National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Vegetation Inventory, Mapping, and Characterization Report, Gila Cliff Dwellings National Monument

Natural Resource Report NPS/SODN/NRR—2019/1946









ON THE COVER

Clockwise from top left: *Pseudotsuga menziesii - Quercus gambelii* Forest Association; *Quercus grisea / Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous Association; *Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis* Tree Savanna Association; *Pinus ponderosa* Woodland and Tree Savanna Association. NPS photos.

Vegetation Inventory, Mapping, and Characterization Report, Gila Cliff Dwellings National Monument

Natural Resource Report NPS/SODN/NRR—2019/1946

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June 2019

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Studd, S. E., and J. Galvin. 2019. Vegetation inventory, mapping, and characterization report, Gila Cliff Dwellings National Monument. Natural Resource Report NPS/SODN/NRR—2019/1946. National Park Service, Fort Collins, Colorado.

NPS 349/154792, June 2019

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Acronyms and Abbreviations

AA:	accuracy assessment
ac:	acres
BARC:	burned area reflectance classification
CEGL:	Community Element Code–Global
CES:	NatureServe ecological system
CI:	confidence interval
cm:	centimeter
DOQQ:	digital orthophoto quarter quadrangle
ERDAS:	Earth Resources Data Analysis System
ESRI:	Environmental Systems Research Institute
FGDC:	Federal Geographic Data Committee
ft:	foot/feet
GCP:	ground control point
GDB:	geodatabase
GICL:	Gila Cliff Dwellings National Monument
GIS:	geographic information system
GPS:	global positioning system
ha:	hectares
I&M:	inventory and monitoring
ID:	identifier
ITIS:	Integrated Taxonomic Information System
km:	kilometers
m:	meters
mi:	miles
MMU:	minimum mapping unit
NA:	not applicable
NAD83:	North American Datum of 1983
NAIP:	National Agriculture Imagery Program
NHS:	National Historic Site
NM:	National Monument
NMAS:	National Map Accuracy Standards
NP:	national park
NPS:	National Park Service
NS:	NatureServe
NVCS:	National Vegetation Classification System
NVC:	National Vegetation Classification
OALS:	Office of Arid Lands Studies, University of Arizona
P:	proposed
PRIMER:	Plymouth Routines In Multivariate Ecological Research
PS:	park special
RMSE:	root mean square error
RRQRR:	Reversed Randomized Quadrant-Recursive Raster
SIMPROF:	similarity profile
SODN:	Sonoran Desert Network (National Park Service)
spp.:	species (plural)
TNC:	The Nature Conservancy
UNESCO:	United Nations Education, Science, and Cultural Organization
USDA:	U.S. Department of Agriculture
USFS:	U.S. Forest Service
USGS:	U.S. Geological Survey
UTM:	Universal Transverse Mercator

Executive Summary

From 2012 to 2015, the Sonoran Desert Network conducted vegetation mapping and characterization at Gila Cliff Dwellings National Monument (NM) over several separate phases. This effort was completed under the National Park Service (NPS) Vegetation Mapping Inventory, which aims to complete baseline mapping inventories at over 270 NPS units. The goal of the project was to provide park managers with a digital map product that meets national standards of spatial and thematic accuracy, while also placing park vegetation into a regional and national context. The data standard was designed to facilitate the production of uniform statistics about vegetation across the nation, enable the translation of data collected at various scales, and allow data sharing, aggregation, and comparison across regions.

Vegetation mapping and characterization comprised four major phases: (1) field-based vegetation classification data collection, (2) field-based mapping from aerial imagery (map unit delineation), (3) development of vegetation community types at the National Vegetation Classification System (NVCS) association level, and (4) map thematic accuracy assessment. Phase 1 and the majority of phase 2 were completed during summer 2012, with some additional mapping during summer 2013. Community-type descriptions were subsequently drafted to meet the NVCS standard and applied to each mapped area. This classification was developed concurrently from plot data and field-censused polygon data (map units). Concurrent with the additional mapping in 2013, network staff conducted a thematic validation effort, providing additional data that improved both the detail of the association descriptions and the accuracy of the mapped polygons. A formal accuracy assessment was completed in summer 2015. In the accuracy assessment, plots were distributed proportionally within each vegetation type and sampled by a separate team in an unbiased manner. Following accuracy assessment, final products were developed. Those products include this report, a digital map, and full vegetation descriptions.

Gila Cliff Dwellings NM covers 213 hectares (527 ac) and consists of two separate units: the main unit (196 ha/485 ac) and the TJ unit (71 ha/42 ac), separated by two kilometers of U.S. Forest Service (USFS) lands. To provide more useful mapping products, an additional 833 hectares (2,060 ac) of USFS land, as well as the state-administered Heart Bar Wildlife Area, were included in this mapping project. This allowed us to connect the two units of the park and provide an ecologically meaningful buffer around them, for a total of 1,047 hectares (2,587 ac). Management of these lands is highly coordinated across the partners, so an integrated map was more useful for meeting shared natural resource goals. To accurately assess, classify, and describe the monument's previously undescribed vegetation communities, it was necessary to sample the larger watershed area. This helped ensure we captured the variation within each community and were sampling at the community level, rather than just individual stands. The project area covers a complex landscape of topography, geology, and hydrologic influence. It was also greatly affected by the 2011 Miller Fire and subsequent flooding.

A total of 16 distinct communities were described and mapped at Gila Cliff Dwellings NM. These ranged from lush riparian woodlands lining the west and middle forks of the Gila River, dominated by narrowleaf cottonwood (*Populus angustifolia*) and dewystem willow (*Salix irrorata*); to drier upland woodlands and tree savannas dominated by two-needle pinyon (*Pinus edulis*) and alligator juniper (*Juniperus deppeana*), with an understory of blue grama (*Bouteloua gracilis*). Overall accuracy for all classes was 86.7% (90% CI: 83.2, 90.2), with a Kappa (a measure of overall accuracy minus chance agreement) of 83.7% (90% CI: 80.0, 87.4). Individual accuracies ranged from 57.7% to 100%. Six of the 16 vegetation types were "accepted" types within the National Vegetation Classification (NVC). The others have been described here as specific to the project area and are currently proposed for formal status within the NVC.

The map was designed to facilitate ecologically based natural resources management and research. The vector (polygon) map is in digital format within a geodatabase structure that allows for complex relationships to be established between spatial and tabular data, and makes accessing the product easy and seamless. The GIS format allows user flexibility and will enable updates to be made as new information becomes available (such as revised NVC codes or vegetation type names), or in the event of major disturbance events that could impact vegetation.

Acknowledgements

The authors would like to extend thanks to the staff of Gila Cliff Dwellings National Monument for their support of this project through its many phases. Many wonderful people were involved in collecting the field data, entering and verifying the data, providing input into classification work, and the final phases of field accuracy assessment. Quantitative ecologist Tom Philippi (NPS Inventory & Monitoring Division), provided expert technical assistance during reporting. We would like to thank Southern Plains Network vegetation ecologist Tomye Folts-Zettner, and Chihuahuan Desert Network ecologist Ben Cooper, for their thoughtful review of this report.

1 Introduction

1.1 Background

Vegetation is a primary resource of natural areas, and 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 lifeform levels, such as "tropical rainforest" or "savanna." This report describes the methods and results of a multi-year project (2012–2015) to classify, describe, and map vegetation at Gila Cliff Dwellings National Monument (NM), located in Catron County, in the southwest corner of New Mexico (Figure 1-1).

The Sonoran Desert Network (SODN), part of the National Park Service (NPS) Inventory and Monitoring (I&M) Division, organized and coordinated vegetation inventory, classification, and mapping at Gila Cliff Dwellings NM. A goal of the NPS I&M program is to complete baseline inventories of biological and geophysical resources for each NPS unit. Vegetation classification and mapping products are one of these mandated inventories. For Gila Cliff Dwellings NM and other network parks, SODN needs baseline vegetation data upon which to develop and implement specific monitoring programs. Park managers need baseline data and information on park vegetation resources for management purposes.

The current effort to create a vegetation map for Gila Cliff Dwellings NM is part of the NPS Vegetation Mapping Inventory, in cooperation with SODN. The map is required to meet the standards of the NPS Vegetation Mapping Inventory, including a minimum mapping unit (MMU) of 0.5 hectares, >80% thematic accuracy per class, and spatial accuracy meeting the U.S. National Map Accuracy Standards developed by the Federal Geographic Data Committee (FGDC). In addition to meeting the program standards, every effort was made to provide the mapping and classification data to park managers in a manner best suited to their specific management objectives and needs.

1.2 Scope and products

The aim of this project was to create a vegetation map at the National Vegetation Classification System (NVCS) association level for a study area of about 1,047 hectares (2,587 ac). Gila Cliff Dwellings NM covers 213 hectares (527 ac) and consists of two separate units: the main unit (196 ha/485 ac) and the TJ unit (17 ha/42 ac), separated by two kilometers of U.S. Forest Service (USFS) lands. To provide more useful mapping products, an additional 833 hectares (2,060 ac) of USFS land, as well as the state-administered Heart Bar Wildlife Area, were included in this mapping project. This allowed us to connect the two units of the park and provide an ecologically meaningful buffer around them, for a total of 1,047 hectares (2,587 ac).

Management of these lands is highly coordinated across the partners (NPS 1987), so an integrated map was more useful for meeting shared natural-resource goals. To accurately assess, classify, and describe the monument's previously undescribed vegetation communities, it was necessary to sample the larger watershed area. This helped ensure we captured the variation within each community and were sampling at the community level, rather than just individual stands. The project area covers a complex landscape of topography, geology, and hydrologic influence. It was also greatly affected by the 2011 Miller Fire and subsequent flooding.

Products developed for Gila Cliff Dwellings NM as part of this project include:

- A final report, including a dichotomous vegetation key and full vegetation community-type descriptions,
- Digital reference photos of each vegetation type (four per polygon mapped),
- A geodatabase containing mapped vegetation data, plot data and location, permanent photo point locations, and satellite imagery,
- Printable digital graphics of final map polygons,

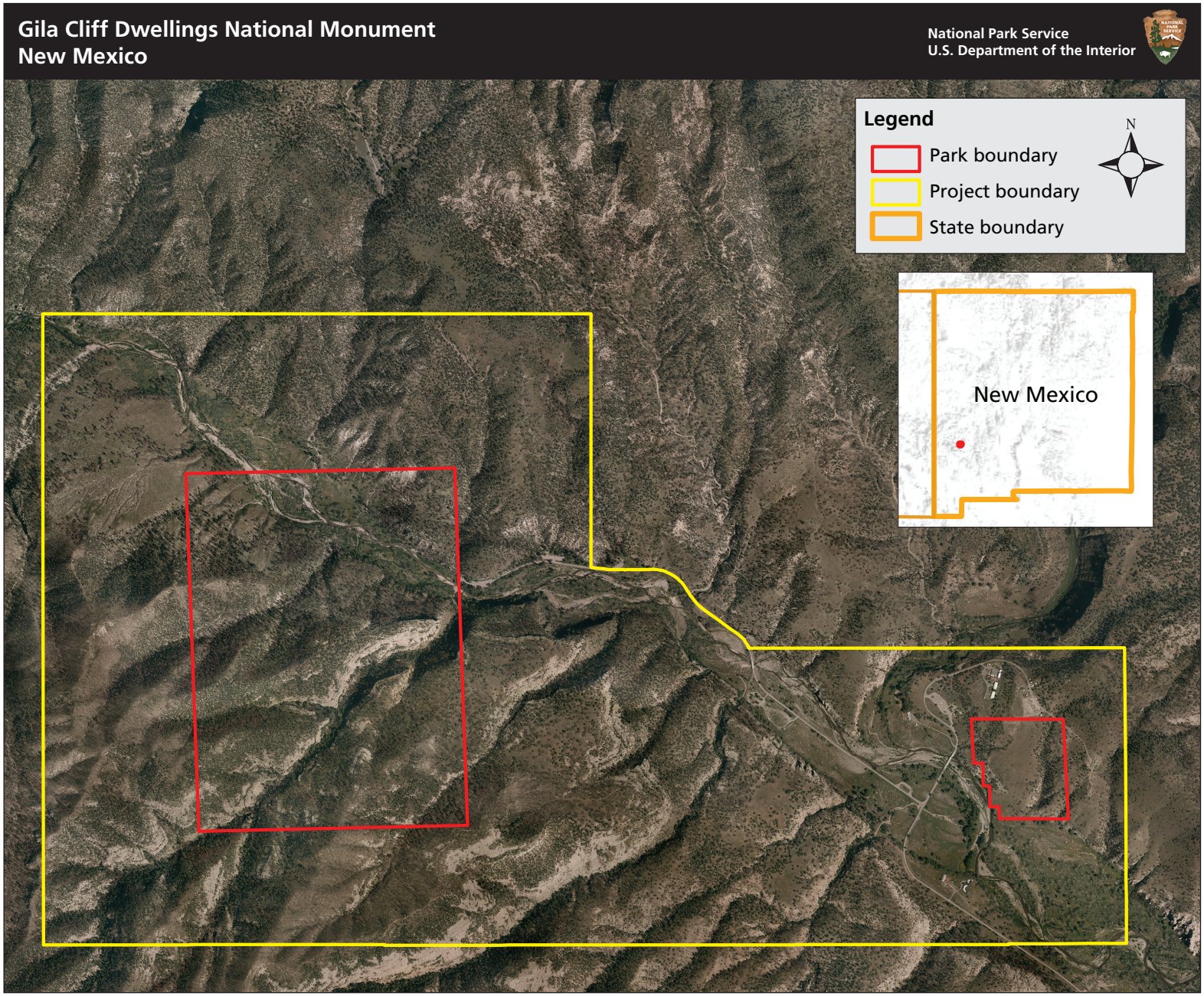


Figure 1-1. Map showing the relative location of Gila Cliff Dwellings National Monument.

- Federal Geographic Data Committee-compliant metadata for all spatial database files and field data, and
- Park-specific plant field guide with annotated check list and voucher specimen list (not a program requirement; rather, an additional product developed by SODN).

