often occurs along the cooler north and east-facing slopes adjacent to stands of *Pseudotsuga menziesii* and/or *Quercus gambelii*.

Photosignature: The *Pinus edulis* and *Juniperus osteosperma* canopy appears as a medium green color with an open structure and a rounded shape. However, the canopy is not always distinguishable in the shadows on the steep slopes and sometimes appears as dark green and mottled against the pale gray of the rocky talus slope. *Fendlera rupicola* is distinguished from *Purshia stansburiana* and *Amelanchier utahensis* by interpretation of habitat based on prior field work knowledge.

Plant communities	*Pinus edulis - Juniperus osteosperma / Fendlera rupicola* Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland (1 of 5)
Number of map units in park & environs	3
Number of map units in park	3
Number of map units less than 0.5 ha	1 (5.3% of total map class area)
Area of map class in park	8.9 ha / 22.0 ac
Area of map class in park & environs	8.9 ha / 22.0 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 0.0 (NA), producer 0.0 (NA)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 70.7 (60.1 - 79.4), producer 55.4 (45.9 - 64.6)
Documentation for base map class	3 2004 relèves, 0 2001/02 plots

B19 Two-needle Pinyon – Utah Juniper / Littleleaf Mountain-mahogany Woodland



Figure G38. Ground photo for map class B19 Two-needle Pinyon – Utah Juniper / Littleleaf Mountain-mahogany Woodland.

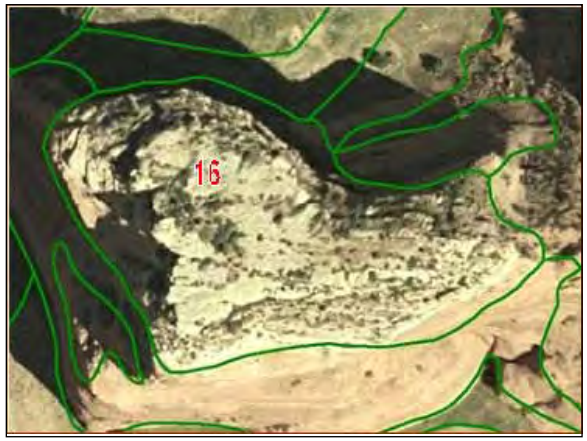


Figure G39. Photosignature for map class B19 Two-needle Pinyon – Utah Juniper / Littleleaf Mountain-mahogany Woodland.

Location: This map class is known to occur in dry, often isolated, areas with lots of exposed bedrock. The vegetation tends to grow in the rock crevices and is often sparse.

Photosignature: As this map class is often fairly sparse, the *Pinus edulis* and *Juniperus osteosperma* photosignature is patchy. A few small, globular-like trees can be seen interspersed between small, black speckled *Cercocarpus intricatus* shrubs. The substrate of this map class is the most distinguishable feature of the photosignature. The striated sandstone is very indicative; it often appears as if the rock's surface was rubbed lightly with dark charcoal over its rough surface. See polygon 16 in the imagery.

Plant communities	*Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus* Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland (1 of 5)
Number of map units in park & environs	42
Number of map units in park	42
Number of map units less than 0.5 ha	17 (5.0% of total map class area)
Area of map class in park	99.8 ha / 246.6 ac
Area of map class in park & environs	99.8 ha / 246.6 ac
Proportion of map class in park	0.3%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 25.0 (57.9 - 64.4), producer 14.3 (3.3 - 45.2)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 70.7 (60.1 - 79.4), producer 55.4 (45.9 - 64.6)
Documentation for base map class	2 2004 relèves, 0 2001/02 plots

B20 Two-needle Pinyon – Utah Juniper / Shrub Live Oak Woodland



Figure G40. Ground photo for map class B20 Two-needle Pinyon – Utah Juniper / Shrub Live Oak Woodland.



Figure G41. Photosignature for map class B20 Two-needle Pinyon – Utah Juniper / Shrub Live Oak Woodland.

Location: This map class always occurs on rocky surfaces most commonly in the lower elevations of the western and central section of the park. It occurs adjacent to the canyon as well as farther away from the rim on large exposed bedrock flats. It also commonly occurs on the dry west and south-facing steep talus slopes.

Photosignature: The *Pinus edulis-Juniperus osteosperma* photosignature is patchy, especially on the exposed bedrock flats. *Pinus edulis* and *Juniperus osteosperma* appear as small, globular-shaped trees. Shrubs appear to be medium to dark or gray-green. Often *Quercus turbinella* grows in large clumps and appears on the aerial photographs as deep green patches with a somewhat smeared appearance. This map class is used as a catch-all for drier talus slopes of the canyon walls, where the photosignature is difficult to discern. See polygon 17 on the imagery.

Plant communities	*Pinus edulis - Juniperus osteosperma / Quercus turbinella* Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland (1 of 5)
Number of map units in park & environs	110
Number of map units in park	101
Number of map units less than 0.5 ha	13 (0.2% of total map class area)
Area of map class in park	1307.3 ha / 3230.4 ac
Area of map class in park & environs	1446.9 ha / 3575.5 ac
Proportion of map class in park	3.5%
Proportion of map class in project environs	9.7%
Base map class accuracy	user 52.6 (34.7 - 69.9), producer 33.3 (21.1 - 48.3)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 70.7 (60.1 - 79.4), producer 55.4 (45.9 - 64.6)
Documentation for base map class	10 2004 relèves, 5 2001/02 plots,

B21 Two-needle Pinyon – Utah Juniper / Sparse Understory Woodland



Figure G42. Ground photo for map class B21 Two-needle Pinyon – Utah Juniper / Sparse Understory Woodland.

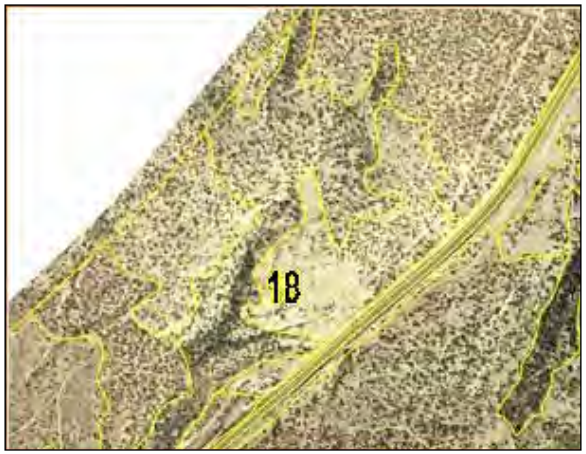


Figure G43. Photosignature for map class B21 Two-needle Pinyon – Utah Juniper / Sparse Understory Woodland.

Location: This map class occurs in dry and often rocky areas with a sparse understory. It is commonly found in the canyon bottom, along the canyon rims, on steep talus slopes with shallow soils, or in drier areas on top of the canyon with poor soil development.

Photosignature: *Pinus edulis* and *Juniperus osteosperma* height varies considerably from a medium size shrub to a true tree form. All of the trees have a rounded canopy with an open structure. The understory is sparse (<10%) and can appear absent on the photographs. In some areas the soil photosignature masks the vegetation and can cause misinterpretation of a sparse understory. In areas with slickrock, this map class can be confused with those with a sparse understory. Shrub cover must be carefully assessed to distinguish this map class. Polygon 18 illustrates the photosignature.

Plant communities	*Pinus edulis* - *Juniperus osteosperma* / *Sparse* Understory Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland (1 of 5)
Number of map units in park & environs	301
Number of map units in park	246
Number of map units less than 0.5 ha	48 (0.3% of total map class area)
Area of map class in park	3693.9 ha / 9127.9 ac
Area of map class in park & environs	4716.5 ha / 11654.7 ac
Proportion of map class in park	9.9%
Proportion of map class in project environs	21.7%
Base map class accuracy	user 50.0 (34.6 - 65.4), producer 44.8 (30.7 - 56.8)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 70.7 (60.1 - 79.4), producer 55.4 (45.9 - 64.6)
Documentation for base map class	9 2004 relèves, 3 2001/02 plots

B22 Two-needle Pinyon – Utah Juniper / Stansbury Cliffrose Woodland



Figure G44. Ground photo for map class B22 Two-needle Pinyon – Utah Juniper / Stansbury Cliffrose Woodland.

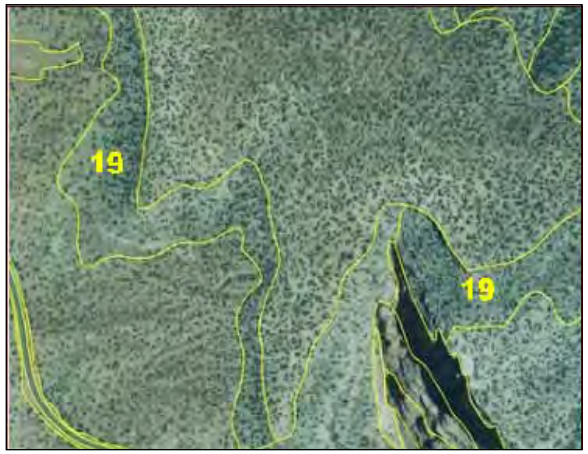


Figure G45. Photosignature for map class B22 Two-needle Pinyon – Utah Juniper / Stansbury Cliffrose Woodland.

Location: This map class occurs on canyon rims and talus slopes. It often occurs in cooler areas adjacent to *Pseudotsuga menziesii*. It also occurs on top of the canyon rims in areas with rocky hillsides.

Photosignature: *Pinus edulis* and *Juniperus osteosperma* are the dominant trees in the canopy. All of the trees have a rounded canopy with an open structure. This photosignature is distinguishable by the dark green color of the *Purshia stansburiana* shrubs and the pale bluish-green color of the *Poa fendleriana* in the understory. This map class, when on the canyon rims, is difficult to distinguish from mixed shrub communities dominated by *Cercocarpus montanus*. It is common in the cooler high elevation areas adjacent to *Pseudotsuga menziesii* communities. See polygon 19 on the imagery.

Plant communities	*Pinus edulis* - *Juniperus osteosperma* / *Purshia stansburiana* Woodland; *Pinus edulis* - *Juniperus* spp. / *Poa fendleriana* Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Two-needle Pinyon - Juniper species / Mountain-mahogany - Stansbury Cliff-rose Shrub Woodland (1 of 2)
Number of map units in park & environs	102
Number of map units in park	99
Number of map units less than 0.5 ha	3 (0.1% of total map class area)
Area of map class in park	803.7 ha / 1986.1 ac
Area of map class in park & environs	907.1 ha / 2241.6 ac
Proportion of map class in park	2.1%
Proportion of map class in project environs	11.4%
Base map class accuracy	user 47.4 (30.0 - 65.3), producer 36.0 (22.3 - 52.4)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 55.6 (42.0 - 68.3), producer 45.5 (x to x)
Documentation for base map class	20 2004 relèves, 7 2001/02 plots,

B23 Two-needle Pinyon – Utah Juniper / Utah Serviceberry Woodland



Figure G46. Ground photo for map class B23 Two-needle Pinyon – Utah Juniper / Utah Serviceberry Woodland.