1.3 The NPS Vegetation Mapping Inventory

The NPS Vegetation Mapping Inventory is an effort to "classify, describe and map detailed vegetation communities in more than 270 national parks across the United States" (NPS 2012). Since 1992, the program has been administered as a collaboration between the U.S. Geological Survey (USGS) Center for Biological Informatics and the NPS. More recently, the NPS assumed the role as the primary funding agency, providing parks support through Inventory and Monitoring Division base funds. The program serves the data products through download from the Vegetation Mapping Inventory website. They can also be searched and downloaded via the Integrated Resource Management Applications (IRMA) portal.

The Vegetation Mapping Inventory 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:

- Classification Guidance (Natural Resource Report NPS/NRPC/NRR—2011/374)
- Methodology for Assessing the Utility of Existing Data for Vegetation Mapping (TNC and ESRI 1994a; NPS edited 2009 version)
- Federal Geographic Data Committee National Vegetation Classification Standard, v.2 (2008)
- Accuracy Assessment Guidance (Natural Resource Report NPS/NRPC/NRR—2010/204).

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

- Vegetation classification follows the FGDC standard for vegetation classification, the National Vegetation Classification Standard.
- Spatial data formatting follows FGDC standards for spatial data transfer.
- Metadata for each spatial dataset use the FGDC metadata standard.
- Spatial data are 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) 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 try to meet or exceed 80% accuracy at the 90% confidence level.
- The minimum mapping unit (MMU) is 0.5 hectares (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 under similar environmental conditions. The National Vegetation Classification Standard (NVCS) provides a classification framework that is the standard for all NPS vegetation mapping projects (Comer et al. 2003; TNC and ESRI 1994a). In 1997, the FGDC formally adopted the NVCS version 1 (FGDC 1997). It was recognized as incomplete at the time of its adoption, and work to refine and further develop it began immediately. In October 2007, the FGDC vegetation subcommittee released the NVCS Version 2 Working Draft (FGDC 1997), which was formally endorsed in February 2008.

The NVCS evolved from vegetation classification primarily conducted over more than two decades by The Nature Conservancy (TNC), NatureServe, and the Natural Heritage Program network (Grossman et al. 1998). It derives in part from earlier vegetation classification frameworks produced by

the United Nations Educational, Cultural, and Scientific Organization (UNESCO 1973; Driscoll et al. 1984). Use of this standardized classification system helps ensure data compatibility throughout the National Park Service and other agencies. The NVCS was designed to facilitate the production of uniform statistics about vegetation across the nation, enable the translation of data collected at various scales, and allow data sharing, aggregation, and comparison across regions.

The NVCS is a hierarchical system that allows vegetation classification to occur at multiple scales. Existing vegetation is classified on the basis of both physiognomic and floristic criteria. The upper three levels are physiognomic, based primarily on growth form, structure, and cover, indicating characteristics that reflect geographically widespread (global) topoedaphic factors, such as soils and landscape physical properties. The middle three levels focus on largely biogeographic and habitat factors along very broad, continental-to-regional topographic, edaphic, and disturbance gradients. The lower two levels are floristic, based primarily on species composition and abundance. Tables 1-1 to 1-3 show the revised version 2, under which this project was conducted and which is currently being utilized by NatureServe and the Ecological Society of America (ESA) vegetation panel to substantially update the structure and content of the NVCS.

The NVCS also distinguishes between natural and cultural vegetation, the former being determined primarily by ecological processes and the latter by regular human activity. Vegetated areas intermediate between the two, such as those influenced by both human activity (e.g., logging, fire, and grazing) and ecological processes, are defined as semi-natural.

1.5 The National Vegetation Classification

The NVCS provides a framework for levels of classification but does not provide descriptions of all existing vegetation types at all levels. Those descriptions comprise the National Vegetation Classification (NVC), which is being populated by data from various completed vegetation inventory projects (such as the present one) and other sources. The NVC, which is predominantly maintained by NatureServe and used by many federal agencies, including the NPS, includes the plant communities (associations and alliances) defined for the United States.

NatureServe manages a database of NVC plant community entities. Their online database, NatureServe Explorer, provides public access to regularly updated versions of NVC plant community listings and descriptions. However, the plant community listings within the NVC are incomplete; many are still in development and/or undergoing revisions. A newer website, www.usnvc.org, which posts all new descriptions as well as information on the changes to the hierarchy and displays these vegetation-type descriptions in the new hierarchy, is now available (see Tables 1-1 to 1-3). Most vegetation associations listed on this site link to a full and updated description on the NatureServe explorer site. As of 2018, the alliance level of the system was still incomplete/undescribed. As such, there were few alliances formally accepted at that time. After NatureServe and the ESA vegetation panel review the upper and mid-levels, and associations have been peer-reviewed, the effort to revise the alliance concepts will begin.

Therefore, all classes have been developed and reported here at the association level, with group membership noted when known. This project has utilized information available through usnvc.org and NatureServe to describe and classify the vegetation types within the broader system of known types. Where information is lacking or incomplete, classification of vegetation sampled at Montezuma Castle NM was based solely on data collected during this effort, and naming conventions were developed as fitting.

For more information on the NVC, see the NPS Vegetation Mapping Inventory website or Grossman and others (1998).

1.6 Terminology and naming conventions

Alliances and associations are based on both the dominant (greatest-canopy-cover) species in the upper stratum of a contiguous vegetation unit and on diagnostic species

Table 1-1. Example of the National Vegetation Classification Standard (version 2) hierarchy: Upper levels.

Level	Level name	Criteria	Example
L1	Formation Class	Broad combinations of general dominant growth forms that are adapted to basic temperature (energy budget), moisture, and/or substrate or aquatic conditions.	Mesomorphic Shrub and Herb Vegetation (Shrubland and Grassland)
L2	Formation Subclass	Combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate or aquatic conditions.	Temperate and Boreal Shrub and Herb Vegetation (Temperate and Boreal Shrubland & Grassland)
L3	Formation	Combinations of dominant and diagnostic growth forms that reflect global macroclimatic factors as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.	Temperate Shrub and Herb Vegetation (Temperate Shrubland & Grassland)

Table 1-2. Example of the National Vegetation Classification Standard (version 2) hierarchy: Mid levels.

Level	Level name	Criteria	Example
L4	Division	Combinations of dominant and diagnostic growth forms and a broad set of diagnostic plant taxa that reflect biogeographic differences in composition and continental differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon - Stipa - Bouteloua* Grassland & Shrubland Division (North American Great Plains Grassland & Shrubland)
L5	Macrogroup	Combinations of moderate sets of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences in composition and subcontinental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii - Schizachyrium scoparium - Sorghastrum nutans* Grassland & Shrubland Macrogroup (Great Plains Tall Grassland & Shrubland)
L6	Group	Combinations of relatively narrow sets of diagnostic plant species (including dominants and co-dominants), broadly similar composition, and diagnostic growth forms that reflect biogeographic differences in composition and sub-continental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii - Sporobolus heterolepis* Grassland Group (Great Plains Mesic Tallgrass Prairie)

Table 1-3. Example of the National Vegetation Classification Standard (version 2) hierarchy: Lower levels.

Level	Level name	Criteria	Example
L7	Alliance	Diagnostic species, including some from the dominant growth form or layer, and moderately similar composition that reflect regional to subregional climate substrates, hydrology, moisture/ nutrient factors, and disturbance regimes.	*Andropogon gerardii - (Calamagrostis canadensis - Panicum virgatum)* Herbaceous Alliance (Wet-mesic Tallgrass Prairie)
L8	Association	Diagnostic species, usually from multiple growth forms or layers, and more narrowly similar composition that reflect topo-edaphic climate, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii - Panicum virgatum - Helianthus grosseserratus* Herbaceous Vegetation (Central Wet-mesic Tallgrass Prairie)

(those consistently found in some land-cover types but not others). Associations, which describe and identify the two or three dominant species of a community, are the most specific classification, and are hierarchically subsumed in alliances. Typically, each association is included in only one alliance, while each alliance may include many associations.

Associations define distinct plant compositions that repeat across the landscape. They are generally named using both the dominant species in the uppermost stratum of the vegetation and one or more dominant species in lower strata (or a diagnostic species in any stratum). Associations are defined as having consistent species composition, uniform physiognomy, and similar habitat conditions.

Naming conventions and syntax for all NVC names are as follows:

- 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. (Indicator species are those that are restricted to certain environments, so that while not dominant, they are indicative of, or can represent certain communities.)
- 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.
- Square brackets [] around two species names indicate that the species are co-dominant, with either being dominant in a given stand.
- Association names include the dominant species of the significant strata, followed by the structural class in which they are classified (e.g., Forest, Woodland, or Herbaceous).
- Alliance names also include the structural class in which they are classified (e.g., Forest, Woodland, or Herbaceous), but are followed by the word "Alliance" to distinguish them from associations (alliances are not used in this report).
- A "(P)" at the end of an alliance or association name implies that the type is proposed only and is not yet a formally accepted vegetation type within the NVC. These proposed types are reviewed on an ongoing basis and are added to the NVCS when sufficient data have been collected to support their addition.
- A "(PS)" at the end of an association name implies that the type is a "park special," meaning it has been described as a unique community only been found in the given park unit to date. This typically occurs when an area has a unique disturbance or management history.

The species nomenclature for all associations follows Kartesz (1999). Examples of association names from Gila Cliff Dwellings NM include the following:

- *Populus angustifolia* / *Salix irrorata* Riparian Woodland Association
- *Pseudotsuga menziesii* - *Quercus gambelii* Forest Association

1.7 Project area description

1.7.1 Location and setting

Though it is part of the Sonoran Desert Network, Gila Cliff Dwellings NM lies east of the Sonoran Desert, in the Arizona–New Mexico Mountains ecoregion (Bailey 1998; Figure 1-2), a 30 million-acre area that extends from the vicinity of Flagstaff, Arizona, through southeastern New Mexico. Located near the confluence of three major ecoregions in the American Southwest, Gila Cliff Dwellings NM shares many ecological traits with Chiricahua National Monument, Coronado National Memorial, and Fort Bowie National Historic Site (NHS), in the Apache Highlands ecoregion to the west; Bandelier National Park (NP) to the north (Arizona–New Mexico Mountains); and Guadalupe Moun-

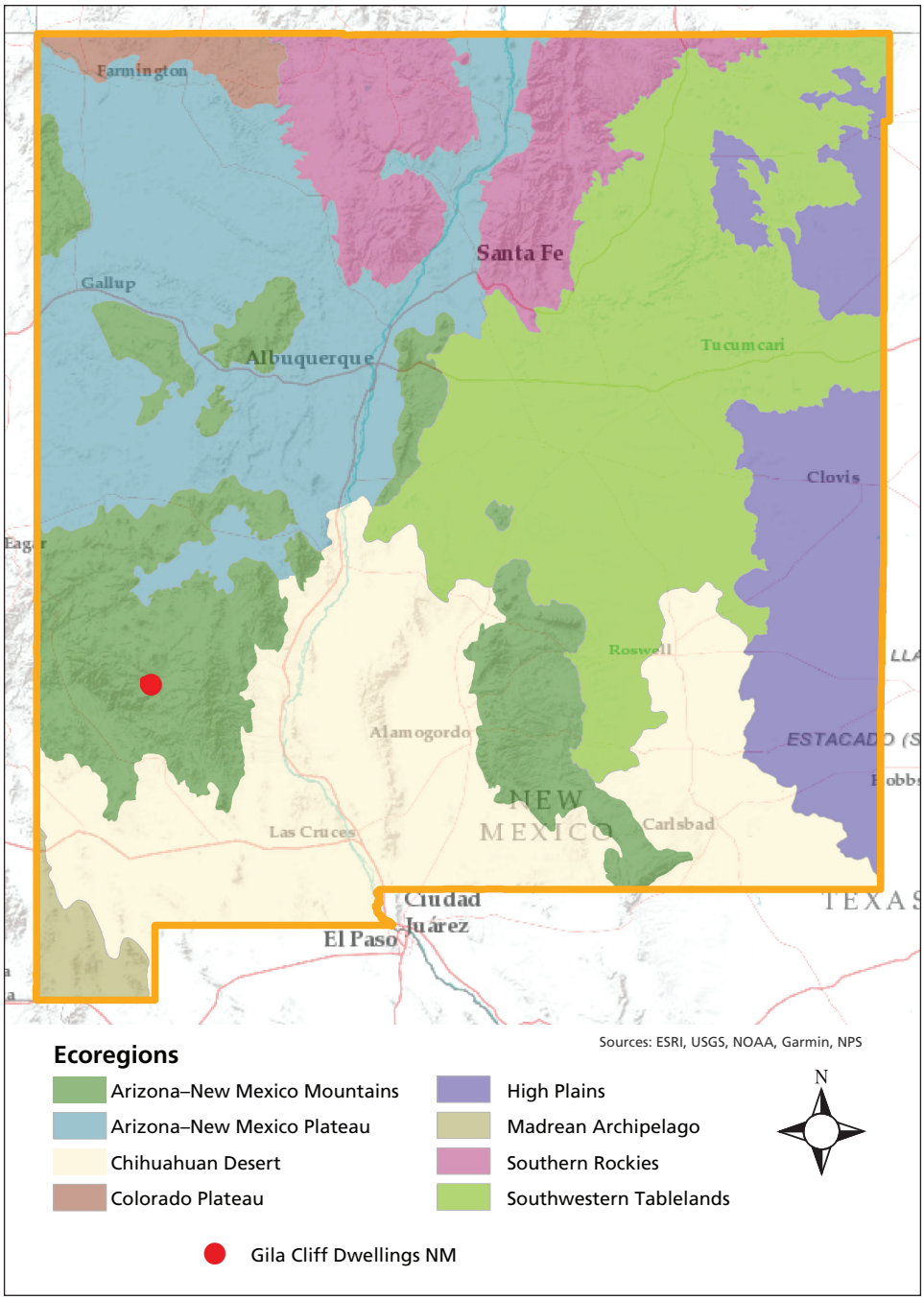


Figure 1-2. Location of Gila Cliff Dwellings in the Arizona/New Mexico ecoregion, as described by Bailey (1998).

tains NP, which straddles the Arizona–New Mexico Mountains and Chihuahuan Desert ecoregions. This continental position—a transition between the Sonoran and Chihuahuan deserts on the east and west, and the Rocky Mountains and Sierra Madre to the north and south—is reflected in the composition and biodiversity of the park's flora and fauna (Powell et al. 2006).