Figure G47. Photosignature for map class B23 Two-needle Pinyon – Utah Juniper / Utah Serviceberry Woodland.

Location: This map class most commonly occurs on cooler north and east-facing canyon rims in side canyons and on talus slopes.

Photosignature: *Pinus edulis* and *Juniperus osteosperma* are the dominant trees in the canopy. Depending on the steepness of the slope, the tree cover varies considerably. All of the trees have a rounded canopy with an open structure. *Amelanchier utahensis* is a bright green shrub with a fluffy and soft texture. Occasionally *Amelanchier utahensis* occurs in dense patches and appears darker in color. Polygons labeled 20 in the image illustrate the photosignature.

Plant communities	*Pinus edulis - Juniperus osteosperma / Amelanchier utahensis* Woodland
Group map class	Colorado Plateau Pinyon Juniper Woodland (1 of 11)
Management map class	Mixed Conifer Gambel Oak Woodland (1 of 5)
Number of map units in park & environs	280
Number of map units in park	278
Number of map units less than 0.5 ha	49 (0.7% of total map class area)
Area of map class in park	1837.7 ha / 4541.1 ac
Area of map class in park & environs	1838.0 ha / 4541.9 ac
Proportion of map class in park	4.9%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 50.0 (24.9 - 75.1), producer 26.7 (12.6 - 47.9)
Group map class accuracy	user 94.7 (91.3 - 96.8), producer 77.2 (72.3 - 81.4)
Management map class accuracy	user 52.4 (42.1 - 62.4), producer 62.3 (51.0 - 71.4)
Documentation for base map class	1 2004 relève, 0 2001/02 plots

B24 Big Sagebrush / Black Sagebrush Shrubland



Figure G48. Ground photo for map class B24 Big Sagebrush / Black Sagebrush Shrubland.



Figure G49. Photosignature for map class B24 Big Sagebrush / Black Sagebrush Shrubland.

Location: This map class occurs primarily in the eastern higher elevations of the monument on top of the canyon rim, to the east and south of middle mesa and downstream of Tsaile Lake.

Photosignature: This map class appears on the aerial photographs as a nearly uniform gray-green color with patches of brown. The texture sometimes appears smooth and occasionally has a very finely dark gray-green speckle. This map class is mixed and occasionally has a few scattered *Pinus edulis*, *Juniperus osteosperma*, and *Pinus ponderosa* trees. See polygon 26 on the imagery.

Plant communities	*Artemisia tridentata* ssp. *wyomingensis* / *Artemisia nova* Shrubland
Group map class	Inter-Mountain Basins Big Sagebrush Shrubland (1 of 3)
Management map class	Big Sagebrush / Natural and Semi-natural Understory Shrubland (1 of 3)
Number of map units in park & environs	112
Number of map units in park	61
Number of map units less than 0.5 ha	24 (.06% of total map class area)
Area of map class in park	325.9 ha / 805.3 ac
Area of map class in park & environs	1135.3 ha / 2805.5 ac
Proportion of map class in park	0.09%
Proportion of map class in project environs	71.3%
Base map class accuracy	user (15.3 to 42.9), producer 77.8 (50.4 – 92.4)
Group map class accuracy	user 96.4 (89.8 to 98.8), producer 85.7 (77.0 to 91.5)
Management map class accuracy	user 96.4 (89.8 to 98.8)), producer 88.5 (80.1 to 93.7)
Documentation for base map class	0 2004 relevés, 0 2001/02 plots,

B25 Big Sagebrush / Blue Grama Shrubland



Figure G50. Ground photo for map class B25 Big Sagebrush / Blue Grama Shrubland.



Figure G51. Photosignature for map class B25 Big Sagebrush / Blue Grama Shrubland.

Location: This map class is found throughout the monument and is especially common in the eastern half of the monument. It is often adjacent to Two-Needle Pinyon– Juniper species / Basin Big Sagebrush Woodland (map class B13).

Photosignature: This map class is identified by sparse (less than10%) *Pinus edulis* and *Juniperus osteosperma* in the canopy. *Artemisia tridentata* occurs as small dark speckles within a light greenish/tan smooth texture of *Bouteloua gracilis*. In some areas *Artemisia tridentata* is small, masked by the understory, and appears as one large smooth texture. It is shown in polygon 25 in the image.

Plant communities	*Artemisia tridentata* ssp. *wyomingensis* / *Bouteloua gracilis* Shrubland
Group map class	Inter Mountain Basins Big Sagebrush Shrubland (1 of 3)
Management map class	Big Sagebrush / Natural and Semi-Natural Understory Shrubland (1 of 3)
Number of map units in park & environs	738
Number of map units in park	455
Number of map units less than 0.5 ha	197 (0.8% of total map class area)
Area of map class in park	2932.4 ha / 7246.2 ac
Area of map class in park & environs	7701.7 ha / 19031.2 ac
Proportion of map class in park	7.8%
Proportion of map class in project environs	61.9%
Base map class accuracy	user 47.6 (31.0 - 64.8), producer 76.9 (54.2 - 90.4)
Group map class accuracy	user 96.4 (89.8 - 98.8), producer 85.7 (77.0 - 91.5)
Management map class accuracy	user 96.4 (89.8 - 98.8), producer 88.5 (80.1 - 93.7)
Documentation for base map class	5 2004 relèves, 21 2001/02 plots

B26 Big Sagebrush / Disturbed Understory Semi-natural Shrubland



Figure G52. Ground photo for map class B26 Big Sagebrush / Disturbed Understory Semi-natural Shrubland.



Figure G53. Photosignature for map class B26 Big Sagebrush / Disturbed Understory Semi-natural Shrubland.

Location: This map class occurs in disturbed areas throughout the monument, including adjacent to roads, streambeds, and agricultural areas in the uplands on top of the canyon.

Photosignature: This photosignature is similar to the undisturbed Big Sagebrush / Blue Grama Shrubland map class. The photosignature appears to be a smooth greenish-brown with dark black speckles. Some of these areas have a low cover (<10%) of *Pinus edulis* and *Juniperus osteosperma*. This class is most notably identified by the location (disturbed areas near roads, streams, or residences) and the evidence of a modified landscape seen as striations in the aerial photographs. In the adjacent image, it is illustrated in the uneven edged polygons running adjacent to the straight edged road polygon.

Plant communities	*Artemisia tridentata* ssp. *wyomingensis* / Disturbed Understory Semi-natural Shrubland
Group map class	Inter Mountain Basins Big Sagebrush Shrubland (1 of 3)
Management map class	Big Sagebrush / Natural and Semi-Natural Understory Shrubland (1 of 3)
Number of map units in park & environs	27
Number of map units in park	22
Number of map units less than 0.5 ha	6 (3.4% of total map class area)
Area of map class in park	31.9 ha / 78.9 ac
Area of map class in park & environs	60.5 ha / 149.6 ac
Proportion of map class in park	0.1%
Proportion of map class in project environs	47.3%
Base map class accuracy	user 88.9 (62.3 - 97.5), producer 21.6 (12.6 - 34.5)
Group map class accuracy	user 96.4 (89.8 - 98.8), producer 85.7 (77.0 - 91.5)
Management map class accuracy	user 96.4 (89.8 - 98.8), producer 88.5 (80.1 - 93.7)
Documentation for base map class	5 2004 relèves, 5 2001/02 plots

B27 Gambel Oak / Cliff Fendlerbush Shrubland



Figure G54. Ground photo for map class B27 Gambel Oak / Cliff Fendlerbush Shrubland.

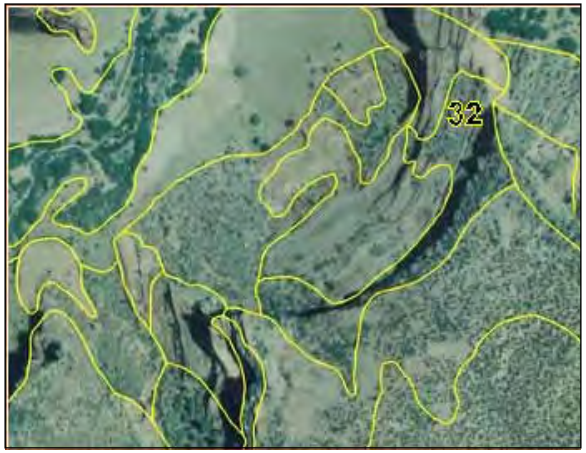


Figure G55. Photosignature for map class B27 Gambel Oak / Cliff Fendlerbush Shrubland.

Location: This map class occurs in cooler, north and east-facing slopes or in cooler side drainages. This map class is often found adjacent to map classes with *Pseudotsuga menziesii*.

Photosignature: *Quercus gambelii* tends to form dense, dark clumps. *Fendlera rupicola* is often associated with this map class and occurs in the understory. This species has a light green signature; however, it is often not visible under the *Quercus gambelii* canopy. The map class is illustrated in polygon 32 in the image.

Plant communities	*Quercus gambelii* / *Fendlera rupicola* Shrubland [Provisional]
Group map class	Rocky Mountain Gambel Oak Mixed Montane Shrubland (1 of 3)
Management map class	Mixed Conifer Gambel Oak Woodland (1 of 5)
Number of map units in park & environs	8
Number of map units in park	8
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	33.6 ha / 83.0 ac
Area of map class in park & environs	33.6 ha / 83.0 ac
Proportion of map class in park	0.1%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 0.0 (NA), producer 0.0 (NA)
Group map class accuracy	user 36.0 (22.3 - 52.4), producer 81.8 (57.3 - 93.8)
Management map class accuracy	user 52.4 (42.1 - 62.4), producer 62.3 (51.0 - 71.4)
Documentation for base map class	1 2004 relève, 0 2001/02 plots

B28 Gambel Oak Woodland



Figure G56. Ground photo for map class B28 Gambel Oak Woodland.



Figure G57. Photosignature for map class B28 Gambel Oak Woodland.

Location: This map class often occurs on top of the canyon rim in the western and central extents of the monument. In the central and eastern extents of the monument, it was mapped as occurring on talus slopes and on the canyon floor at the base of talus slopes.

Photosignature: *Quercus gambelii* clones often occur in dense, dark green clumps. Canopy height varies between tall shrub and tree height. Where the canopy is distinguished within the thick stands, it has spindly, erratic branches. On the canyon floor, this canopy shape and its dark green color are useful in distinguishing *Quercus gambelii* from other species along the riparian corridor such as *Populus deltoides* and *Elaeagnus angustifolia*. This map class is not co-dominated by other trees, but is generally speckled with small shrubs in the understory. It is illustrated in polygon 8 in the image.

Plant communities	*Quercus gambelii* Shrubland
Group map class	Rocky Mountain Gambel Oak Mixed Montane Shrubland (1 of 3)
Management map class	Mixed Conifer Gambel Oak Woodland (1 of 5)
Number of map units in park & environs	73
Number of map units in park	70
Number of map units less than 0.5 ha	14 (1.8% of total map class area)
Area of map class in park	264.5 ha / 653.7 ac
Area of map class in park & environs	268.4 ha / 663.3 ac
Proportion of map class in park	0.7%
Proportion of map class in project environs	1.5%
Base map class accuracy	user 37.5 (20.8 - 57.8), producer 100.0 (68.9 - 100.0)
Group map class accuracy	user 36.0 (22.3 - 52.4), producer 81.8 (57.3 - 93.8)
Management map class accuracy	user 52.4 (42.1 - 62.4), producer 62.3 (51.0 - 71.4)
Documentation for base map class	1 2004 relève, 0 2001/02 plots

B29 Prickly-pear Dwarf-shrubland



Figure G58. Ground photo for map class B29 Prickly-pear Dwarf-shrubland.

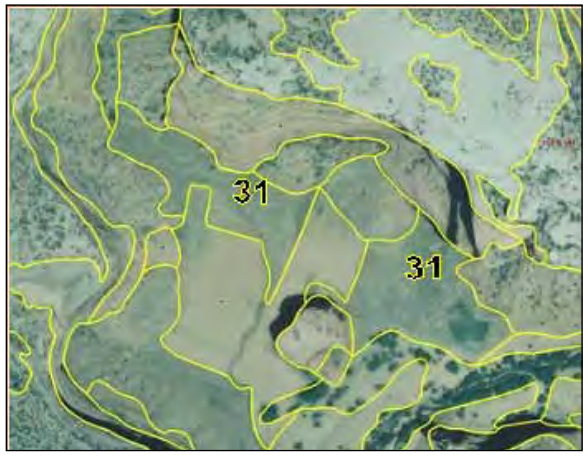


Figure G59. Photosignature for map class B29 Prickly-pear Dwarf-shrubland.

Location: This map class commonly occurs in the canyon bottom on dry flat broad expanses. It most commonly occurs in the western half of the monument.

Photosignature: This map class appears as a light greenish brown signature. Darker green oblong clumps are often visible and indicate various densities of *Opuntia* sp. Depending on the soil signature, the texture may appear from coarse and mottled to smooth. It is illustrated in polygon 31 on the image.

Plant communities	*Opuntia* (*fragilis*, *polyacantha*, *phaeacantha*) Shrubland
Group map class	Inter Mountain Basins Semi Desert Shrub Steppe (1 of 4)
Management map class	Rubber Rabbitbrush - Prickly Pear Shrubland (1 of 4)
Number of map units in park & environs	128
Number of map units in park	126
Number of map units less than 0.5 ha	18 (0.7% of total map class area)
Area of map class in park	748.4 ha / 1849.4 ac
Area of map class in park & environs	749.9 ha / 1853.1 ac
Proportion of map class in park	2.0%
Proportion of map class in project environs	0.2%
Base map class accuracy	user 50.0 (33.5 - 66.5), producer 44.0 (29.1 - 60.1)
Group map class accuracy	user 71.7 (61.3 - 80.1), producer 72.9 (62.5 - 81.2)
Management map class accuracy	user 77.6 (66.5 - 85.8), producer 74.5 (63.4 - 83.1)
Documentation for base map class	4 2004 relèves, 2 2001/02 plots

B30 Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland



Figure G60. Ground photo for map class B30 Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland.

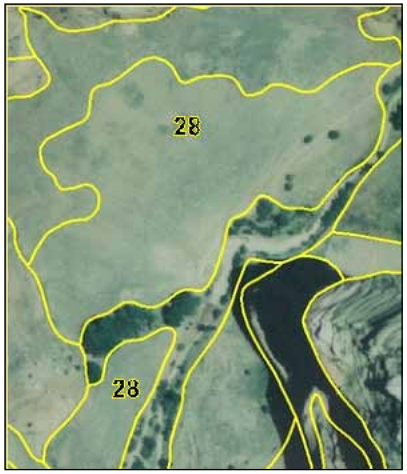


Figure G61. Photosignature for map class B30 Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland.

Location: This map class commonly occurs in the wide canyon bottom in the western part of the monument.

Photosignature: The photosignature of this map class is similar to Prickly-pear Dwarf-shrubland map class (B29) and they commonly occur adjacent to one another in the canyon bottom. Both map classes appear as a smooth gray color. However, this map class often has higher vegetation cover and appears darker gray with more obvious green speckling. Occasionally this map class has a high cover of *Sarcobatus vermiculatus* or *Atriplex canescens* with dark gray-green mottled speckles. It is illustrated in polygon 28 on the image.

Plant communities	*Ericameria nauseosa* / *Bromus tectorum* Semi-natural Shrubland
Group map class	Inter Mountain Basins Semi Desert Shrub Steppe (1 of 4)
Management map class	Rubber Rabbitbrush - Prickly Pear Shrubland (1 of 4)
Number of map units in park & environs	159
Number of map units in park	135
Number of map units less than 0.5 ha	35 (1.0% of total map class area)
Area of map class in park	511.6 ha / 1264.3 ac
Area of map class in park & environs	980.0 ha / 2421.7 ac
Proportion of map class in park	1.4%
Proportion of map class in project environs	47.8%
Base map class accuracy	user 52.2 (35.7 - 68.2), producer 54.5 (37.6 - 70.5)
Group map class accuracy	user 71.7 (61.3 - 80.1), producer 72.9 (62.5 - 81.2)
Management map class accuracy	user 77.6 (66.5 - 85.8), producer 74.5 (63.4 - 83.1)
Documentation for base map class	2 2004 relèves, 4 2001/02 plots

B31 Saltcedar Temporarily Flooded Shrubland



Figure G62. Ground photo for map class B31 Saltcedar Temporarily Flooded Shrubland.



Figure G63. Photosignature for map class B31 Saltcedar Temporarily Flooded Shrubland.

Location: This map class occurs throughout the riparian areas of the monument. *Tamarix* sp. generally is associated with *Populus deltoides* and *Elaeagnus angustifolia*; however, in some areas *Tamarix* sp. dominates the stand and was mapped separately. This map class was mostly delineated in the east, south of Tsaile Lake, where it occurs as the dominant species in the drainage channel.

Photosignature: The photosignature of this map class is dense dark gray/green patches. *Tamarix* sp. forms monocultures, appearing with a slightly rough texture. The yellow polygons on the image identify this map class.

Plant communities	*Tamarix* spp. *Temporarily Flooded Semi-natural* Shrubland
Group map class	Colorado Plateau Riparian Woodland and Shrubland (1 of 5)
Management map class	Russian Olive - Saltcedar Woodland and Shrubland (1 of 2)
Number of map units in park & environs	7
Number of map units in park	4
Number of map units less than 0.5 ha	6 (69.6% of total map class area)
Area of map class in park	1.1 ha / 2.8 ac
Area of map class in park & environs	2.3 ha / 5.7 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	51.4%
Base map class accuracy	user 0.0 (NA), producer 0.0 (NA)
Group map class accuracy	user 86.9 (78.2 - 92.4), producer 76.8 (67.5 - 84.1)
Management map class accuracy	user 27.3 (11.5 - 52.0), producer 27.3 (11.5 - 52.0)
Documentation for base map class	0 2004 relevés, 0 2001/02 plots,

B32 Shadscale / Galleta Shrubland



Figure G64. Ground photo for map class B32 Shadscale / Galleta Shrubland.

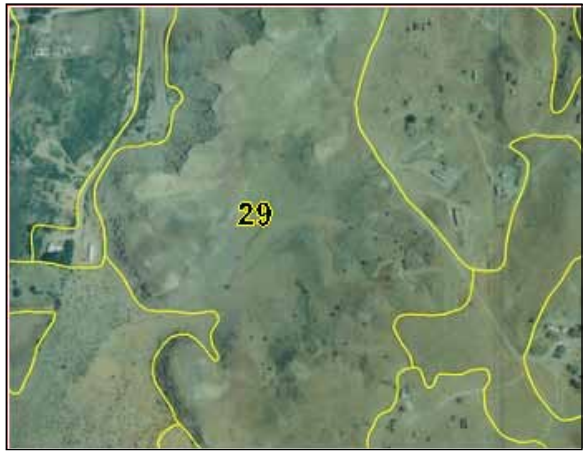


Figure G65. Photosignature for map class B32 Shadscale / Galleta Shrubland.

Location: This map class commonly occurs in the western half of the project area in the uplands on top of the canyon rim. It occurs on the Chinle shale south and east of Chinle, Arizona.

Photosignature: This map class is easily identifiable by the shale substrate that appears as a dark reddish purple, blue, tan, white or slate-gray on the aerial photographs. The vegetation is completely masked by the soil signature and the signature appears barren. See polygon 29 on the image.

Plant communities	*Atriplex confertifolia / Pleuraphis jamesii* Shrubland
Group map class	Inter Mountain Basins Mixed Salt Desert Scrub (1 of 1)
Management map class	Shadscale / Galleta Shrubland (1 of 1)
Number of map units in park & environs	50
Number of map units in park	28
Number of map units less than 0.5 ha	3 (0.1% of total map class area)
Area of map class in park	309.1 ha / 763.9 ac
Area of map class in park & environs	671.0 ha / 1658.2 ac
Proportion of map class in park	0.8%
Proportion of map class in project environs	53.9%
Base map class accuracy	user 54.2 (37.9 - 69.6), producer 100.0 (82.7 - 100.0)
Group map class accuracy	user 54.2 (37.9 - 69.6), producer 100.0 (82.8 - 100.0)
Management map class accuracy	user 54.2 (37.9 - 69.6), producer 100.0 (82.8 - 100.0)
Documentation for base map class	2 2004 relevés, 1 2001/02 plots

B33 Utah Serviceberry – Cliff Fendlerbush Shrubland



Figure G66. Ground photo for map class B33 Utah Serviceberry – Cliff Fendlerbush Shrubland.



Figure G67. Photosignature for map class B33 Utah Serviceberry – Cliff Fendlerbush Shrubland.