Lying between 1,700 and 1,900 meters (~5,575–6,235 ft) in elevation, Gila Cliff Dwellings NM encompasses steep but relatively shallow canyons that dissect surrounding mesas, as well as portions of the channels and associated floodplains of the Middle and West forks of the Gila River. The rugged country found within the park is typical of the Arizona–New Mexico Mountains ecoregion (TNC 1999) and, more generally, the Basin and Range topography of the Intermountain West (Scarborough 2000).

1.7.2 Park establishment and purpose

Gila Cliff Dwellings NM protects and interprets a complex of 15th century Mogollon cliff dwellings and other associated prehistoric sites, and the diverse natural environment that attracted and supported these early civilizations (Russell 1992). In 1907, through the authority of the Antiquities Act, President Theodore Roosevelt established a 65-hectare (160-acre) monument to be administered by the U.S. Forest Service, based largely on the impressive site reports from pioneering archeologist Adolph Bandelier in the late 19th century.

Located near the heart of the 558,065-acre Gila Wilderness, the monument was difficult to access and infrequently visited until the wilderness area was modified and a road blazed to the mouth of Cave Dweller Canyon in the mid-20th century (Russell 1992). Increasing public interest and greater documentation of the park's cultural resources led to the addition of the 17-hectare (42-acre) TJ unit, near the visitor center, and the expansion of the original unit to 196 hectares (485 acres), including a contact station and visitor facilities at the mouth of Cave Dweller Canyon (Russell 1992).

Gila Cliff Dwellings NM was transferred to the National Park Service in 1933, and added to the Southwestern Monuments group led by famed superintendent Frank "Boss" Pinkley. In the 1940s, the monument and surrounding wilderness were briefly considered for a proposed, 650,000-acre Gila National Park that never came to fruition. Since the 1960s, the USFS and NPS have managed the unit cooperatively, despite an official shift back to USFS oversight in 1975, and return to the NPS a quarter-century later (Russell 1992).

As with other cultural sites in the American Southwest, the location of these important prehistoric resources is directly related to scarce and important natural resources: the perennial waters and associated rich natural resources of the upper Gila River.

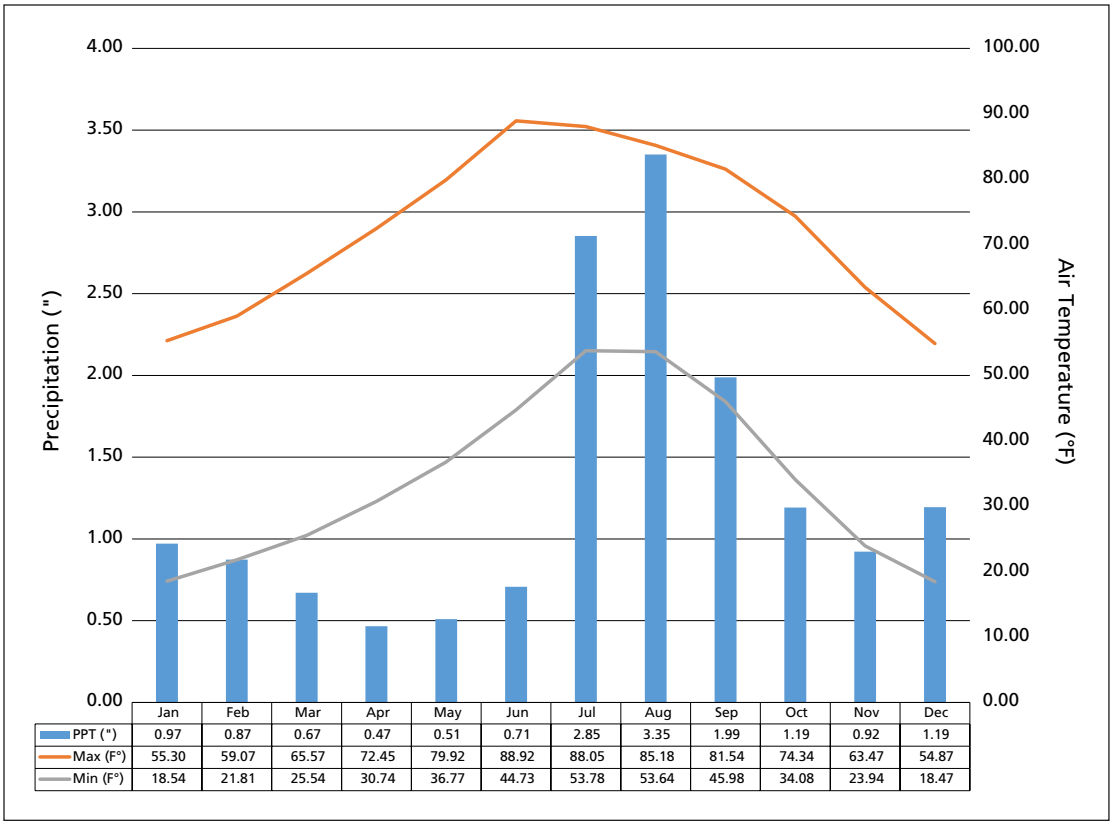
1.7.3 Climate, geology and hydrology

1.7.3.1 Climate

The climate of Gila Cliff Dwellings NM is typical of the Arizona–New Mexico Mountains ecoregion: highly variable, bimodal precipitation with a considerable range in daily and seasonal air temperature, and relatively high potential evapotranspiration rates (TNC 1999). Recent (1987–2017) average annual precipitation is 15.7 inches, the average maximum temperature is 72°F, and the average minimum temperature is 34°F (climateanalyzer.org). Approximately half of the annual precipitation falls during the summer monsoon, when maximum air temperatures often exceed 30°C (86°F). Monsoon rainstorms are often violent and localized (Figure 1-3). The bulk of the remaining annual precipitation falls in relatively gentle events of broad extent, occasionally as snow. Winters are often cold relative to many other SODN parks.

1.7.3.2 Hydrology

The middle and west forks of the Gila River drain 4,200 km^2 (~1,037,843 acres), at an average discharge of approximately five cubic meters per second (~177 cubic feet per second), as estimated from downstream stream gages (Sprouse et al. 2002). Streamflow is highly variable and tightly linked to upstream weather events. Flooding is common, particularly following rain-on-snow events, spring



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PPT (")	0.97	0.87	0.67	0.47	0.51	0.71	2.85	3.35	1.99	1.19	0.92	1.19
Max (F°)	55.30	59.07	65.57	72.45	79.92	88.92	88.05	85.18	81.54	74.34	63.47	54.87
Min (F°)	18.54	21.81	25.54	30.74	36.77	44.73	53.78	53.64	45.98	34.08	23.94	18.47

Figure 1-3. Mean monthly precipitation (PPT) and maximum/minimum (max/min) air temperature for Gila Cliff Dwellings National Monument, based on climate normals for 1987–2017 (National Climate Data Center, ID#293530).

snowmelt peaks, and, to a lesser extent, intense, localized summer thunderstorms.

1.7.3.3 Geology

As with several other SODN parks, Gila Cliff Dwellings NM and the surrounding wilderness lie within an ancient caldera that collapsed following an enormous volcanic eruption (USFS 2003). The surrounding mesas are composed of rhyolite, andesite, basalt, and welded tuffs interbedded with Gila Conglomerate. Floodplains and channels are composed of shallow alluvium from local deposition of these same materials (Figure 1-4). Soil information for Gila Cliff Dwellings NM is scant; the park has never had a comprehensive soil survey due to a lack of funding for this core inventory. Soil properties have important consequences for vegetation composition, persistence, and productivity (McAullife 1999).

1.7.4 Vegetation

Gila Cliff Dwellings NM and its adjacent lands encompass a diverse array of vegetation communities, ranging from dense riparian woodlands along the Gila River to upland habitats dominated by large conifers and oaks intermixed with vast expanses of exposed bedrock. The main unit is characterized by low-angled mesas and steep slopes dominated by two-needle pinyon (*Pinus edulis*), alligator juniper (*Juniperus deppeana*), and/or ponderosa pine (*Pinus ponderosa*), bisected by deep, narrow drainages dominated by Douglas fir (*Pseudotsuga menziesii*) and Gambel oak (*Quercus gambelii*). The TJ unit is predominately a mix of large, herbaceous expanses solely dominated by blue grama (*Bouteloua gracilis*), bisected by tree savannas and sparse woodlands dominated by two-needle pinyon (*P. edulis*) and alligator juniper (*J. deppeana*), usually associated with the more sheltered drainages. The main unit and the lands between the units are heavily influenced by the Gila River, with vast stretches of narrowleaf cottonwood (*Populus angustifolia*) and dewystem willow (*Salix irrorata*), and shrubby expanses dominated by rubber rabbitbrush (*Ericameria nauseosa*).

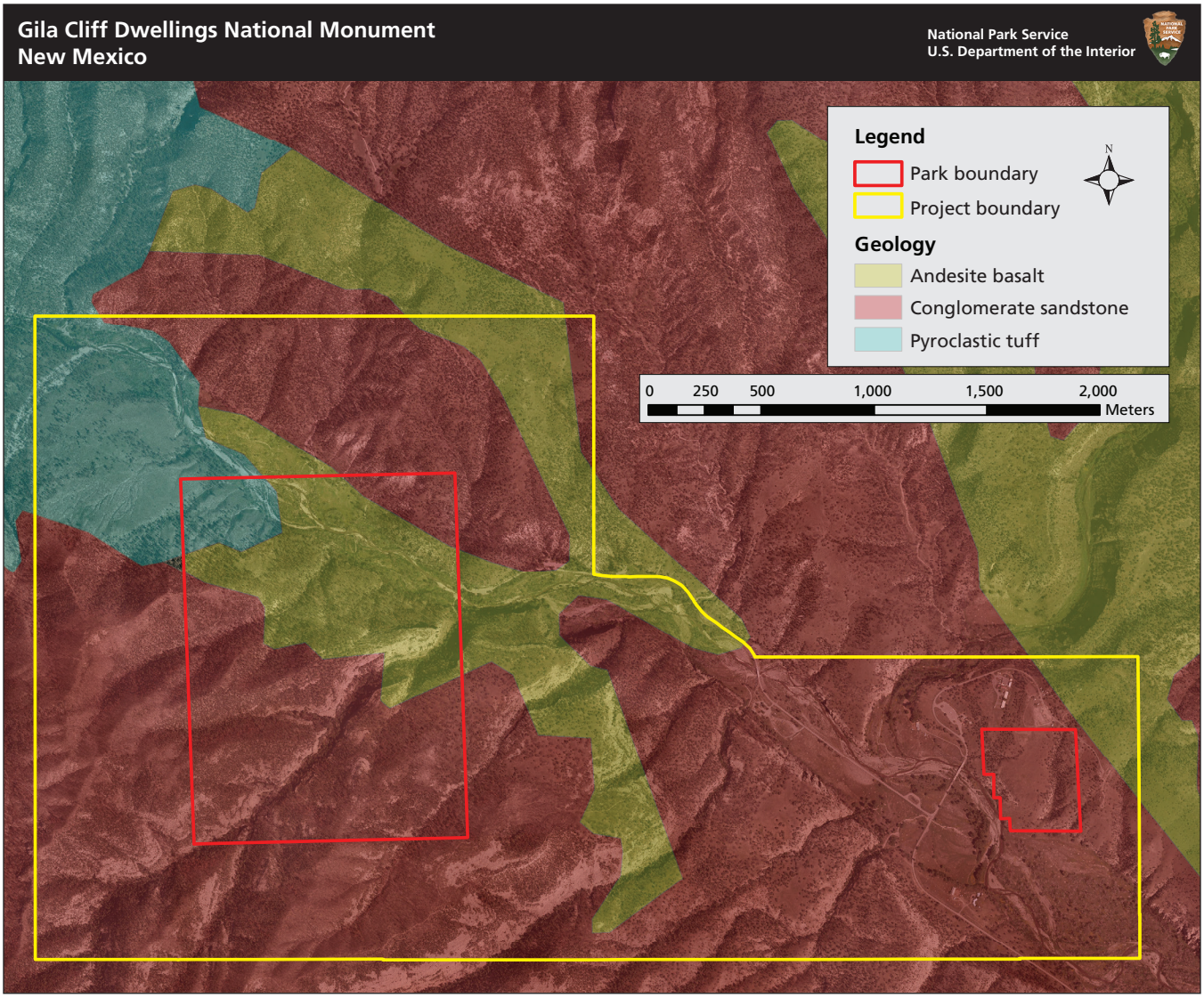


Figure 1-4. Geologic map of Gila Cliff Dwellings National Monument and surrounding area.

1.7.5 Previous vegetation studies

To date, Gila Cliff Dwellings NM has not been the focus of extensive natural-resources research—possibly due to the park's remote location, small size, shifting administration, and emphasis on cultural resources. Beyond SODN efforts, there are only two vegetation studies of which we are aware. The first is a collection, dating to the mid-1970s, conducted by a graduate student (S. Lambert) from the University of Texas at El Paso (UTEP). This project produced 204 specimens, currently located in the UTEP herbarium. No documentation from the original study has persisted, and the specimens are in generally poor shape. See Powell and others (2006) for additional details on this project.

A more recent effort to collect voucher specimens for the park flora was initiated in 2015, with funding from the Western National Parks Association. Three regional botanical experts collected specimens throughout the monument and its immediate environs. These will be permanently housed at Western New Mexico University, in Silver City, New Mexico.