Location: This map class generally occurs on the talus slopes of the canyon wall. This map class tends to occur in cooler climates, including east and north-facing slopes and cooler side canyons.

Photosignature: This map class is used as a catch-all for mixed shrub communities on cooler rim and talus areas without *Pinus edulis* or *Juniperus osteosperma*. *Amelanchier utahensis* and *Fendlera rupicola* appear as small green shrubs, with dark, irregular canopies. *Amelanchier utahensis* is generally larger and brighter green than *Fendlera rupicola* and often grows in large clumps which may be visible on the aerial photography. Polygon 30 on the image illustrates this map class.

Plant communities	*Amelanchier utahensis* Shrubland*; Fendlera rupicola Talus* Shrubland
Group map class	Rocky Mountain Gambel Oak Mixed Montane Shrubland (1 of 3)
Management map class	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland (1 of 5)
Number of map units in park & environs	32
Number of map units in park	32
Number of map units less than 0.5 ha	2 (0.4 % of total map class area)
Area of map class in park	134.2 ha / 331.6 ac
Area of map class in park & environs	134.2 ha / 331.6 ac
Proportion of map class in park	0.4%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 14.3 (3.3 - 45.2), producer 33.3 (7.8 - 74.6)
Group map class accuracy	user 36.0 (22.3 - 52.4), producer 81.8 (57.3 - 93.8)
Management map class accuracy	user 70.7 (60.1 - 79.4), producer 55.4 (45.9 - 64.6)
Documentation for base map class	2 2004 relevés, 0 2001/02 plots

B34 Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation



Figure G68. Ground photo for map class B34 Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation.



Figure G69. Photosignature for map class B34 Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation.

Location: This map class is found mainly in the western part of the monument, near the junction of Canyon de Chelly and Canyon del Muerto; it occurs mainly on canyon benches below the rim.

Photosignature: The photosignature for this map class is generally sparse with rocky outcrops and a sparse vegetation layer. *Artemisia bigelovii* is a small light gray-green compact sub-shrub that is not easily identified on aerial photographs. It generally appears as dominated by grasses with a light green, smooth photosignature patch on a talus canyon bench. The grass cover can often appear as a homogenous stand on the aerial photo. Polygon 42 on the image illustrates this map class.

Plant communities	*Artemisia bigelovii / Bouteloua gracilis* Dwarf-shrub Herbaceous Vegetation
Group map class	Colorado Plateau Mixed Bedrock and Tableland (1 of 1)
Management map class	Rubber Rabbitbrush - Prickly Pear Shrubland (1 of 4)
Number of map units in park & environs	15
Number of map units in park	15
Number of map units less than 0.5 ha	5 (4.7% of total map class area)
Area of map class in park	23.2 ha / 57.3 ac
Area of map class in park & environs	23.2 ha / 57.3 ac
Proportion of map class in park	0.1%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 25.0 (5.8 - 64.4), producer 50.0 (12.1 - 87.9)
Group map class accuracy	user 25.0 (57.9 - 64.4), producer 100.0 (27.0 - 100.0)
Management map class accuracy	user 77.6 (66.5 - 85.8), producer 74.5 (63.4 - 83.1)
Documentation for base map class	1 2004 relevé, 0 2001/02 plots

B35 Blue Grama Herbaceous Vegetation



Figure G70. Ground photo for map class B35 Blue Grama Herbaceous Vegetation.



Figure G71. Photosignature for map class B35 Blue Grama Herbaceous Vegetation.

Location: This map class commonly occurs on top of the canyon rim, in dry flat areas. Most occurrences are in the western or central areas of the monument.

Photosignature: *Bouteloua gracilis*, a short-grass prairie species, appears as an evenly textured meadow of pale green, fading occasionally to a washed-out light tan or beige, depending on its phenological stage. The pure patches of *Bouteloua gracilis* often grow near areas of *Bouteloua gracilis / Artemisia tridentata*, or *Pinus edulis / Juniperus osteosperma - Bouteloua gracilis* map classes. The polygon on the image indicated by the arrow and number 34 illustrates this map class.

Plant communities	*Bouteloua gracilis* Herbaceous Vegetation
Group map class	Inter Mountain Basins Semi Desert Grassland (1 of 5)
Management map class	Blue Grama Herbaceous Vegetation (1 of 1)
Number of map units in park & environs	28
Number of map units in park	25
Number of map units less than 0.5 ha	8 (2.5% of total map class area)
Area of map class in park	83.4 ha / 206.00 ac
Area of map class in park & environs	102.7 ha / 253.8 ac
Proportion of map class in park	0.2%
Proportion of map class in project environs	18.8%
Base map class accuracy	user 53.3 (33.3 - 72.3), producer 80.0 (54.1 - 93.1)
Group map class accuracy	user 56.3 (41.9 - 69.6), producer 60.0 (45.1 - 73.3)
Management map class accuracy	user 53.3 (33.3 - 72.3), producer 80.0 (54.1 - 93.1)
Documentation for base map class	0 2004 relevés, 3 2001/02 plots,

B36 California Brickelbush Shrubland



Figure G72. Ground photo for map class B36 California Brickelbush Shrubland.

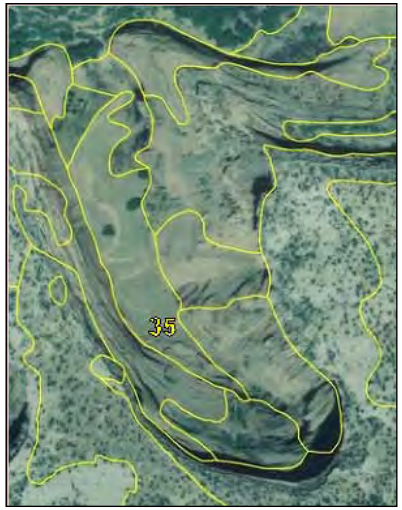


Figure G73. Photosignature for map class B36 California Brickelbush Shrubland.

Location: This map class mostly occurs in the western half of the canyon bottoms. *Brickellia californica* is found in dense patches at the base of cliff slopes with little other vegetation. It is generally found in sheltered areas with deep soils.

Photosignature: The photosignature is medium to bright light green, consisting of a soft texture. This is distinguished from other canyon bottom communities by the medium height of the suffrutescent herb and its bright green color. See polygon 35 on the image.

Plant communities	*Brickellia californica* Shrubland
Group map class	Inter Mountain Basins Semi Desert Shrub Steppe (1 of 4)
Management map class	California Brickelbush Shrubland (1 of 1)
Number of map units in park & environs	9
Number of map units in park	9
Number of map units less than 0.5 ha	2 (4.9% of total map class area)
Area of map class in park	11.3 ha / 27.9 ac
Area of map class in park & environs	11.3 ha / 27.9 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 66.7 (25.3 - 92.2), producer 50.0 (18.2 - 81.8)
Group map class accuracy	user 71.7 (61.3 - 80.1), producer 72.9 (62.5 - 81.2)
Management map class accuracy	user 66.7 (25.4 - 92.2), producer 50.0 (x to x)
Documentation for base map class	3 2004 relevés, 0 2001/02 plots

B37 Cheatgrass Herbaceous Vegetation



Figure G74. Ground photo for map class B37 Cheatgrass Herbaceous Vegetation.



Figure G75. Photosignature for map class B37 Cheatgrass Herbaceous Vegetation.

Location: This map class is generally found in disturbed areas. Its most common occurrences were along the flat, broad canyon bottoms towards the western end of the park.

Photosignature: The vegetation in this map class is almost a homogenous stand of *Bromus tectorum*. *Bromus tectorum* is a non-native annual species that varies in photosignature color and texture, depending on its seasonality. The homogeneity of the map class appears on the aerial photography as any shade between medium green to pale tan and often with a smooth texture. Evidence of land use is often seen in the texture of this map class, including old fields and grazing. Polygon 36 illustrates this map class on the image.

Plant communities	*Bromus tectorum* Semi-natural Herbaceous Vegetation
Group map class	Inter Mountain Basins Semi Desert Grassland (1 of 5)
Management map class	Mixed Upland Herbaceous Vegetation (1 of 4)
Number of map units in park & environs	12
Number of map units in park	12
Number of map units less than 0.5 ha	3 (2.9% of total map class area)
Area of map class in park	32.6 ha / 80.6 ac
Area of map class in park & environs	32.6 ha / 80.6 ac
Proportion of map class in park	0.1%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 0.0 (NA), producer 0.0 (NA)
Group map class accuracy	user 56.3 (41.9 - 69.6), producer 60.0 (45.1 - 73.3)
Management map class accuracy	user 29.4 (15.1 - 49.4), producer 26.3 (13.4 - 45.1)
Documentation for base map class	0 2004 relevés, 0 2001/02 plots

B38 Desert Wheatgrass Herbaceous Vegetation



Figure G76. Ground photo for map class B38 Desert Wheatgrass Herbaceous Vegetation.



Figure G77. Photosignature for map class B38 Desert Wheatgrass Herbaceous Vegetation.

Location: *Agropyron desertorum* as the dominant plant was observed as patches within agriculture and barren sandstone in the lower canyon.

Photosignature: The signature can be seen as a washed-out area of lighter beige than the surrounding vegetation. Evidence of disturbance in the form of plowing or chaining can be seen in the photosignature, such as in the yellow circled polygon on the image.

Plant communities	*Agropyron desertorum* Semi-natural Herbaceous Vegetation
Group map class	Inter Mountain Basins Semi Desert Grassland (1 of 5)
Management map class	Mixed Upland Herbaceous Vegetation (1 of 4)
Number of map units in park & environs	1
Number of map units in park	1
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	3.8 ha / 9.4 ac
Area of map class in park & environs	9.2 ha / 22.6 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	58.6%
Base map class accuracy	Not calculated.
Group map class accuracy	user 56.3 (41.9 - 69.6), producer 60.0 (45.1 - 73.3)
Management map class accuracy	user 29.4 (15.1 - 49.4), producer 26.3 (13.4 - 45.1)
Documentation for base map class	0 2004 relevés, 1 2001/02 plots

B39 Indian Ricegrass Colorado Plateau Herbaceous Vegetation



Figure G78. Ground photo for map class B39 Indian Ricegrass Colorado Plateau Herbaceous Vegetation.

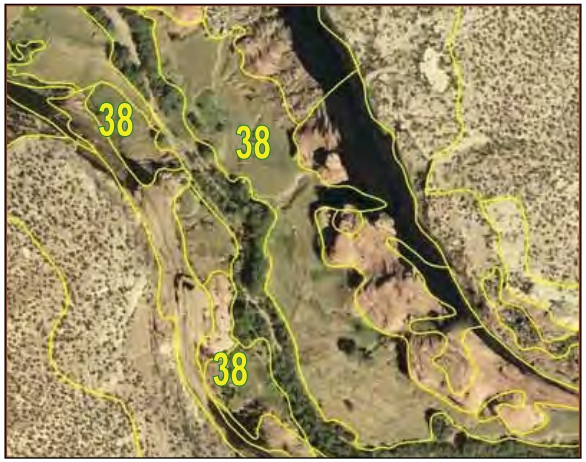


Figure G79. Photosignature for map class B39 Indian Ricegrass Colorado Plateau Herbaceous Vegetation.

Location: This map class was identified at four locations based on field observations in the western half of the monument in the canyon bottom on open slopes.

Photosignature: The photosignature appears as a light green color with a low cover of shrubs or trees (indicated by dark speckles or blobs). These areas were difficult to differentiate from *Bromus tectorum* or *Bouteloua gracilis*; field observations were used to delineate this map class. The map class photosignature is illustrated on the polygons labeled 38 on the image.

Plant communities	*Achnatherum hymenoides* Colorado Plateau Herbaceous Vegetation
Group map class	Inter Mountain Basins Semi Desert Grassland (1 of 5)
Management map class	Mixed Upland Herbaceous Vegetation (1 of 4)
Number of map units in park & environs	4
Number of map units in park	4
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	17.9 ha / 44.3 ac
Area of map class in park & environs	17.9 ha / 44.3 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 25.0 (57.9 - 64.4), producer 100.0 (27.0 - 100.0)
Group map class accuracy	user 56.3 (41.9 - 69.6), producer 60.0 (45.1 - 73.3)
Management map class accuracy	user 29.4 (15.1 - 49.4), producer 26.3 (13.4 - 45.1)
Documentation for base map class	1 2004 relevés, 0 2001/02 plots

B40 Mixed Riparian Herbaceous



Figure G80. Ground photo for map class B40 Mixed Riparian Herbaceous.



Figure G81. Photosignature for map class B40 Mixed Riparian Herbaceous.

Location: This map class was identified in areas with surface water. It commonly occurred adjacent to riparian corridors, seeps, tanks, along stream channels or on stream terraces mainly in the eastern section of the canyon bottom.

Photosignature: This map class appears as a bright, vivid, primary green color. It is immediately recognizable as herbaceous vegetation by its lack of height, generally sinuous shape (wherever it follows the stream bed), and uniform flat texture. Around Tsaile Lake, this class is used to delineate the large patches of *Juncus* sp. See the yellow circled polygons in the image.

Plant communities	
Group map class	Colorado Plateau Riparian Woodland and Shrubland (1 of 2)
Management map class	Mixed Riparian Herbaceous Vegetation (1 of 2)
Number of map units in park & environs	55
Number of map units in park	42
Number of map units less than 0.5 ha	19 (4.7% of total map class area)
Area of map class in park	72.6 ha / 179.3 ac
Area of map class in park & environs	100.2 ha / 247.7 ac
Proportion of map class in park	0.2%
Proportion of map class in project environs	27.6%
Base map class accuracy	user 52.6 (34.7 - 69.9), producer 100.0 (78.7 - 100.0)
Group map class accuracy	user 86.9 (78.2 - 92.4), producer 76.8 (67.5 - 84.1)
Management map class accuracy	user 69.6 (52.4 - 82.6), producer 48.5 (34.8 - 62.4)
Documentation for base map class	0 2004 relevés, 0 2001/02 plots

B41 Mixed Weedy Herbaceous



Figure G82. Ground photo for map class B41 Mixed Weedy Herbaceous.



Figure G83. Photosignature for map class B41 Mixed Weedy Herbaceous.

Location: This map class was found mainly in the western half of the monument along the canyon bottom and near Chinle, Arizona. It occurs in highly disturbed areas including abandoned or fallow agricultural fields and in areas used for animal agriculture.

Photosignature: This map class is typically identified by its context – abandoned or fallow agricultural fields, animal agriculture, and proximity to residences. The photosignature is not consistent between polygons, due to the various appearances of weedy herbaceous species. Additional sites were identified based on ancillary field data collection. The polygon indicated by the arrow and number 41 shows a typical photosignature.

Plant communities	
Group map class	Inter Mountain Basins Semi Desert Grassland (1 of 5)
Management map class	Mixed Upland Herbaceous Vegetation (1 of 4)
Number of map units in park & environs	16
Number of map units in park	11
Number of map units less than 0.5 ha	3 (1.5% of total map class area)
Area of map class in park	29.3 ha / 72.4 ac
Area of map class in park & environs	48.5 ha / 120.0 ac
Proportion of map class in park	0.1%
Proportion of map class in project environs	39.7%
Base map class accuracy	user 66.7 (34.7 - 88.3), producer 22.2 (10.4 - 41.3)
Group map class accuracy	user 56.3 (41.9 - 69.6), producer 60.0 (45.1 - 73.3)
Management map class accuracy	user 29.4 (15.1 - 49.4), producer 26.3 (13.4 - 45.1)
Documentation for base map class	0 2004 relevés, 0 2001/02 plots

B42 Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous



Figure G84. Ground photo for map class B42 Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous.



Figure G85. Photosignature for map class B42 Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous.

Location: This map class is found exclusively above the canyon rim, typically in shallow sandy soils. It was found in the western half of the monument, east of Chinle, Arizona.

Photosignature: The photosignature appears as open grassland with a sparse *Pinus edulis* and *Juniperus osteosperma* cover. *Ephedra viridis*, (labeled as EPVI on the attached images), appears as faded blotches of grayish debris. This map class tends to commonly occur in sandy areas or on sand dunes. Although *Ephedra viridis* has a light yellow green color on the ground, its photosignature appears as a light gray-green circular pattern. The species tends to be clonal with the middle often dying with the outer edges on the clone persistent. *Bromus tectorum* appears on the photo as a light muted greenish brown covering the red sandy soils. The grass looks as if it masks the substrate, even though the ground cover is low and varies throughout the season. The ground cover also will vary annually due to *Bromus tectorum* being a winter annual species. It likely responds to different levels of precipitation as well as landscape disturbance. Polygons labeled 43 illustrate this map class on the image.

Plant communities	*Juniperus osteosperma* / *Ephedra viridis* Woodland
Group map class	Inter Mountain Basins Semi Desert Shrub Steppe (1 of 4)
Management map class	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation (1 of 1)
Number of map units in park & environs	14
Number of map units in park	14
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	187.5 ha / 463.3 ac
Area of map class in park & environs	193.0 ha / 476.8 ac
Proportion of map class in park	0.5%
Proportion of map class in project environs	2.8%
Base map class accuracy	user 58.3 (35.6 - 78.0), producer 87.5 (58.9 - 97.2)
Group map class accuracy	user 71.7 (61.3 - 80.1), producer 72.9 (62.5 - 81.2)
Management map class accuracy	user 58.3 (35.6 - 78.0), producer 87.5 (58.9 - 97.2)
Documentation for base map class	1 2004 relevé, 0 2001/02 plots

B43 Artificial Catchment



Figure G86. Ground photo for map class B43 Artificial Catchment.

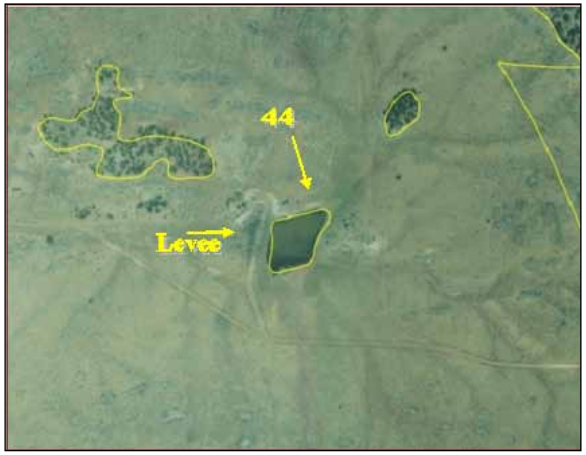


Figure G87. Photosignature for map class B43 Artificial Catchment.

Location: Artificial catchments are found throughout the monument above the canyon rim.

Photosignature: Using stereoscopy, the map class appears as a raised levee with shallow dark gray-green water. The basin of the catchment generally stands out on the aerial photos. The water level likely changes seasonally and annually depending on water availability. The arrow points to an example on the imagery.

Plant communities	Not applicable - land cover type
Group map class	Agriculture (1 of 4)
Management map class	Artificial catchment (1 of 1)
Number of map units in park & environs	11
Number of map units in park	5
Number of map units less than 0.5 ha	8 (47.8% of total map class area)
Area of map class in park	2.4 ha / 5.8 ac
Area of map class in park & environs	4.4 ha / 10.8 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	45.8%
Base map class accuracy	user 100.0 (52.6 - 100.0), producer 60.0 (27.2 - 85.7)
Group map class accuracy	user 75.0 (65.9 - 82.4), producer 94.7 (87.5 - 97.9)
Management map class accuracy	user 100.0 (52.8 - 100.0), producer 60.0 (27.2 - 85.7)
Documentation for base map class	0 2004 relevés, 0 2001/02 plots

B44 Barren Wash Bottom



Figure G88. Ground photo for map class B44 Barren Wash Bottom.



Figure G89. Photosignature for map class B44 Barren Wash Bottom.

Location: This map class occurs throughout the monument in areas with seasonal active water flow, restricting vegetation establishment. It commonly occurs in the main canyon bottoms of Canyon de Chelly and Canyon del Muerto. Due to the active nature of the stream channel, this map class is likely to change depending on the seasonal flows.

Photosignature: This map class appears as a stream bed or a wash with little to no vegetation. It is often linear with meandering features. The color often appears pale white, brown, or gray depending on the soil color, presence of standing water, and stream morphology. See polygon 51 on the imagery.

Plant communities	
Group map class	Barren (1 of 3)
Management map class	Barren Wash Bottom (1 of 1)
Number of map units in park & environs	9
Number of map units in park	9
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	95.9 ha / 236.9 ac
Area of map class in park & environs	109.9 ha / 271.5 ac
Proportion of map class in park	0.3%
Proportion of map class in project environs	12.7%
Base map class accuracy	user 88.9 (62.3 - 97.5), producer 100.0 (74.7 - 100.0)
Group map class accuracy	user 85.0 (67.8 - 93.8), producer 100.0 (27.0 - 100.0)
Management map class accuracy	user 88.9 (62.3 - 97.5), producer 100.0 (74.7 - 100.0)
Documentation for base map class	Defined by photointerpretation.

B45 Major Roads



Figure G90. Ground photo for map class B45 Major Roads.