1.7.6 Exotic (non-native) plants

Biological invasions into new regions, whether accidental or deliberate, have increased at unprecedented rates in the past few hundred years (D'Antonio & Vitousek 1992). Once established, non-native plant species introductions often lead to changes in ecosystem pro-

cesses that are self-maintaining and evolving, leading to functional as well as compositional change. Several studies have implicated environmental and climatic variables as potential drivers for sustaining or accelerating non-native plant dominance in semi-arid ecosystems (Shinneman and Baker 2009). In the American Southwest, historic and current land-management activities, such as livestock grazing and fire suppression, are thought to have contributed to the susceptibility of arid lands to invasion and subsequent loss of native species and decreased biodiversity (Brown and Archer 1999).

Reduced species richness and biological soil cover are indicative of communities degraded by grazing, and these factors have been linked to invasion by non-native grasses in place of native species that are less able to adapt to such pressures (Shinneman and Baker 2009). In general, the southwestern semi-desert grasslands, savannas, and riparian community types are at greatest risk of invasion, due to modified disturbance regimes involving fire and herbivory.

To our knowledge, prior to 2012, invasive plants had never been extensively surveyed or mapped at Gila Cliff Dwellings NM, except during SODN's ongoing riparian-vegetation monitoring and its vertebrate and vascular plant inventory (Powell et al. 2006), which detected 37 non-native species comprising 8.5% of the flora. The Gila National Forest includes portions of the middle fork of the Gila River in its annual surveys for invasive riparian tamarisk (*Tamarix* spp.; Steve Riley, personal communication). To date, tamarisk has not been detected within the park.

During May and July 2012, just prior to start of this vegetation-mapping project, SODN completed extensive exotic-plant surveys at the park and throughout the adjacent USFS lands (SODN 2012). The survey employed linear vectors (roads, trails, and waterways) to delineate transects along which surveyors documented exotic species into density categories at four distance classes. Surveyors documented a total of 27 exotic species along transects that spanned approximately 17.5 kilometers (Appendix A). Survey results were shared with the park, USFS, and regional exotic plant management team. Additional surveys were completed the following year, covering approximately 14 kilometers of vectors. These surveys were a mix of repeated vectors from the previous year, along with additional vectors in areas at high risk for exotic-plant invasion. A total of 25 exotic species were documented during these surveys (Appendix A).

1.7.7 Disturbance history

Gila Cliff Dwellings NM is remarkably free of major anthropogenic stressors. The park lies within the Gila Wilderness—one of the first such designated areas in the world. Mining, agriculture, and other forms of development are largely absent, beyond scattered vacation homes and public infrastructure to support outdoor recreation. Livestock grazing was retired in the 1950s, to support the recovery of elk herds (Russell 1992). Overall visitation (Figure 1-5) is the second-lowest (to Fort Bowie NHS) in the Sonoran Desert Network (NPS 2019).

Early visitors to Gila Cliff Dwellings NM often caused significant damage to park cultural resources by excavating for artifacts (pothunting) and climbing in and on the fragile structures (Russell 1992). Both issues were largely addressed by the presence of onsite park staff and infrastructure development, such as the contact station, paved access trail, and effective interpretive signage and programs. Despite these improvements, impacts to the cliff dwellings persist (albeit on a much-reduced scale) and have led to repeated calls for a visitor-impacts study, with focus on visitor carrying capacity (NPS 1987; Russell 1992; Steve Riley, personal communication).

Negative consequences for natural resources appear to be minor and are likely unintentional, as the park's remote location makes incidents of vandalism and poaching generally rarer than at parks closer to large population centers. However, dramatic visitation increases since road improvements occurred in the 1960s, and the relatively concentrated use of USFS campgrounds and trails in the area, indicate the potential for visitor-use impacts to park ecosystems.

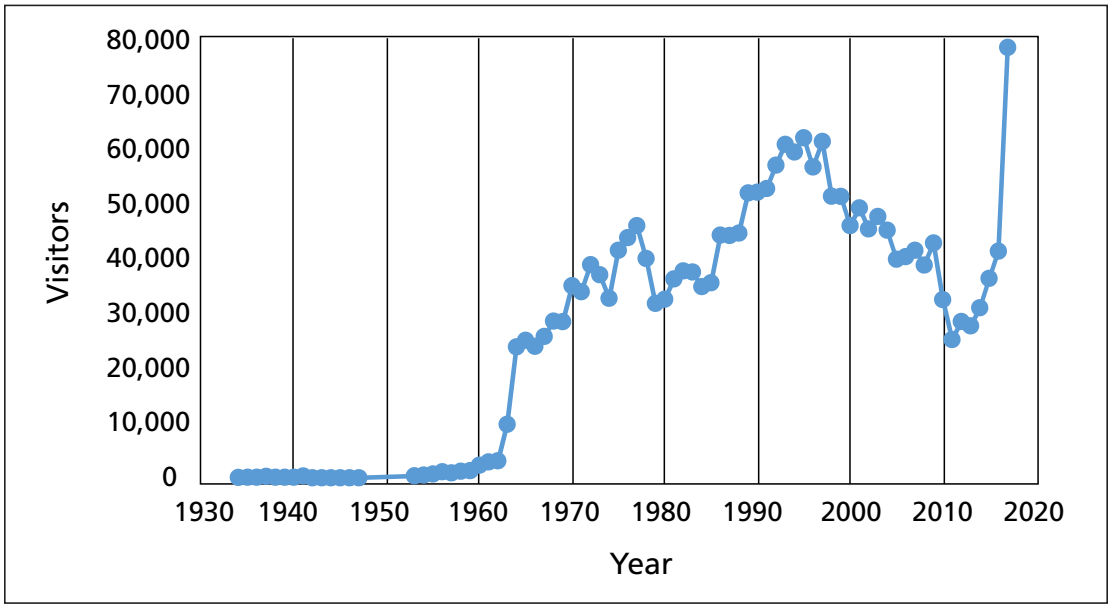


Figure 1-5. Visitation at Gila Cliff Dwellings National Monument, 1934–2017.

1.7.7.1 Wildfire

Wildfire is common in the Gila Wilderness area. Although many large fires have burned close to the park in recent decades (e.g., the Straw Fire in 1993 and the Dry Lake Complex and Turnbo fires in 2003), only the 2011 Miller Fire burned any considerable acreage within the park. The Miller Fire was first sighted around midnight on April 28, 2011, in an area of the Gila National Forest within the Gila Wilderness Area, southwest of the park and about 25 miles north of Silver City, New Mexico. Strong winds fueled its steady growth as the fire began moving to the northeast, eventually threatening the park. Fire crews took steps to protect the visitor center and park headquarters building complex, visitor contact station, and park residences. In addition, given the sensitive nature of the park's archeological resources, fire crews pre-treated a number of sites by reducing fuels and wrapping surfaces in fire-retardant fabric (park archeologist, personal communication). The fire burned across the park, which had been evacuated, on May 10, 2011. The park remained closed until May 27, when it re-opened to the public in limited capacity. The fire was officially contained around 5:00 p.m. on June 14, after burning 35,950 hectares (88,835 ac) (Veech 2011).

The Miller Fire severely burned the riparian forests along the north fork of the Gila River, with crown fire consuming or killing most trees. There had been considerable woody debris buildup, as is typical after flood events. This fuel loading contributed to the intensity of the fire. Upland areas were also burned, with mixed severity and a more patchy distribution. Fire travelled up some side canyons from the river corridor, but bedrock outcroppings along the canyon rims often limited its spread.

2 Classification and Mapping

2.1 Planning, data collection, and mapping

2.1.1 Planning and scoping

Scoping for this vegetation-mapping project took place in October 2010, as part of a larger natural resource-planning meeting between staff from SODN, Gila Cliff Dwellings NM, and the Gila National Forest. Overall objectives were to explore possibilities for collaboration and data-sharing between this project and any similar efforts underway on USFS lands between the two park units and both upstream and downstream of the park.

As the park is quite small and surrounded by USFS lands, the desire to have data integration, or at least data comparison, was highly desired to provide context for natural-resource conditions within the park. USFS representatives were similarly eager to have data from NPS efforts, as we were able to provide much finer-scaled and more detailed data than the forest service was able to collect (due to the sheer size of the Gila Wilderness, at ~560,000 acres).

At the time, the USFS was involved in a mid-scale vegetation mapping effort, into which it was thought the finer-scale NPS products could be integrated. To that end, it was broadly agreed by all parties present that to the extent possible, the map should provide seamless coverage between the two park units and also expand mapping to better represent the natural breaks in vegetation that correlate to landform changes. Using watershed boundaries as possible extents for mapping was discussed but ultimately, the more contracted riparian area/greater floodplain and entire side canyons surrounding the main river corridor were of greatest interest to expand knowledge and provide data relevant to the management context. The area south of the TJ unit was also suggested for inclusion due to the potential for the heavier vegetation in that area to be a fuel source that could carry fire into the culturally sensitive TJ unit. A proposed project boundary (developed as a boundary for imagery purchase) was used to distribute classification plots (see Figure 2-2, below), but based on the above considerations, we did not map within that entire extent and instead mapped only to the riparian and side-canyon boundaries.

2.1.2 Data collection overview

The methods used to classify and map vegetation generally followed the guidelines outlined in the technical guidance and support documents found at https://www.nps.gov/im/technical-guidance.htm. However, our approach was more integrated than the traditional practice. Rather than have ecologists collect plot data to develop a classification, then have photo interpreters delineate polygons solely using imagery, we used a team of observers who first collected plot-scale data for classification, followed by creation of map polygons in the field. Map polygons were drawn based on imagery, topographic relief, and field observations. As Gila Cliff Dwellings NM is relatively small, this method worked well and was achieved by way of a census, meaning the entire area was observed.

2.1.3 Digital imagery acquisition and processing

For this project, imagery was acquired from four separate sources, all of which were used during the project. SODN worked with the Office of Arid Lands Studies (OALS) at the University of Arizona to acquire a new task order of 8-band World View II imagery, which OALS staff pan-sharpened and georeferenced. Unfortunately, the World View image could not be adequately georeferenced in some parts of the image, so we sought additional images from which to conduct the actual mapping.

Orthoimagery at 1-m resolution was downloaded from the National Agriculture Imagery Program (NAIP), which provided highly accurately georeferenced images for the project team to work with (Figure 2-1). The downloaded images were flown May 13, 2009. Two zone-12 New Mexico State Quarter Quandrangles covered the project area, plus additional area outside our needed

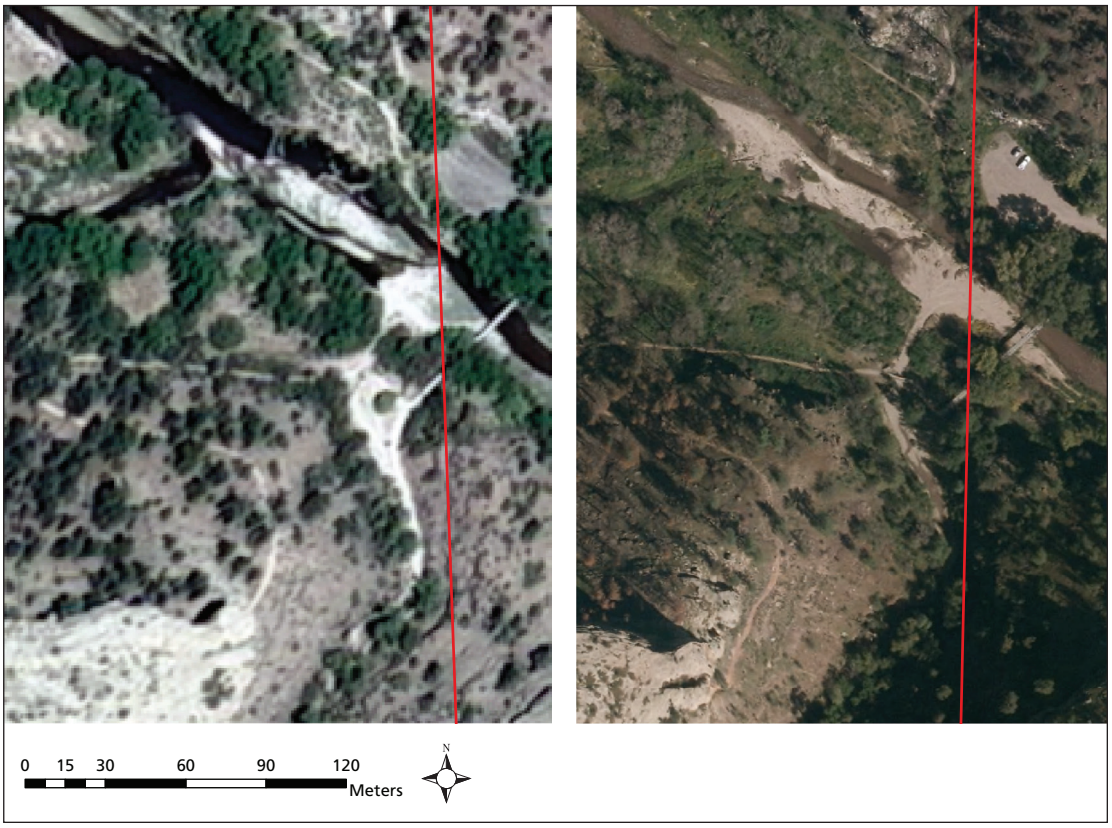


Figure 2-1. Examples of the 2009 NAIP imagery (left) and 2012 post-fire imagery (right) used to map vegetation during this project.

zone. These were the Little Turkey Park, NE and the Gila Hot Springs, SW. NAIP quarter quads are formatted to the UTM coordinate system using NAD83.

Post-fire imagery flown in March 2012 was provided to us free of charge from the GIS specialist at the Gila National Forest Supervisor's office, Silver City, New Mexico. This was used to help validate the on-the-ground changes apparent between the pre-fire images and the current status at time of ground mapping.

The Gila National Forest's former GIS coordinator also gave us a copy of a mosaicked air photo of the park and its environs from 2005. Together, these image resources provided more-than-adequate coverage and detail (both pre- and post-fire) for us to accurately evaluate and map the vegetation.