Figure G91. Photosignature for map class B45 Major Roads.

Location: This map class contains the paved roads within the Canyon de Chelly National Monument mapping area. The paved roads run parallel to Canyon del Muerto and Canyon de Chelly up to Spider Rock. The non-paved roads were mapped as part of a separate mapping effort and were not delineated as part of this mapping effort.

Photosignature: The paved roads appear as gray straight lines with a uniform width. The arrow on the imagery points out an example polygon.

Plant communities	Not applicable - land cover type
Group map class	Transportation (1 of 1)
Management map class	Major Roads (1 of 1)
Number of map units in park & environs	4
Number of map units in park	9
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	41.6 ha / 102.9 ac
Area of map class in park & environs	66.9 ha / 165.2 ac
Proportion of map class in park	0.1%
Proportion of map class in project environs	37.7%
Base map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Group map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Management map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Documentation for base map class	Defined by photointerpretation.

B46 Mixed Urban Chinle



Figure G92. Photosignature for map class B46 Mixed Urban Chinle.

Location: This map class is found only in the urban areas of Chinle, Arizona, outside of the boundary of Canyon de Chelly National Monument.

Photosignature: The photosignature contains a mix of human developed structures, including roads, buildings, yards, parks, and parking lots. See polygon 45 in the imagery.

Plant communities	Not applicable - land cover type
Group map class	Residential (1 of 2)
Management map class	Mixed Urban Chinle (1 of 1)
Number of map units in park & environs	9
Number of map units in park	1
Number of map units less than 0.5 ha	2 (0.4% of total map class area)
Area of map class in park	2.1 ha / 5.1 ac
Area of map class in park & environs	56.5 ha / 139.6 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	96.4%
Base map class accuracy	user 100.0 (76.9 - 100.0), producer 90.0 (65.2 - 97.8)
Group map class accuracy	user 100.0 (78.7 - 100.0), producer 71.4 (49.4 - 86.5)
Management map class accuracy	user 100.0 (76.9 - 100.0), producer 90.0 (62.2 - 97.7)
Documentation for base map class	Defined by photointerpretation.

B47 Mixed Urban Monument



Figure G93. Ground photo for map class B47 Mixed Urban Monument.



Figure G94. Photosignature for map class B47 Mixed Urban Monument.

Location: This map class is found adjacent to Chinle, Arizona, and includes human development inside the boundary of Canyon de Chelly National Monument.

Photosignature: This map class contains a mix of human development, including roads, buildings, yards, parks, and parking lots. See polygon 46 on the image.

Plant communities	
Group map class	Residential (1 of 2)
Management map class	Mixed Monument and Rim Rural Residential (1 of 2)
Number of map units in park & environs	1
Number of map units in park	1
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	10.2 ha / 25.3 ac
Area of map class in park & environs	10.2 ha / 25.3 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 100.0 (27.0 - 100.0), producer 20.0 (4.6 - 56.5)
Group map class accuracy	user 100.0 (78.7 - 100.0), producer 71.4 (49.4 - 86.5)
Management map class accuracy	user 66.7 (49.9 - 80.1), producer 80.0 (62.2 - 90.7)
Documentation for base map class	Defined by photointerpretation.

B48 Rim Agriculture



Figure G95. Ground photo for map class B48 Rim Agriculture.



Figure G96. Photosignature for map class B48 Rim Agriculture.

Location: This map class is found solely on top of the canyon rims. Most of the rim top agriculture is evident outside of Canyon de Chelly National Monument usually near residences or other structures.

Photosignature: Agricultural fields generally are easily distinguished from surrounding native plant communities by an abrupt change in vegetation pattern, as well as by straight, fenced edges. Regular, straight lines, developed via plowing or managing fields, are usually evident throughout the area. The texture is often even and smooth. A typical photosignature is shown in polygon 48 on the image.

Plant communities	Not applicable - land cover type
Group map class	Agriculture (1 of 4)
Management map class	Mixed Monument and Rim Rural Residential (1 of 2)
Number of map units in park & environs	62
Number of map units in park	15
Number of map units less than 0.5 ha	11 (2.8% of total map class area)
Area of map class in park	38.3 ha / 94.5 ac
Area of map class in park & environs	147.7 ha / 365.1 ac
Proportion of map class in park	0.1%
Proportion of map class in project environs	74.1%
Base map class accuracy	user 60.9 (43.9 - 75.6), producer 93.3 (74.9 - 98.5)
Group map class accuracy	user 75.0 (65.9 - 82.4), producer 94.7 (87.5 - 97.9)
Management map class accuracy	user 66.7 (49.9 - 80.1), producer 80.0 (62.2 - 90.7)
Documentation for base map class	Defined by photointerpretation.

B49 Sand Dunes



Figure G97. Ground photo for map class B49 Sand Dunes.

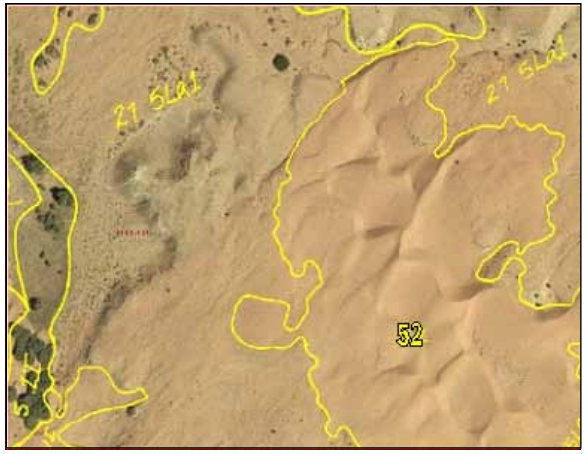


Figure G98. Photosignature for map class B49 Sand Dunes.

Location: Sand dunes are found southeast and north of Chinle, Arizona.

Photosignature: The photosignature of sand dunes has a soft and smooth texture with small hills shading the surface and a beige or red color. This landform is different from the adjacent map classes, due to the lack of vegetation. See polygon 52 for an illustration of this map class.

Plant communities	
Group map class	Barren (1 of 3)
Management map class	Sand Dunes (1 of 1)
Number of map units in park & environs	5
Number of map units in park	1
Number of map units less than 0.5 ha	0 (0.0% of total map class area)
Area of map class in park	6.9 ha / 17.2 ac
Area of map class in park & environs	48.5 ha / 119.9 ac
Proportion of map class in park	0.0%
Proportion of map class in project environs	85.7%
Base map class accuracy	user 100.0 (52.6 - 100.0), producer 100.0 (52.6 - 100.0)
Group map class accuracy	user 85.0 (67.8 - 93.8), producer 100.0 (27.0 - 100.0)
Management map class accuracy	user 100.0 (52.6 - 100.0), producer 100.0 (52.6 - 100.0)
Documentation for base map class	Defined by photointerpretation.

B50 Sandstone Rock



Figure G99. Ground photo for map class B50 Sandstone Rock.



Figure G100. Photosignature for map class B50 Sandstone Rock.

Location: This map class most commonly occurs on the canyon walls of Canyon de Chelly and Canyon del Muerto. It also occurs on top of the rims as large exposed expanses of bedrock.

Photosignature: The photosignature appears as a non-vegetated red, tan, or gray slick rock. It often occurs at very steep grades on vertical cliffs, but also can occur on flat expanses. Polygon 53 on the image provides an example.

Plant communities	
Group map class	Barren (1 of 3)
Management map class	Sandstone Rock (1 of 1)
Number of map units in park & environs	620
Number of map units in park	594
Number of map units less than 0.5 ha	142 (3.4% of total map class area)
Area of map class in park	1348.9 ha / 3333.1ac
Area of map class in park & environs	1390.1 ha / 3434.9 ac
Proportion of map class in park	3.6%
Proportion of map class in project environs	3.0%
Base map class accuracy	user 75.0 (46.0 - 91.3), producer 100.0 (68.9 - 100.0)
Group map class accuracy	user 85.0 (67.8 - 93.8), producer 100.0 (27.0 - 100.0)
Management map class accuracy	user 75.0 (46.0 - 91.3), producer 100.0 (68.9 - 100.0)
Documentation for base map class	Defined by photointerpretation.

B51 Traditional Community-Use Agriculture (Canyon del Chelly)



Figure G101. Ground photo for map class B51 Traditional Community-Use Agriculture (Canyon del Chelly).



Figure G102. Photosignature for map class B51 Traditional Community-Use Agriculture (Canyon del Chelly).

Location: This map class occurs exclusively on the canyon bottom floor in Canyon de Chelly. It is particularly common in the western half of the monument, in the broad open ends of the canyon.

Photosignature: Agricultural fields are obvious human derived linear features. This map class often has a rectangular shape from fenced boundaries with a different color and texture than the adjacent natural vegetation. Many of the agricultural fields have a smooth uniform texture or a striated pattern from plowing or furrowing. When agricultural fields are in transition between crops, the fields appear as mottled texture, due to standing water, encroaching vegetation, and fallen harvested crops. See the map class photosignature with the polygons labeled 50 on the image.

Plant communities	Not applicable - land cover type
Group map class	Agriculture (1 of 4)
Management map class	Traditional Community-Use Agriculture (Canyon de Chelly) (1 of 1)
Number of map units in park & environs	29
Number of map units in park	29
Number of map units less than 0.5 ha	1 (0.2% of total map class area)
Area of map class in park	91.2 ha / 225.3 ac
Area of map class in park & environs	91.2 ha / 225.3 ac
Proportion of map class in park	0.2%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 63.2 (44.4 - 78.6), producer 92.3 (71.8 - 98.3)
Group map class accuracy	user 75.0 (65.9 - 82.4), producer 94.7 (87.5 - 97.9)
Management map class accuracy	user 63.2 (44.4 - 78.6), producer 92.3 (71.8 - 98.3)
Documentation for base map class	Defined by photointerpretation.

B52 Traditional Community-Use Agriculture (Canyon del Muerto)



Figure G103. Ground photo for map class B52 Traditional Community-Use Agriculture (Canyon del Muerto).



Figure G104. Photosignature for map class B52 Traditional Community-Use Agriculture (Canyon del Muerto).

Location: This map class is exclusive to the canyon bottom flats, often adjacent to a stream of a side canyon tributary. This map class is common especially in the broader canyon bottom of the west side of the project boundary. This map class is exclusive to Canyon del Muerto.

Photosignature: This map class has the same photosignature as Traditional Community-Use Agriculture (Canyon de Chelly), map class 50. It is distinguished by location and is illustrated with polygon 50 on the imagery.

Plant communities	Not applicable - land cover type
Group map class	Agriculture (1 of 4)
Management map class	Traditional Community-Use Agriculture (Canyon del Muerto) (1 of 1)
Number of map units in park & environs	50
Number of map units in park	50
Number of map units less than 0.5 ha	10 (2.3% of total map class area)
Area of map class in park	180.3 ha / 445.6 ac
Area of map class in park & environs	180.3 ha / 445.6 ac
Proportion of map class in park	0.5%
Proportion of map class in project environs	0.0%
Base map class accuracy	user 85.2 (70.8 - 93.2), producer 95.8 (83.3 - 99.1)
Group map class accuracy	user 75.0 (65.9 - 82.4), producer 94.7 (87.5 - 97.9)
Management map class accuracy	user 85.2 (70.8 - 93.2), producer 95.8 (83.3 - 99.1)
Documentation for base map class	Defined by photointerpretation.

B53 Tsaile Lake



Figure G105. Ground photo for map class B53 Tsaile Lake.



Figure G106. Photosignature for map class B53 Tsaile Lake.

Location: This map class was used for Tsaile Lake.

Photosignature: The photosignature appears as a large gray green to black body of water. The draw-down from the Tsaile Lake reservoir was provided a modifier that indicated reservoir draw-down, the small letter 'o'. Polygon 54 shows the map class photosignature.

Plant communities	Not applicable - land cover type
Group map class	Water (1 of 1)
Management map class	Tsaile Lake (1 of 1)
Number of map units in park & environs	6
Number of map units in park	4
Number of map units less than 0.5 ha	2 (0.8% of total map class area)
Area of map class in park	26.2 ha / 64.7 ac
Area of map class in park & environs	80.8 ha / 199.7 ac
Proportion of map class in park	0.1%
Proportion of map class in project environs	67.6%
Base map class accuracy	user 100.0 (27.0 - 100.0), producer 25.0 (5.8 - 64.4)
Group map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Management map class accuracy	user 100.0 (27.0 - 100.0), producer 100.0 (27.0 - 100.0)
Documentation for base map class	Defined by photointerpretation.

Appendix H: Accuracy Assessment Data

Appendix H consists of three contingency tables, also known as error matrices, showing the accuracy assessment for the base map classes (H.1), group map classes (H.2), and management map classes (H.3). Each table includes rows (Vegetation Map Database Map Class) representing the map classes for polygons in the vegetation map database, and columns (Field Assessment Map Class) representing the accuracy assessment made in the field for that polygon. A perfect correspondence between the map and the field is indicated by a tally in the matrix where the row and column intersect for the same map class. For example, in Table H.2, the intersection of row and column G1 shows a tally 54, indicating that in the field accuracy assessment, fifty-four of the polygons on the map were found to be the same map class in the field as that mapped. The contingency table also shows the source of error in the map. For row G1, the table shows that the field crew found the mapped polygon to actually be map class G8 seven times in the field rather than what was mapped.

The number of correctly mapped polygons, as determined in the accuracy assessment, occurs on the shaded major diagonal of the contingency table. User and producer accuracy, 90% confidence intervals for each, overall accuracy, Kappa accuracy, and Kappa accuracy standard error are reported. The Kappa accuracy and standard error do not include vegetation map database map classes that were not field-assessed.

Each table is accompanied by a key code to map classes. In the example given above, G8 is Inter-Mountain Basins Semi-Desert Grassland.

For each table, the following notations are used:

NTF: None that fits; the assessment in the field did not match any existing map classes.

N/A: Not applicable; unable to compute confidence intervals because there were no polygons assessed as correct in the field.

N/S: Not sampled; unable to compute producer or user accuracy assessment since the polygons were not sampled.

Note: Due to their size, Tables H-1 and H-3 are spread across two pages and should be read accordingly. The key for each table appears on the page that follows it.

Table H-1. Contingency table: Base map classes.

Field assessment map class

Vegetation map database map class: Map Code	None	B43	B48	B51	B52	B46	B47	B45	B53	B44	B49	B50	B35	B37	B39	B40	B41	B25	B24	B26	B32	B34	B36	B29	B30	B42	B27
B43		3																									
B48	1		14		1		1										3			3							
B51				12												1	3							1			
B52				1	23											1	1							1			
B46						9																					
B47							1																				
B45								1																			
B53									1																		
B44										8						1											
B49											3																
B50		1										6															
B35							3						8				2										
B37													1	0		1							1	1	1		
B39															1								1	1			
B40		1							3							13	2							1			
B41						1											4										
B25													1					10	1	9							
B24																		3	7	13							
B26																				8					1		
B32			1																		13			1		1	
B34																						1		1	1		
B36																							2				
B29																4	2					1		11	4		
B30																3	1							6	12		
B42																										7	
B27	1																										0
B28	1																										1
B33																											
B17																									1		
B13	3																										
B16																											
B18																											
B14																									1		
B19																											
B15																											
B20																			1								
B21	1																										
B22																											
B23																											
B3																											
B4																								1			
B5																											
B11	1													1		2											
B12																											
B31																4				1					1		
B1																											
B6																											
B2																											
B8																				3							
B9	4																										
B10	1																										
Number of samples	13	5	15	13	24	10	5	1	4	8	3	6	10	1	1	30	18	13	9	37	13	2	4	25	22	8	1
Producer accuracy/ omission error (%correct)	NTF	60.0	93.3	92.3	95.8	90.0	20.0	100.0	25.0	100.0	100.0	100.0	80.0	0.0	100.0	36.7	22.2	76.9	77.8	21.6	100.0	50.0	50.0	44.0	54.5	87.5	0.0
90% confidence interval (-)	NTF	27.2	74.9	71.8	83.3	65.2	4.6	27.0	5.8	74.7	52.6	68.9	54.1	N/A	27.0	29.6	10.4	54.2	50.4	12.6	82.7	12.1	18.2	29.1	37.6	58.9	N/A
90% confidence interval (+)	NTF	85.7	98.5	98.3	99.1	97.8	56.5	100.0	64.4	100.0	100.0	100.0	93.1	N/A	100.0	58.1	41.3	90.4	92.4	34.5	100.0	87.9	81.8	60.1	70.5	97.2	N/A

Overall accuracy = 50.8% Kappa index = 53.1% Standard error = 0.02

B28	B33	B17	B13	B16	B18	B14	B19	B15	B20	B21	B22	B23	B3	B4	B5	B11	B12	B31	B1	B6	B2	B8	B9	B10	Number of samples	User accuracy/ commission error (%)	90% Confidence intervals	
																											-	+
																									3	100.0	52.6	100.0
																									23	60.9	43.9	75.6
																	2								19	63.2	44.4	78.6
																									27	85.2	70.8	93.2
																									9	100.0	76.9	100.0
																									1	100.0	27.0	100.0
																									1	100.0	27.0	100.0
																									1	100.0	27.0	100.0
																									9	88.9	62.3	97.5
																									3	100.0	52.6	100.0
								1																	8	75.0	46.0	91.3
			1							1															15	53.3	33.3	72.3
		1															1								7	0.0	N/A	N/A
															1										4	25.0	39.7	71.9
																1	1	1							23	56.5	5.8	64.4
																		1							6	66.7	34.7	88.3
																									21	47.6	31.0	64.8
			3																						26	26.9	15.3	42.9
																									9	88.9	62.3	97.5
		2					1	1		3		1													24	54.2	37.9	69.6
	1																								4	25.0	5.8	64.4
									1																3	66.7	25.3	92.2
																									22	50.0	33.5	66.5
									1																23	52.2	35.7	68.2
		3							2																12	58.3	35.6	78.0
				1																					2	0.0	N/A	N/A
6					1	3		1				2									1				16	37.5	20.8	57.8
	1			2			2		2																7	14.3	3.3	45.2
		15	1						1	3	3														24	62.5	45.8	76.7
			17	1							3														24	70.8	54.1	83.3
		5	7	13		1																	1	2	29	44.8	30.7	59.8
					0				2																2	0.0	N/A	N/A
		1	1		1	4	1	3		1	2	2													17	23.5	11.0	43.3
							1		3																4	25.0	57.9	64.4
			1			1		6	5	2	2														17	35.3	19.5	55.1
	1				1			1	10	3	2														19	52.6	34.7	69.9
		1	4		1		1	3		13	1	1													26	50.0	34.6	65.4
			1	3			1	2	1	1	9	1													19	47.4	30.0	65.3
									2	1	1	4													8	50.0	24.9	75.1
													1												1	100.0	27.0	100.0
														0											1	0.0	N/A	N/A
															0										0	N/S	N/S	N/S
						1						1				18	1	1							26	69.2	53.1	81.7
																2	1	2							5	20.0	4.6	56.5
																		0							6	0.0	N/A	N/A
												1							6					3	10	60.0	35.2	80.6
					1						1									1					3	33.3	7.8	74.6
																			1		2				3	66.7	25.4	92.2
			10	2																		6		3	24	25.0	13.5	41.5
			1	1						1	1	1										4	4	3	20	20.0	9.3	37.8
			2			2						1										3	2	9	20	45.0	28.4	62.8
6	3	28	49	23	5	12	7	18	30	29	25	15	1	0	1	21	6	5	7	1	3	13	7	20	**Total number of samples: 636**			
100.0	33.3	53.6	34.7	56.5	0.0	33.3	14.3	33.3	33.3	44.8	36.0	26.7	100.0	N/S	0.0	85.7	16.7	0.0	85.7	100.0	66.7	46.2	57.1	45.0				
68.9	7.8	38.4	24.6	39.7	N/A	15.9	3.3	18.3	21.1	30.7	22.3	12.6	27.0	N/S	N/A	69.1	3.8	N/A	54.8	27.0	25.4	26.1	28.9	28.4	**Total correct: 323**			
100.0	74.6	68.1	46.4	71.9	N/A	56.9	45.2	52.7	48.3	56.8	52.4	47.9	100.0	N/S	N/A	94.1	50.2	N/A	96.7	100.0	92.2	67.5	81.4	62.8				