2.1.4 Field data collection

Jennings and others (2009) states the need for vegetation units to be sampled and described through the use of plot data. They recommend that plots be distributed in homogenous areas so as to minimize sampling in areas with high physiognomic, floristic, and environmental variation, which would make interpretation of the plot data difficult. Determination of plot locations can be achieved via subjective or objective means. However, the former method necessitates prior knowledge of the various types to be sampled and the latter can provide a less-biased set of plots. One further consideration was that objectively placed plots may miss rare or unusual types. We decided to sample primarily by objectively locating plots, but to sample a smaller number of plots subjectively to account for any under- or un-sampled areas.

Prior to commencing fieldwork, plot locations were pre-selected using the spatially balanced RRQRR (Reversed Randomized Quadrant-Recursive Raster) algorithm, to provide an objective, parkwide sampling basis for vegetation classification (Theobald et al. 2007). Using this method, 97 points were distributed throughout the project area. To capture the often narrow drainages

that bisect the landscape, points were separately distributed within upland habitat and areas heavily influenced by surface hydrology. Within the priority set, we distributed 54 plots within upland habitat, and 43 were restricted to drainages and other hydrologic features, for a total of 97 plots. Due to time constraints, eight of the distributed plots were not sampled, creating a final sample size of 89 plots (Figure 2-2).

All data collection was conducted by an NPS crew of four people, working in pairs. Crew leads had worked on vegetation mapping at other SODN parks (e.g., Saguaro NP) for several months prior to this field effort and were proficient in all mapping and classification methodologies. Field-based data collection for classification plots was conducted over the course of two eight-day tours in late July and August 2012. On average, crews completed around four classification plots per day.

In the field, these generated points served as one corner of a 1,000-m^2 classification plot. Ideally, the plot represented the surrounding community. When it did not, the protocol allowed crews to evaluate the surrounding vegetation and move the point up to 50 meters if deemed necessary. Crews laid out the plots so as to best capture the orientation and shape of the sampled community. Various shapes were employed to capture the targeted community, but the preponderance of plots were square, with sides measuring 31.6 meters. Within these plots, the crews collected semi-quantitative data (Table 2-1) on absolute canopy cover for all vascular plant species in four height strata: field (0–0.5 m), subcanopy (0.5–2 m), lower canopy (2–5 m), and upper canopy (>5 m). For these strata, crewmembers placed each documented species into one of nine broad cover classes: 1 (< 1%), 2 (1–5%), 3 (6–10%), 4 (11–25%), 5 (26–33%), 6 (34–50%), 7 (51–75%), 8 (76–95%), and 9 (96–100%).

In general, crews only included perennial and non-native annual species. Native annuals were occasionally documented when they provided a noteworthy amount of cover or were indicative of the community. Up to three species per strata were assigned a dominance rank based on their cover class and/or importance to the sampled vegetation community. Additionally, crews recorded the average plant height (lower and upper canopy only), lifeform (excluding the field stratum), disturbance types (using the NVC constrained vocabulary), total absolute cover by strata, and a range of soil and landscape characteristics (Appendix B). A single photograph was taken at a 45-degree angle into the plot from one of the corners. Two brief narratives were written to describe the tentative association type of the polygon, noting the ways in which this association/area differed from the adjacent areas, and any topographic features contributing to the divisions of floristic similarities.

Immediately following plot-based data collection, crews, assisted by hardcopy prints of imagery and GPS-linked handheld computers (Trimble Junos), created polygons to define the extent of each vegetation association. This effort continued for two additional eight-day tours in 2012, with six more days of mapping completed in late July/early August 2013. Crews walked the boundary and interior of each proposed polygon (aka map unit) while hand-drawing its extent onto the printed imagery. Within each polygon, crews collected qualitative data on the dominant and commonly associated species that defined the captured association. In addition, brief narratives were drafted to describe the vegetation community, including a tentative association name, differences from the surrounding vegetation, defining landscape features, and features used to bound the polygon (Appendix B). A sequence of four representative photographs was taken in the four cardinal directions from near the center of the polygon, which was marked with a GPS point for future repeat photography.

At the end of each field day, crews transferred all edits made to field maps to a set of master paper maps that did not go into the field. These will be archived along with the datasheets. Upon completion of the mapping effort, polygon boundaries were transferred from the master maps into a digital format using ArcMap GIS software (ESRI 2011). The dataset is housed in a file geodatabase structure (.gdb), enabling establishment of topology rules and relationships. Strict no-

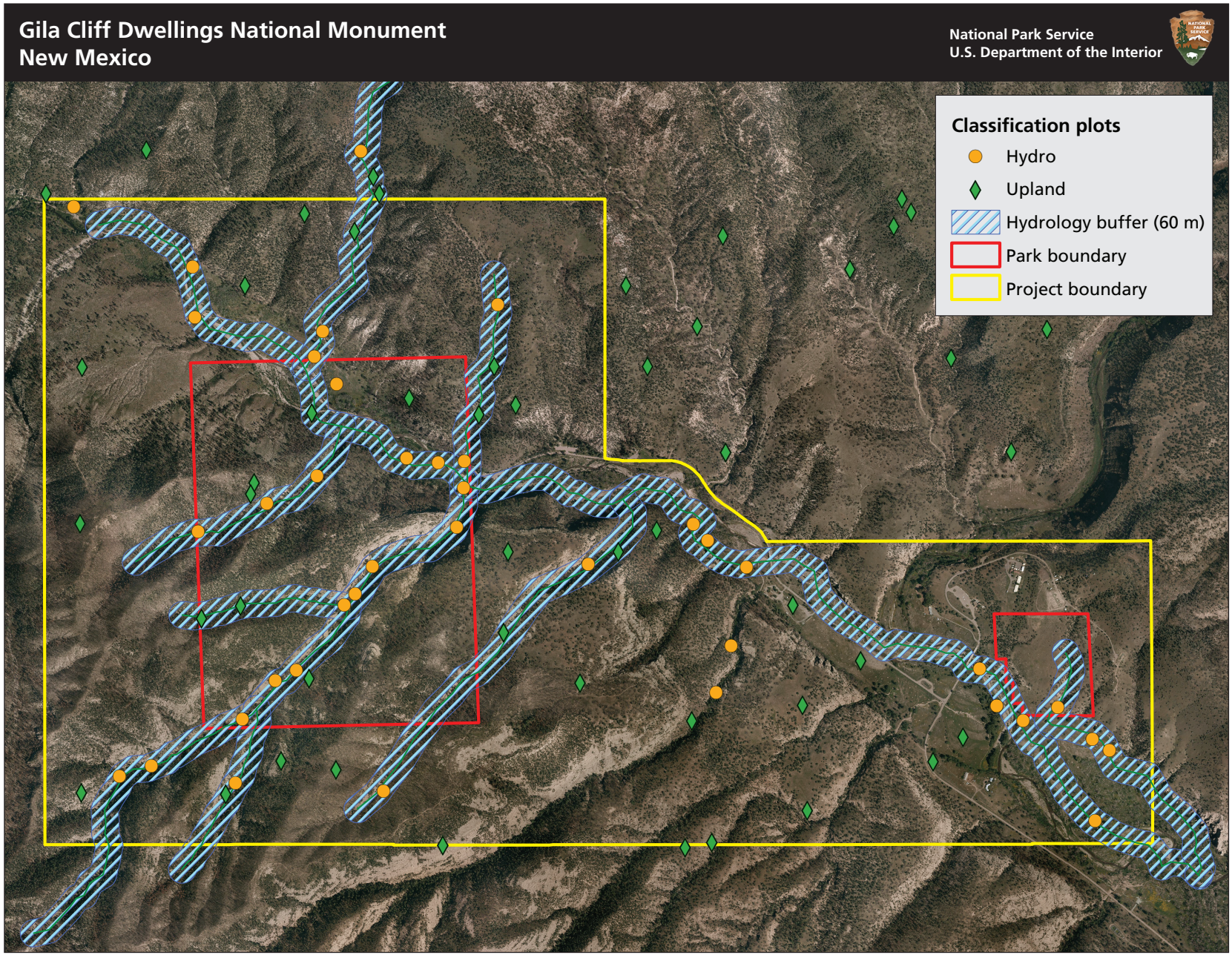


Figure 2-2. Map showing the distribution of the 89 classification plots across the project area. Circles represent the plots located in drainages and along the main river corridor. Diamonds show plot locations in upland areas.

Table 2-1. Specific attributes collected on the vegetation and landscape datasheets for polygons and classification plots.

Type of information	Items noted
Plot/Polygon metadata	Date, time, observer name(s), recorder name(s), park code, sub-map number, protocol version
Polygon documentation	Location, original ID, field ID, new ID, tentative formation, keyed formation, area (standard for all plots)
Environmental description	Topographic position, landform type, parent material, slope class, erosion features, aspect
Surface cover (% cover classes)	Bare soil, gravel, rock, bedrock outcrops, physical crust, biological crust, down wood, litter
Vegetation description	Qualitative narrative: community structure, notable inclusions, leaf phenology, community structure
Vegetation strata data	Lifeform, dominance rank, cover class and height in each of four height classes (0–0.5 m, 0.5–2 m, 2–5 m, >5 m). Associated species.
Plant species	Scientific name (ITIS codes)
Other vegetation characteristics	Homogeneity, stand maturity, similarity to other types, mortality, disturbance

menclature was enforced for polygons, such that unique names were assigned to each polygon. These reflected the verified physiognomic formation type by a prefix of representative letters (e.g., W = Woodland, SS = shrub savanna), followed by a number (e.g, W001, SS034, IFW020).

2.1.5 Plot and polygon data management

All plot and polygon data were entered into a Microsoft Access (2007) database created by the SODN data manager. The digital data were subsequently quality-checked for accuracy against the original datasheets, and any transcription errors were rectified prior to analysis. An alternate mapping-team member also validated data for logical errors or unusual species entries. These processes followed the quality standards outlined in the global operating procedures written by the SODN data management program. All datasheets were copied and stored separately from the original set.

Each polygon was edited to reflect any boundary changes and was attributed to reflect changed polygon identification numbers and tentative alliance names. Hardcopy maps are archived at SODN. Photographs were verified to be present for each polygon and plot, and for correct naming conventions. Photopoint locations (shapefiles) were similarly quality-checked for spatial accuracy and attribute completeness. After all data checks were completed, the entire project team reviewed and analyzed the field data.

2.2 Vegetation Classification Analysis

2.2.1 Methods

Using the program PRIMER version 7 (Clarke and Gorley 2015, Clarke et al. 2014), we employed a multi-variate approach to delineate vegetation communities using our sampled classification plots (n = 89) and polygon data (n = 123). Mid-point cover-class values for all species, at all plot locations, were exported from the Access database post-quality assessment and imported into PRIMER for analysis (Clarke and Warwick 2001). This data matrix had species as variables (rows), plots as samples (columns), and mid-point cover values as matrix values. These data were first-square-root transformed to balance the contributions from common and rare species in the measure of similarity between two samples (Clarke and Warwick 2001). Then, using the resemblance tool in PRIMER, these transformed values were converted into a similarity matrix using the Bray-Curtis similarity coefficient (Bray and Curtis 1957). This matrix contains a value comparing the

similarity of every combination of samples (plots) with values ranging from 0, indicating no similarity, to 100, indicating identical samples. Using this matrix, we employed a group average cluster analysis with an associated dendrogram to aid in assigning plots to groups based on the similarity/dissimilarity of documented species and their associated cover values. In addition, a SIMPROF (similarity profile) test was performed in conjunction with the cluster analysis. SIMPROF is a permutation test of the null hypothesis that "a specified set of samples, which are not a priori divided into groups, do not differ from one another in a multivariate structure" (Clarke and Gorley 2006).

2.2.2 Identification of macrogroups

The resulting dendrogram and SIMPROF test showed 35 groups with a minimum membership of two plots and an additional 12 groups represented by a solitary plot. Initially, we evaluated the results at a subjective, within-group similarity of 22%, where plots were easily placed into four distinct macro groups and a solitary plot, and viewed in both a non-metric multidimensional scaling (nMDS) diagram (Figure 2-3) and the dendrogram (Figure 2-4). These groups were primarily defined by the dominance of 1–3 species:

- **Macro Group A:** 1 plot, defined by the dominance of Apache plume (*Fallugia paradoxa*).
- **Macro Group B:** 17 plots, defined by the dominance of narrowleaf cottonwood (*Populus angustifolia*) and dewystem willow (*Salix irrorata*), accounting for 56% of the cumulative group similarity.
- **Macro Group C:** 27 plots, defined by the dominance of forbs, grasses, and low shrubs without a dominant overstory. Spike dropseed (*Sporobolus cryptandrus*), mixed annual forbs, rubber rabbitbrush (*Ericameria nauseosa*), Fendler's globemallow (*Sphaeralcea fendleri*), and blue grama (*Bouteloua gracilis*) account for 75% of the cumulative group similarity.
- **Macro Group D:** 42 plots, defined by the dominance of ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga*

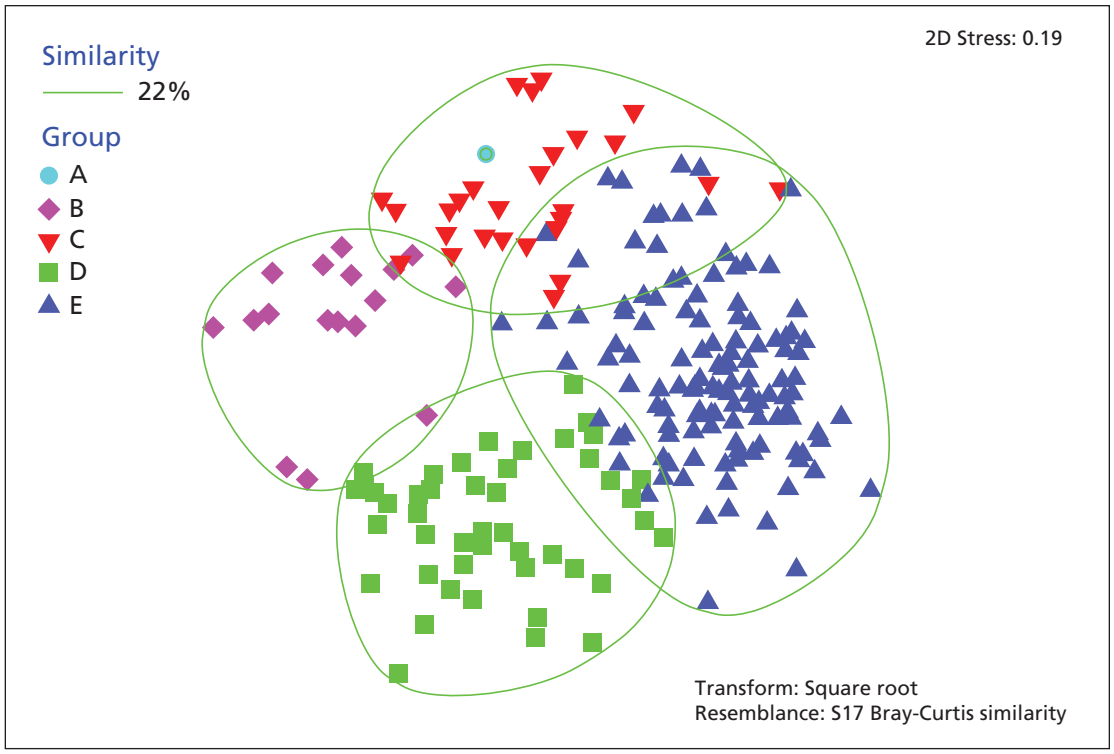


Figure 2-3. Multidimensional scaling diagram showing all data from classification plots and classification polygons. The solid green lines indicate a similarity level of 22%, wherein the data break into one solitary plot group (A) and four major groups (B–E).

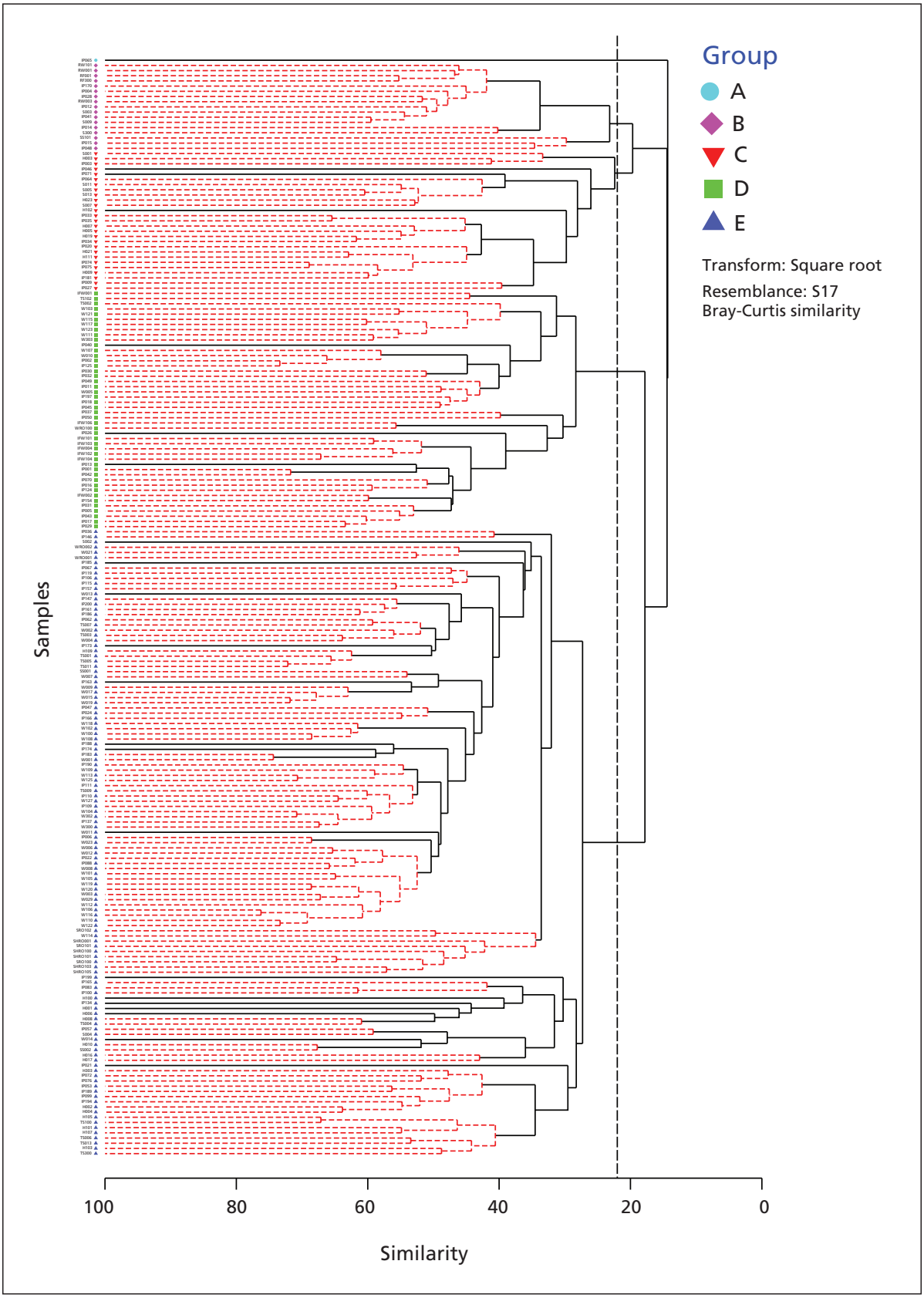


Figure 2-4. Dendrogram showing all data from classification plots and classification polygons. The dashed line indicates a similarity level of 22%, below which the data break into one solitary plot group (A) and four major groups (B–E).

menziesii), and Gambel oak (*Quercus gambelii*), accounting for 60% of the cumulative group similarity.

- **Macro Group E:** 121 plots, defined by the dominance of blue grama (*Bouteloua gracilis*), oneseed juniper (*Juniperus monosperma*), gray oak (*Quercus grisea*), and two-needle pinyon (*Pinus edulis*), accounting for 65% of the cumulative group similarity.

Upon confirming that these groupings made sense and aligned with field observations, we began to look at the finer groupings present within each macro group. We identified 16 associations from the classification-plot data within the five macro groups.

2.2.3 Macrogroup associations

2.2.3.1 Macro Group A

Macro group A (0 associations), Apache plume (*Fallugia paradoxa*), was merged into the *Cercocarpus montanus* Shrubby Rock Outcrop Association, located in Macro Group E.

2.2.3.2 Macro Group B

Macro Group B (3 associations) was split into three groups based on the results of a SIMPROF test (Figure 2-5). While these groupings aligned with field observations, two of these groups (the burned and unburned versions of the *Populus angustifolia* / *S. irrorata* Riparian Woodland Association) showed considerable mixing with one another. As vegetation height was not factored into the analysis, it's not surprising that unburned and post-fire regenerating types were mixed. The final membership of these two groups was based on a manual assessment of plot/polygon data.

- Association Ba (n = 6) was designated a *Populus angustifolia* / *Salix irrorata* Riparian Woodland Association.
- Association Bb (n = 8) was designated a Regenerating *Populus angustifolia* / *S. irrorata* Riparian Woodland Association.
- Association Bc (n = 3) was designated a *Robinia neomexicana* Shrubland Association.

2.2.3.3 Macro Group C

Macro Group C (4 associations), the forb, grass, and low-shrub communities, was split into six groups based on the SIMPROF test, with an additional four solitary plots/polygons (Figure 2-6). Of these groups, two aligned well with our field observations. The remaining four were a mix of various post-fire and post-flooding communities. Based on review of the data and photos, we assigned these to four associations.

- Association Ca (n = 6) was designated an *Ericameria nauseosa* Shrubland Association.
- Association Cb (n = 16) is a combination of four SIMPROF groups and two solitary plots merged into two associations, an Annual Forb - Mixed *Bouteloua* spp. Herbaceous Association and a Post-fire Riparian Mixed Herbaceous Association. Both associations are a result of disturbance, fire, and agriculture, and exhibit highly variable species composition and distribution.
- Association Cc (n = 3) was designated an *Atriplex canescens* Shrubland Association. While one of these plots perfectly aligns with our field observation of this type, the remaining two were erroneously placed here due to their relatively high cover of little hogweed (*Portulaca oleracea*). These plots were instead placed in the *Ericameria nauseosa* Shrubland Association (Ca) and the *Bouteloua gracilis* Grassland Association (Ec).
- Association Cd encompasses the remaining two solitary plots. Based on their associated data, they appear to be plots that are transitions between the *Ericameria nauseosa* Shrubland Association (Ca) and the Regenerating *Populus*

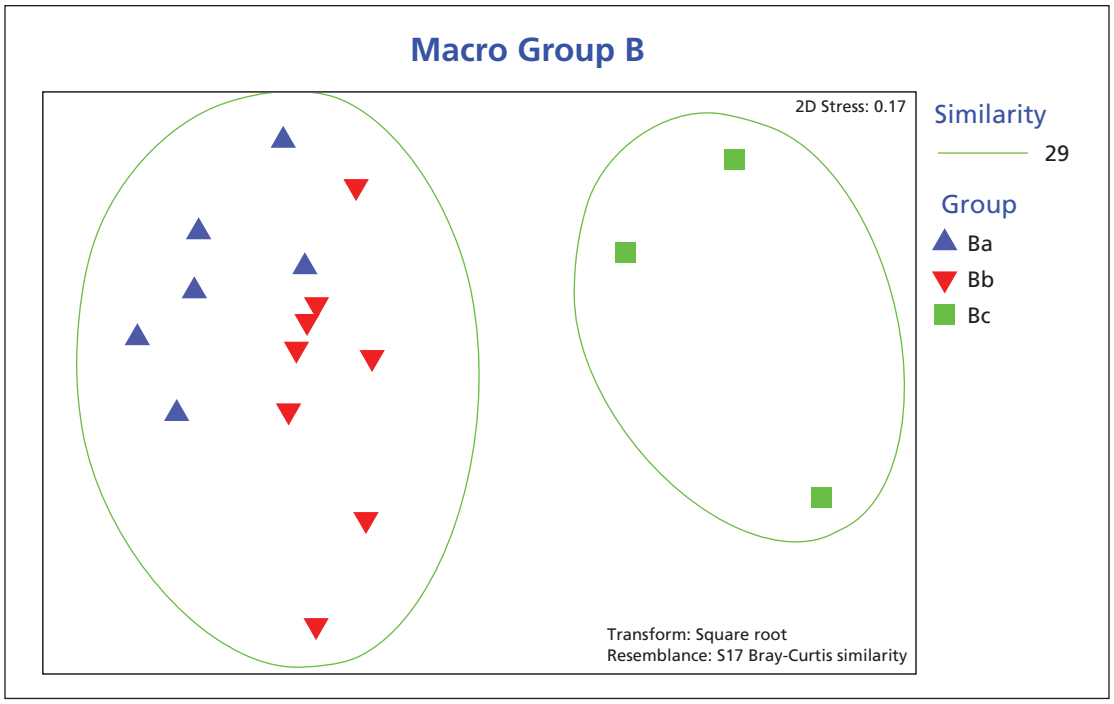


Figure 2-5. Multidimensional scaling diagram showing the three associations derived from the Macro Group B ordination.

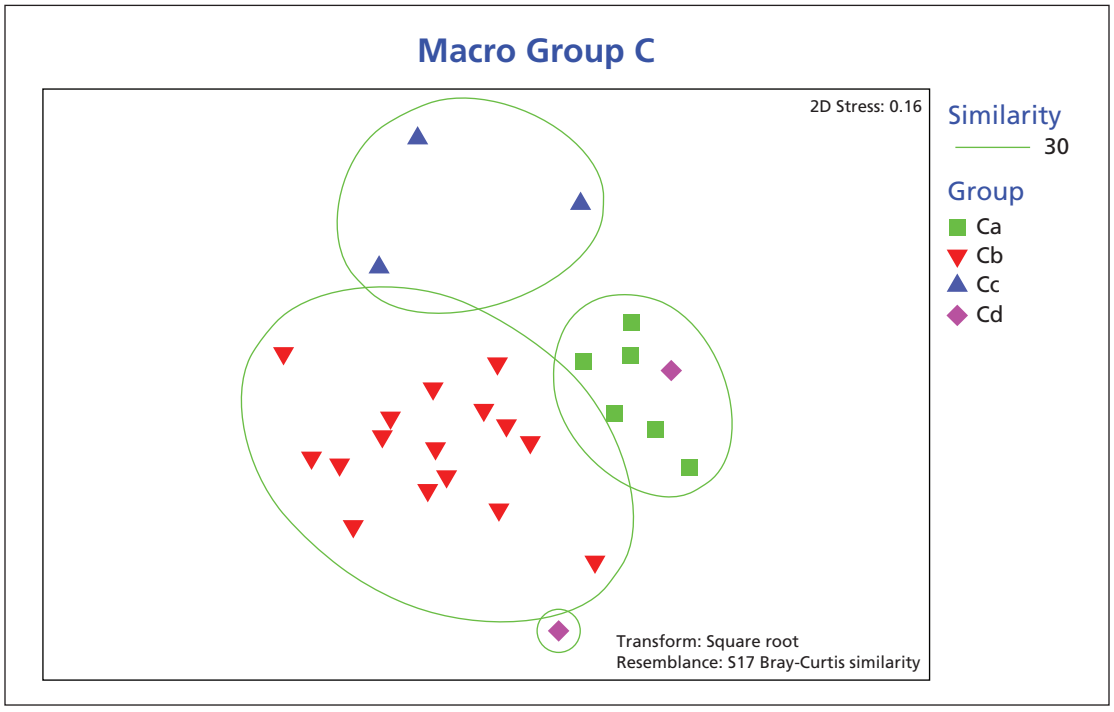


Figure 2-6. Multidimensional scaling diagram showing the four associations derived from the Macro Group C ordination.

angustifolia - *Salix irrorata* Shrubland Association (Bb).