Key to base map class codes in Appendix H1	
FOREST	
B1	Douglas-fir / Gambel Oak Forest
B2	Douglas-fir / Rio Grande Cottonwood Forest
B3	Quaking Aspen / Three-leaf Sumac Forest
WOODLAND	
B4	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland
B5	Boxelder / Disturbed Understory Woodland
B6	Douglas-fir / Muttongrass Woodland
B8	Ponderosa Pine / Black Sagebrush - Big Sagebrush Woodland
B9	Ponderosa Pine / Blue Grama Woodland
B10	Ponderosa Pine / Gambel Oak Woodland
B11	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland
B12	Russian Olive Woodland
B13	Two-needle Pinyon - Juniper spp. / Big Sagebrush Woodland
B14	Two-needle Pinyon - Juniper spp. / Gambel Oak Woodland
B15	Two-needle Pinyon - Juniper spp. / Mountain-mahogany Mixed Shrubs Woodland
B16	Two-needle Pinyon - Utah Juniper / Black Sagebrush Woodland
B17	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland
B18	Two-needle Pinyon - Utah Juniper / Cliff Fendlerbush Woodland
B19	Two-needle Pinyon - Utah Juniper / Littleleaf Mountain-mahogany Woodland
B20	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland
B21	Two-needle Pinyon - Utah Juniper / Sparse Understory Woodland
B22	Two-needle Pinyon - Utah Juniper / Stansbury Cliffrose Woodland
B23	Two-needle Pinyon - Utah Juniper / Utah Serviceberry Woodland
SHRUBLAND	
B24	Big Sagebrush / Black Sagebrush Shrubland
B25	Big Sagebrush / Blue Grama Shrubland
B26	Big Sagebrush / Disturbed Understory Semi-natural Shrubland
B27	Gambel Oak / Cliff Fendlerbush Shrubland
B28	Gambel Oak Woodland
B29	Prickly-pear Dwarf-shrubland
B30	Rubber Rabbitbrush / Cheatgrass Semi-natural Shrubland
B31	Saltcedar Temporarily Flooded Shrubland
B32	Shadscale / Galleta Shrubland
B33	Utah Serviceberry - Cliff Fendlerbush Shrubland
HERBACEOUS	
B34	Bigelow Sagebrush / Blue Grama Dwarf-shrub Herbaceous Vegetation
B35	Blue Grama Herbaceous Vegetation
B36	California Brickelbush Shrubland
B37	Cheatgrass Herbaceous Vegetation
B39	Indian Ricegrass Colorado Plateau Herbaceous Vegetation
B40	Mixed Riparian Herbaceous
B41	Mixed Weedy Herbaceous
B42	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation

LAND USE/LANDFORMS	
B43	Artificial Catchment
B44	Barren Wash Bottom
B45	Major Roads
B46	Mixed Urban Chinle
B47	Mixed Urban Monument
B48	Rim Agriculture
B49	Sand Dunes
B50	Sandstone Rock
B51	Traditional Community-Use Agriculture (Canyon del Chelly)
B52	Traditional Community-Use Agriculture (Canyon del Muerto)
B53	Tsaile Lake
NOT ASSESSED	
B7	Douglas-fir Scree Woodland
B38	Desert Wheatgrass Herbaceous Vegetation

Table H-2. Contingency table: Group map classes.

Vegetation map database map class	Field assessment map class																	Number of samples	User accuracy/ commission error (%)	90% Confidence intervals	
	Map Code	None	G1	G10	G15	G16	G2	G8	G6	G7	G3	G9	G12	G4	G11	G5	G13	G14			-	+
	G1	1	54	1				7	3			2				4			72	75.0	65.9	82.4
	G10			10															10	100.0	78.7	100.0
	G15				1														1	100.0	27.0	100.0
	G16					1													1	100.0	27.0	100.0
	G2		1				17							1		1			20	85.0	67.8	93.8
	G8			3				18				5		2		4			32	56.3	41.9	69.6
	G6							1	54			1							56	96.4	89.8	98.8
	G7		1							13		2		8					24	54.2	37.9	69.6
	G3										1	2	1						4	25.0	57.9	64.4
	G9							2	1			43		7		7			60	71.7	61.3	80.1
	G12	2											9	13			1		25	36.0	22.3	52.4
	G4	4							1			2	1	179				2	189	94.7	91.3	96.8
	G11														1				1	100.0	27.0	100.0
	G5		1					2	1			2		2		53			61	86.9	78.2	92.4
	G13													3			10	3	16	62.5	42.2	79.2
	G14								3					17				44	64	68.8	58.6	77.4
Number of samples		7	57	14	1	1	17	30	63	13	1	59	11	232	1	69	11	49	**Total number of samples: 629**			
Producer accuracy/ omission error (%correct)		NTF	94.7	71.4	100.0	100.0	100.0	60.0	85.7	100.0	100.0	72.9	81.8	77.2	100.0	76.8	90.9	89.8				
90% confidence interval (-)		NTF	87.5	49.4	27.0	27.0	27.0	45.1	77.0	82.8	27.0	62.5	57.3	72.3	27.0	67.5	67.7	80.5	**Total correct: 508**			
90% confidence interval (+)		NTF	97.9	86.5	100.0	100.0	100.0	73.3	91.5	100.0	100.0	81.2	93.8	81.4	100.0	84.1	97.9	94.9				

Overall accuracy = 79.9% Kappa index = 77.1% Standard error = 0.02

Key to group map class codes in Appendix H2	
G1	Agriculture
G2	Barren
G3	Colorado Plateau Mixed Bedrock and Tableland
G4	Colorado Plateau Pinyon Juniper Woodland
G5	Colorado Plateau Riparian Woodland and Shrubland
G6	Inter-Mountain Basins Big Sagebrush Shrubland
G7	Inter-Mountain Basins Mixed Salt Desert Scrub
G8	Inter-Mountain Basins Semi-Desert Grassland
G9	Inter-Mountain Basins Semi-Desert Shrub-Steppe
G10	Residential
G11	Rocky Mountain Aspen Forest and Woodland
G12	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
G13	Southern Rocky Mountain Montane Mixed Conifer Forest and Woodland
G14	Southern Rocky Mountain Ponderosa Pine Woodland
G15	Transportation
G16	Water

Table H-3. Contingency table: Management map classes.

Field assessment map class

Vegetation map database map class: Map Code	None	M1	M22	M23	M11	M14	M8	M24	M2	M19	M20	M4	M12	M13	M3	M21
M1		3														
M22			12										1	3		
M23			1	23									1	1		
M11	1			1	16									3	3	
M14						9										
M8							1									
M24								1								
M2									8				1			
M19										3						
M20		1									6					
M4					3							8		2		
M12		1											16	2		
M13						1						1	1	5		
M3												1			54	
M21					1											13
M17													7	2		
M6																
M28																
M9	4															
M27	1														1	
M26																
M10	5														2	
M25																
M15																
M7																
M5																
M16	1												2	1		
M18													4		1	
Number of samples	12	5	13	24	20	10	1	1	8	3	6	10	33	19	61	13
Producer accuracy/ omission error (%correct)	NTF	60.0	92.3	95.8	80.0	90.0	100.0	100.0	100.0	100.0	100.0	80.0	48.5	26.3	88.5	100.0
90% confidence interval (-)	NTF	27.2	71.8	83.3	62.2	62.2	27.0	27.0	74.7	52.6	68.9	54.1	34.8	13.4	80.1	82.8
90% confidence interval (+)	NTF	85.7	98.3	99.1	90.7	97.7	100.0	100.0	100.0	100.0	100.0	93.1	62.4	45.1	93.7	100.0

Overall accuracy = 69.0% Kappa index = 68.2% Standard error = 0.02

	M17	M6	M28	M9	M27	M26	M10	M25	M15	M7	M5	M16	M18	Number of samples	User accuracy/ commission error (%)	90% Confidence intervals	
																-	+
														3	100.0	52.8	100.0
	1												2	19	63.2	44.4	78.6
	1													27	85.2	70.8	93.2
														24	66.7	49.9	80.1
														9	100.0	76.9	100.0
														1	100.0	27.0	100.0
														1	100.0	27.0	100.0
														9	88.9	62.3	97.5
														3	100.0	52.6	100.0
								1						8	75.0	46.0	91.3
					1		1							15	53.3	33.3	72.3
	1											1	2	23	69.6	52.4	82.6
	4	2				1							2	17	29.4	15.1	49.4
	1													56	96.4	89.8	98.8
	1		1	1	4	2		1						24	54.2	37.9	69.6
	38				2									49	77.6	66.5	85.8
		2			1									3	66.7	25.4	92.2
			7		2	3								12	58.3	35.6	78.0
	1			33	7	1	9	7		1				63	52.4	42.1	62.4
				1	41	1	6	7						58	70.7	60.1	79.4
	1				4	15	1	3						24	62.5	45.8	76.7
				10	1	2	73	4						97	75.3	67.4	81.7
				2	10		4	20						36	55.6	42.0	68.3
									1					1	100.0	27.0	100.0
				4	1			1		10				16	62.5	42.2	79.2
	1										0			1	0.0	N/A	N/A
				2								18	2	26	69.2	53.1	81.7
	1											2	3	11	27.3	11.5	52.0
	51	4	8	53	74	25	94	44	1	11	0	21	11				
	74.5	50.0	87.5	62.3	55.4	60.0	77.7	45.5	100.0	90.9	N/S	85.7	27.3				
	63.4	18.2	58.9	51.0	45.9	43.7	69.9	33.7	27.0	67.7	N/S	69.1	11.5				
	83.1	81.8	97.2	71.4	64.6	74.4	83.9	57.7	100.0	97.9	N/S	94.1	52.0				

Total number of samples: 636

Total correct: 439

Key to management map class codes in Appendix H3	
M1	Artificial Catchment
M2	Barren Wash Bottom
M3	Big Sagebrush / Natural and Semi-natural Understory Shrubland
M4	Blue Grama Herbaceous Vegetation
M5	Boxelder / (Big Sagebrush / Netleaf Hackberry) Woodland
M6	California Brickelbush Shrubland
M7	Douglas-fir Mixed Forest
M8	Major Roads
M9	Mixed Conifer Gambel Oak Woodland
M10	Mixed Conifer Sagebrush Woodland
M11	Mixed Monument and Rim Rural Residential
M12	Mixed Riparian Herbaceous Vegetation
M13	Mixed Upland Herbaceous Vegetation
M14	Mixed Urban Chinle
M15	Quaking Aspen / Three-leaf Sumac Forest
M16	Rio Grande Cottonwood / Russian Olive Semi-natural Woodland
M17	Rubber Rabbitbrush - Prickly Pear Shrubland
M18	Russian Olive - Saltcedar Woodland and Shrubland
M19	Sand Dunes
M20	Sandstone Rock
M21	Shadscale / Galleta Shrubland
M22	Traditional Community-Use Agriculture (Canyon de Chelly)
M23	Traditional Community-Use Agriculture (Canyon del Muerto)
M24	Tsaile Lake
M25	Two-needle Pinyon - Juniper spp. / Mountain-mahogany - Stansbury Cliff-rose Shrub Woodland
M26	Two-needle Pinyon - Utah Juniper / Blue Grama Woodland
M27	Two-needle Pinyon - Utah Juniper / Shrub Live Oak Woodland
M28	Utah Juniper / Mormon-tea / Cheatgrass Wooded Herbaceous Vegetation

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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