2.2.3.4 Macro Group D

Macro Group D (2 associations), the large conifer and oak types, split into 10 SIMPROF groups and two solitary plots/polygons. Upon a more detailed examination of the associated data, we determined that placing the SIMPROF groups into two associations aligned best with our field observations (Figure 2-7). The finer SIMPROF groups accounted for some of the variations documented throughout these types that were mainly a result of fire disturbance.

- Association Da (*n* = 23) was designated a *Pseudotsuga menziesii* - *Quercus gambelii* Forest Association.
- Association Db (*n* = 23) was designated a *Pinus ponderosa* Woodland and Tree Savanna Association.

2.2.3.5 Macro Group E (2 associations)

Macro Group E, the pinyon-juniper woodland types, split into 20 SIMPROF groups and 10 solitary plots/polygons. In addition, the MDS for this group produced a high stress value (0.24), making interpretation difficult. Instead, based on our field observations, we manually sorted the plots/polygons into four distinct groups containing six associations.

- Association Ea (*n* = 76) is a variable mix, closed-to-open woodland, dominated by two-needle pinyon (*Pinus edulis*), oneseed juniper (*Juniperus monosperma*), gray oak (*Quercus grisea*), and blue grama (*Bouteloua gracilis*). Much of the variation, evidenced by the high number of SIMPROF groups, can be attributed to fire disturbance and changes in tree dominance. Using the associated data, we manually sorted these plots/polygon into two associations based on their formation and dominance of understory species:
  - *Pinus edulis - Juniperus monosperma* (*Quercus grisea*) / *Bouteloua gracilis* Tree Savanna Association and
  - *Pinus edulis - (Juniperus monosperma, Juniperus deppeana)* / *Bouteloua gracilis* Open Woodland Association.
- Association Eb (*n* = 17) contains two post-fire, pinyon-juniper associations defined by the presence of regenerating gray oak (*Quercus grisea*) with a mix of forbs, subshrubs, and grasses. These types include:
  - *Quercus grisea* / Mixed Perennial Grass (*Artemisia dracunculus*) Post-fire Shrubland and Herbaceous Association and
  - *Quercus grisea* / *Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous Association.
- Association Ec (*n* = 16) was designated a *Bouteloua gracilis* Grassland Association. The two SIMPROF groups this association encompasses account for minor variations in associate species and include some transitional plots with adjacent, grass-dominated communities.
- Association Ed (*n* = 9) was designated a *Cercocarpus montanus* Shrubby Rock Outcrop Association.

2.2.3.6 Additional data

One association was only documented by a polygon datasheet without any associated cover data, and was therefore not included in the PRIMER analysis. This association was designated a *Quercus gambelii* (*Quercus grisea*) Shrubland and Shrub Savanna Association, based on the descriptive species information and photograph collected.

2.2.4 Preliminary classification results

In all, a total of 16 associations were identified from field observations, classification plots, and mapped polygons (Table 2-2). Of these, 14 associations, attributed to 51 polygons, were documented within the main unit of the monument (numbers 7 and 14 were not present in the main unit). Eight associations, attributed to nine polygons, were documented within the TJ unit. Sixteen associations, attributed to 158 polygons, were documented across the broader public lands that connect the two units. More detail on where each association is distributed can be found in Table 4-1.

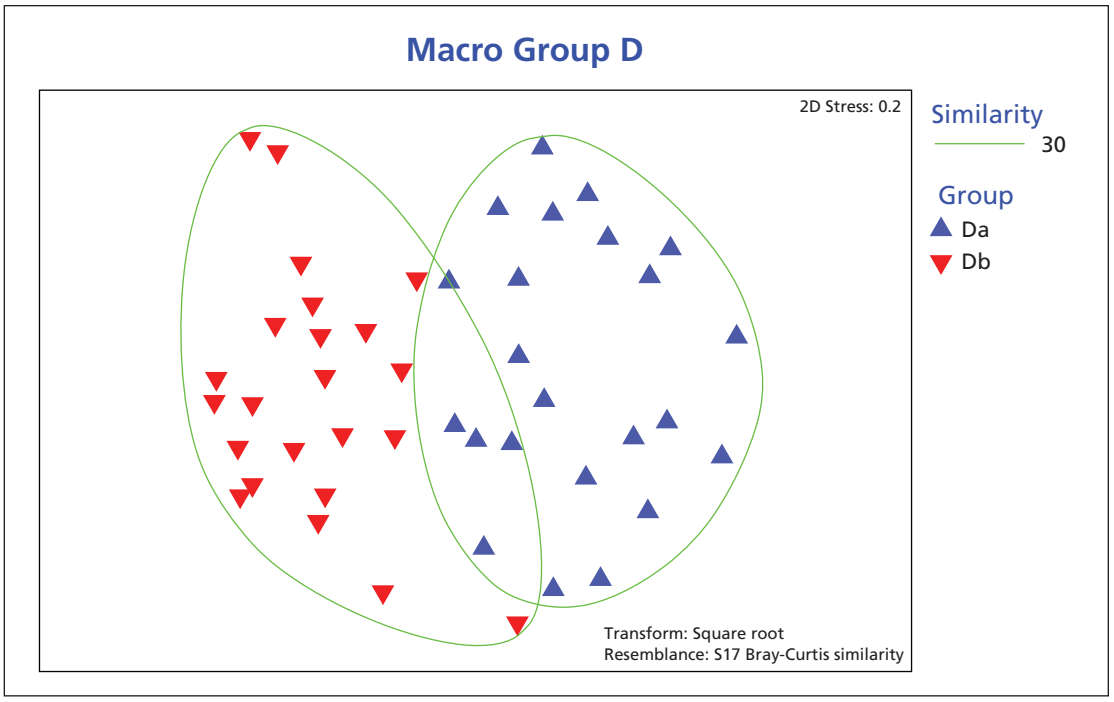


Figure 2-7. Multidimensional scaling diagram showing the two associations derived from the Macro Group D ordination.

Table 2-2. Preliminary vegetation associations by macro group, Gila Cliff Dwellings National Monument.

Group	Association
Ba	*Populus angustifolia* / *Salix irrorata* Riparian Woodland Association
Bb	Regenerating *Populus angustifolia* / *Salix irrorata* Riparian Woodland Association
Bc	*Robinia neomexicana* Shrubland Association
Ca	*Ericameria nauseosa* Shrubland Association
Cb	Annual Forb - Mixed *Bouteloua* spp. Herbaceous Association
Cb	Post-fire Riparian Mixed Herbaceous Association
Cc	*Atriplex canescens* Shrubland Association
Da	*Pseudotsuga menziesii* - *Quercus gambelii* Forest Association
Db	*Pinus ponderosa* Woodland and Tree Savanna Association
Ea	*Pinus edulis* - *Juniperus monosperma (Quercus grisea)* / *Bouteloua gracilis* Tree Savanna Association
Ea	*Pinus edulis* - *(Juniperus monosperma, Juniperus deppeana)* / *Bouteloua gracilis* Open Woodland Association
Eb	*Quercus grisea* / Mixed Perennial Grass (*Artemisia dracunculus*) Post-fire Shrubland and Herbaceous Association
Eb	*Quercus grisea* / *Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous Association
Ec	*Bouteloua gracilis* Grassland Association
Ed	*Cercocarpus montanus* Shrubby Rock Outcrop Association
n/a	*Quercus gambelii (Quercus grisea)* Shrubland and Shrub Savanna Association

3 Accuracy Assessment

3.1 Methods

The protocol used for the accuracy assessment (AA) phase of this project was based on the thematic accuracy assessment procedures outlined by Lea and Curtis (2010). All attempts were made to follow these procedures. However, some changes were made—mainly to accommodate the small and often linear nature of many map classes, and to accommodate crew size and availability.

Using ArcMap (ESRI 2011), we created the AA inference/project area by buffering and removing a number of features throughout the park. All roads (dirt and paved) and facilities were buffered by 10 meters and eliminated from the AA sampling frame. This was done to remove the edge effect that areas close to these features may have.

Prior to the allocation of assessment points via a sample design within the inference area, individual polygons attributed as the same association were merged together to allow calculation of the total area for each association (Table 3-1). Using the RRQRR algorithm, we distributed points based on the total area covered by each association. For associations covering more than 50 hectares, a total of 30 plots were distributed. For associations covering 8.33–50 hectares, a plot was distributed for every 0.6 ha. For associations covering less than 8.33 hectares, we distributed a minimum of five plots. There were a total of 321 plots distributed across 16 associations.

Each point served as the centroid of a circular assessment plot. The area covered by each associated plot varied based on the size

Table 3-1. Accuracy-assessment plot distribution within each association, based on total area covered by each type and plot size.

Association name[1]	AA area (ha)	% of total area	Plots[2]	Plot radius (m)
Pinus ponderosa Woodland and Tree Savanna (P)	163.4	15.27%	30	28
Pseudotsuga menziesii - Quercus gambelii Forest	57.6	5.38%	30	18
Pinus edulis - Juniperus monosperma (*Quercus grisea*) / *Bouteloua gracilis* Tree Savanna (P)	86.8	8.11%	30	40
Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis Open Woodland	356.9	33.36%	30	40
Populus angustifolia / Salix irrorata Riparian Woodland	10.2	0.95%	6	18
Regenerating *Populus angustifolia / Salix irrorata* Riparian Woodland (PS)	53.4	4.99%	30	25
Atriplex canescens Shrubland	0.5	0.04%	4	10
Cercocarpus montanus Shrubby Rock Outcrop (P)	61.0	5.70%	30	18
Ericameria nauseosa Shrubland	26.4	2.47%	16	18
Quercus gambelii (*Quercus grisea*) Shrubland and Shrub Savanna (PS)	3.6	0.34%	5	18
Quercus grisea / Mixed Perennial Grass (*Artemisia dracunculus*) Post-fire Shrubland and Herbaceous (P)	34.3	3.20%	20	28
Quercus grisea / *Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous (P)	120.8	11.29%	30	40
Robinia neomexicana Shrubland (P)	2.9	0.27%	5	10
Annual Forb - Mixed *Bouteloua* spp. Herbaceous (PS)	21.9	2.04%	13	28
Post-fire Riparian Mixed Herbaceous (PS)	37.3	3.48%	22	25
Bouteloua gracilis Grassland	34.1	3.18%	20	25

[1]Codes following community names indicate NVC status and are as follows: (P) = proposed for entry into the NVC, (PS) = "park special," meaning we will not submit it for formal integration into the NVC; rather, it is considerd a unique assemblage found only in this park, resulting from disturbance or other factors. Names without codes are accepted associations within the NVC.
[2]Based on total area and on the shape of the polygons, plots were distributed in the number shown below and with varying radii to account for linear features.

and shape of the polygons within each map class. The recommended size, equivalent to the MMU (0.5 ha), was too large for 13 of the map classes. Due to the linear nature of these map classes and/or the limited area they covered, plot sizes were reduced to avoid removing large portions of the park from the inference area. Plot size was determined on a class-by-class basis, taking into account the ratio of polygon widths to lengths and the area buffered out at different plot sizes. Based on this assessment, we used five different-sized plots: 10-meter radius = 0.03 hectares (n = 9), 18-meter radius = 0.1 hectares (n =87), 25-meter radius = 0.20 hectares (n = 72), 28-meter radius = 0.25 hectares (n = 63), and 40-meter radius = 0.5 hectares (n = 90) (Figure 3-1).

3.2 Field effort

Over the course of six days in June 2015, three crews of two assessors each sampled all but one of the sites distributed across the park (n = 320). Prior to data collection, assessors were thoroughly briefed on the assessment protocol and the vegetation associations assigned to each map class. The crew leads had worked on numerous vegetation-mapping projects throughout Arizona, and were knowledgeable of the park's diverse vegetation. The assessors were provided with keys to the vegetation associations (Appendix C), detailed descriptions of each (Appendix D), and a field guide to aid in plant identification. Using a Juno GPS unit, the assessors walked throughout each plot until they determined the dominant and/or diagnostic species present and their approximate canopy cover. Using the association key and description, they determined which one provided the best match to the community present within the plot. If no association was applicable, then they labeled it unplaced and assigned it a new association name. All plots were assigned a level of fit for their assigned association: excellent, good, fair, or poor.

Excellent: The composition of dominant species (taking into account listed variations within the type) and cover values within the plot match the type description.

Good: The composition of dominant species (taking into account listed variations within the type) within the plot matches the type description, but cover values are outside the values or ranges listed in the type description.

Fair: The composition of the minority of dominant species (taking into account listed variations within the type) does not match the type description (e.g., a dominant species is not listed in the description or a listed dominant is not in the plot), but the plot is clearly best suited for the type.

Poor: The composition of the majority of dominant species (taking into account listed variations within the type) does not match the type description (e.g., a dominant species is not listed in the description or a listed dominant is not in the plot). This indicates that the plot is similar enough to a description to assign a type, but there are major discrepancies between the two.

For plots with a fair or poor fit, assessors described the discrepancies between the plot and its assigned association and acquired four pictures of the plot (one in each cardinal direction) from a representative location. Within each plot, assessors collected a GPS point attributed with the plot ID, and assigned association and level of fit. This served as a check on plot ID transcription errors and allowed for quicker analysis.

3.3 Results

Accuracy assessment compares field observations with the map-class assignments of the sampled area. Errors occur when the two don't agree. The results are meant to inform the end user of the map's accuracy. We assessed every discrepancy (n = 99) between assessors (field-based map checkers) and producers (map makers) to determine their validity. Based on AA datasheets, plot photos, and imagery, we determined that 14 plots were incorrectly assessed and should be in agreement with the producers' designation. A few of these discrepancies (n = 6) were a result of the assessors' accidently recording the wrong type. This determination was based on the dominant species recorded within the plot. Based on imagery, other discrepancies were clearly a result of the assessors' not surveying the entire plot and instead, only considering the vegetation in the immediate area

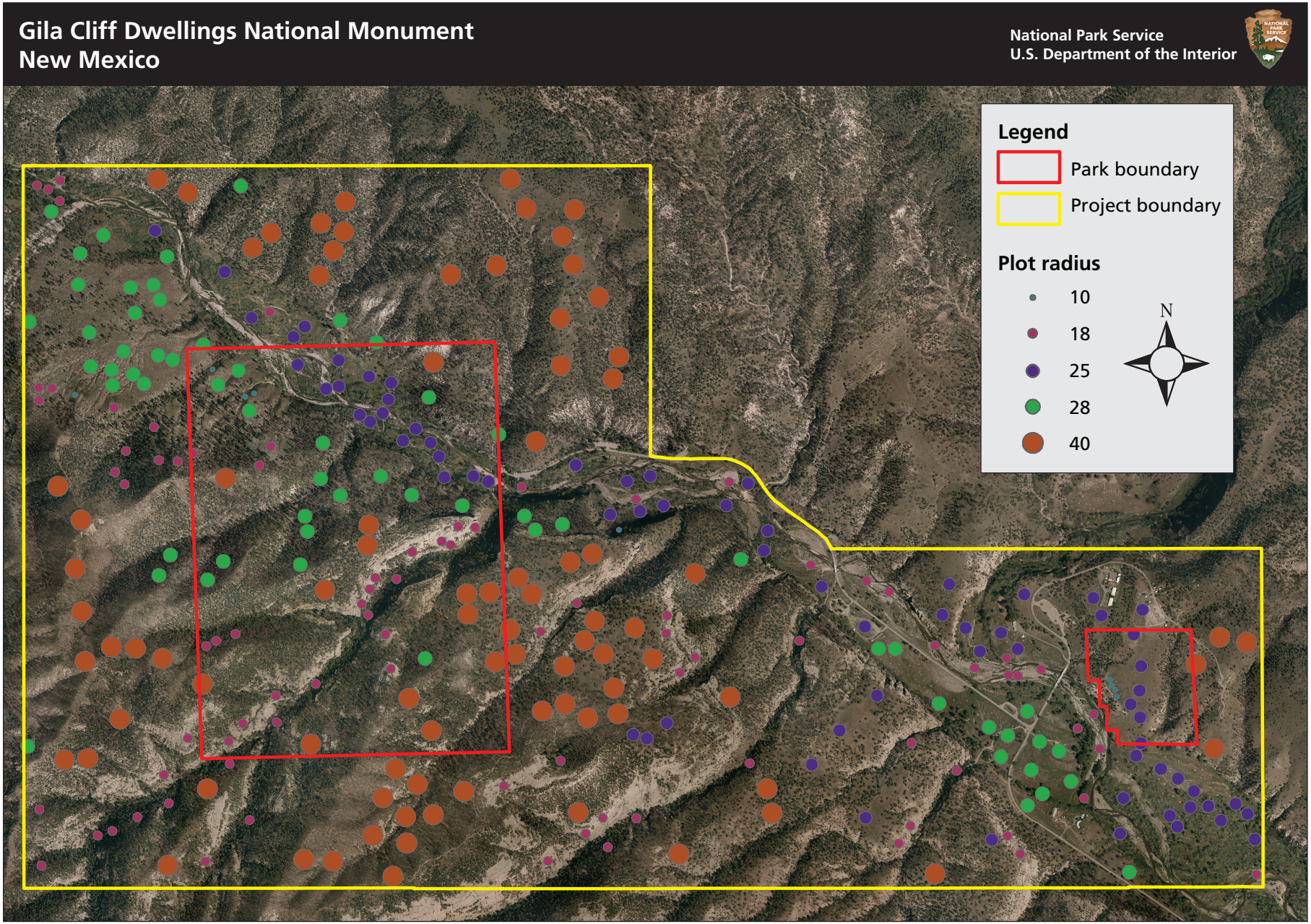


Figure 3-1. Accuracy-assessment plot locations. Different-sized circles represent the radii of each plot.

of the center point. A breakdown of these decisions is found in Appendix E. An additional seven plots were removed from the AA analysis for various reasons. Most of these were a result of disturbance due to extreme flooding that occurred between the mapping and AA phases of the project. In other cases, assessors attempted to survey a plot from a distance, usually due to safety concerns; a comparison of the survey data and imagery showed it was extremely unlikely the plot was actually assessed (Appendix E).

In all, there were 71 discrepancies or mismatches between map classes and AA field classes spread across 15 map classes (Table 3-2). The one class without any discrepancies was also the one occupying the smallest area and containing the fewest plots (*Atriplex canescens* Shrubland). Values that occur within the ochre-shaded diagonal cells indicate agreement (A) between the assessor and the map producer. Values in cells not shaded in ochre indicate disagreement (D). Column totals equal the total number of plots placed within that class by the assessors. Row totals are the number of plots assigned to that class by the producers. Overall accuracy calculated at this point was 76.1% (90% CI: 0.70, 0.81).

Based on review of the mismatches, we identified three pairs of associations that were consistently misidentified as one another (see Table 3-2). This overlap was due to the ecotonal nature of these types, overlap within the type descriptions, and the highly variable composition of post-fire types. As such, we decided to merge these three pairs into three map classes, in which each class contains two similar associations (Table 3-3). This resulted in 13 map classes (Table 3-4), 10 of which had a one-to-one relationship of association to map class.

The AA samples were stratified by draft map classes. When two or more classes are merged, the class-specific accuracy for that merged class cannot be estimated by the overall number correct divided by the total number. Because areas were sampled at different intensities, values must be weighted based on the original map-class areas. Therefore, simply plugging summed numbers into the AA spreadsheet would give invalid estimates for these pooled classes. Instead, the accuracies shown in Table 3-4 were computed in R, taking into account the stratification and weights, and bootstrapping to estimate confidence intervals (R code is available from tom_philippi@nps.gov). Overall "lumped"accuracy was recalculated on the 13 classes and was 84.2% (90% CI: 0.80, 0.88).

Only two associations failed to achieve a users' accuracy above 75%: the *Pinus ponderosa* Woodland and Tree Savanna Association and the *Pseudotsuga menziesii - Quercus gambelii* Forest Association. A low user accuracy indicates that areas mapped as a particular association contain large areas that belong in a different association. For both associations, fire disturbance was the main reason for the low accuracy. Inclusions of high fire severity with considerable canopy mortality were often placed within one of the post-fire oak types: *Quercus gambelii (Quercus grisea)* Shrubland and Shrub Savanna Association, *Robinia neomexicana* Shrubland Association, and the *Quercus grisea* Regenerating Shrubland Association.

Of the 307 plots included in the final analysis, an excellent fit was selected for 172 plots (56%), a good fit for 102 plots (33%), a fair fit for 30 plots (10%), and a poor fit for 3 plots (1%). For all poor and fair fits, datasheets were assessed to determine which characteristics caused the lack of fit. The majority resulted from the variable composition and cover of associate species, mainly due to fire and/or flooding disturbance. Some types received minor additions to account for variations not captured during the classification and mapping phases.

Table 3-2. Accuracy-assessment contingency table (error matrix) showing the number of plots placed within each map class by the producers (rows) and assessors (columns).[1]

#	Association	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Producer's total
1	*Pinus ponderosa* Woodland and Tree Savanna	17 (A)	1 (D)	–	3 (D)	–	–	–	–	–	1 (D)	3 (D)	1 (D)	1 (D)	–	1 (D)	1 (D)	29
2	*Pseudotsuga menziesii - Quercus gambelii* Forest	3 (D)	18 (A)	–	4 (D)	–	–	–	–	–	3 (D)	–	1 (D)	–	–	–	–	29
3	*Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis* Tree Savanna	–	–	23 (A)[2]	5 (D)[2]	–	–	–	–	–	–	–	–	–	–	–	2 (D)	30
4	*Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Open Woodland	1 (D)	–	3 (D)[2]	24 (A)[2]	–	–	–	1 (D)	–	–	–	–	–	–	–	–	29
5	*Populus angustifolia / Salix irrorata* Riparian Woodland	–	–	–	–	5 (A)	1 (D)	–	–	–	–	–	–	–	–	–	–	6
6	Regenerating *Populus angustifolia / Salix irrorata* Riparian Woodland	–	1 (D)	–	–	1 (D)	28 (A)	–	–	–	–	–	–	–	–	–	–	30
7	*Atriplex canescens* Shrubland	–	–	–	–	–	–	4 (A)	–	–	–	–	–	–	–	–	–	4
8	*Cercocarpus montanus* Shrubby Rock Outcrop	–	–	–	2 (D)	–	–	–	24 (A)	–	–	1 (D)	–	–	–	–	–	27
9	*Ericameria nauseosa* Shrubland	–	–	–	–	–	1 (D)	–	–	11 (A)	–	–	–	–	–	–	–	12
10	*Quercus gambelii* (*Quercus grisea*) Shrubland and Shrub Savanna	–	–	–	–	–	–	–	–	–	4 (A)	1 (D)	–	–	–	–	–	5
11	*Quercus grisea* / Mixed Perennial Grass (*Artemisia dracunculus)* Post-Fire Shrubland and Herbaceous	1 (D)	–	–	–	–	–	–	–	–	–	19 (A)[2]	–[2]	–	–	–	–	20
12	*Quercus grisea / Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous	–	–	2 (D)	–	–	–	–	1 (D)	–	–	5 (D)[2]	21 (A)[2]	–	–	–	–	29
13	*Robinia neomexicana* Shrubland	–	–	–	–	–	–	–	–	–	–	1 (D)		3 (A)	–	–	–	4
14	Annual Forb - Mixed *Bouteloua* spp. Herbaceous	–	–	–	–	–	–	–	–	–	–	–	–	–	12 (A)[2]	1 (D)[2]		13
15	Post-fire Riparian Mixed Herbaceous Association	–	–	–	–	–	2 (D)	–	–	3 (D)	–	–	1 (D)	–	7 (D)[2]	5 (A)[2]	2 (D)	20
16	*Bouteloua gracilis* Grassland	–	–	2 (D)	–	–	–	–	–	–	–	–	–	–	–	–	18 (A)	20
	Assessors' total	22	20	30	38	6	32	4	26	14	8	30	24	4	19	7	23	307

[1]In table, A=agreement, D=disagreement. Cells showing agreement are also shaded ochre.

[2]Cells outlined in red indicate the pairs of associations that were subsequently merged into map classes: (*Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis* Tree Savanna AND *Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Open Woodland; *Quercus grisea /* Mixed Perennial Grass (*Artemisia dracunculus)* Post-Fire Shrubland and Herbaceous AND *Quercus grisea / Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous; Annual Forb - Mixed *Bouteloua* spp. Herbaceous AND Post-fire Riparian Mixed Herbaceous Association).

Table 3-3. Associations merged into map classes post-accuracy assessment.

Association	Hybrid map class
Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis Tree Savanna *Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Open Woodland	*Pinus edulis - Juniperus monosperma* / Herbaceous Understory Open Woodland
Annual Forb - Mixed *Bouteloua* spp. Herbaceous Post-fire Riparian Mixed Herbaceous	Mixed Riparian Herbaceous
Quercus grisea / Mixed Perennial Grass (*Artemisia dracunculus)* Post-Fire Shrubland and Herbaceous *Quercus grisea* / *Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous	*Quercus grisea* Regenerating Shrubland

Table 3-4. Calculated per-class accuracies and confidence intervals for the 13 map classes.

#	Map class	*n* correct	*n* sites	Estimated accuracy	Lower 90% CI	Upper 90% CI	Area (ha)
1	*Pinus ponderosa* Woodland and Tree Savanna	17	29	58.6%	0.435	0.723	163.37
2	*Pseudotsuga menziesii - Quercus gambelii* Forest	18	29	62.1%	0.468	0.753	59.3
3	*Pinus edulis - Juniperus monosperma* / Herbaceous Understory Open Woodland	55	59	93.1%	0.861	0.987	442.02
4	*Populus angustifolia* / *Salix irrorata* Riparian Woodland	5	6	83.3%	0.498	0.962	10.18
5	Regenerating *Populus angustifolia* / *Salix irrorata* Riparian Woodland	28	30	93.3%	0.817	0.978	53.43
6	*Atriplex canescens* Shrubland	4	4	100.0%	0.597	1.000	0.46
7	*Cercocarpus montanus* Shrubby Rock Outcrop	24	27	88.9%	0.752	0.955	60.97
8	*Ericameria nauseosa* Shrubland	11	12	91.7%	0.699	0.981	26.42
9	*Quercus gambelii* (*Quercus grisea*) Shrubland and Shrub Savanna	4	5	80.0%	0.435	0.954	3.63
10	*Quercus grisea* Regenerating Shrubland	45	49	90.8%	0.828	0.973	155.11
11	*Robinia neomexicana* Shrubland	3	4	75.0%	0.356	0.942	2.87
12	Mixed Riparian Herbaceous	25	33	74.8%	0.622	0.874	59.12
13	*Bouteloua gracilis* Grassland	18	20	90.0%	0.738	0.966	34.08

4 Final Map Products

In the final map, there are 16 associations placed in 13 map classes. For 10 associations, there is a one-to-one correlation between association and map class. The remaining six associations are grouped into map classes that contain two associations each (Table 4-1). There is also a map class designated Park Facilities that encompasses all developed areas within the project area, including roads, buildings, campgrounds, and parking lots.

Across the project area, there are 203 polygons (Figure 4-1) ranging in size from 0.02 to 54.7 hectares (0.05–141 ac). Many of the small polygons (<0.5 ha) are along the project boundary, where larger mapped areas were clipped to create a straight boundary. The majority of polygons consist of a single feature, but when divided by the Park Facilities, some polygons became multi-part features. Across the entire project area, 14% (149 ha/368 ac) is associated with the Gila River riparian corridor, and 85% (887.5 ha/2,193 ac) with uplands habitat or ephemeral drainages. Within the riparian corridor, 75% of the area (112 ha/276 ac) was described as a post-fire, regenerating community. Within upland habitats, 16% of the area (145 ha/358 ac) was described as a post-fire, regenerating community. The area assigned to post-fire types does not represent the full extent of the Miller Fire's influence—only those areas where the fire caused a type or formation change.

At the park's main unit, there are 52 polygons representing 14 associations, covering a total of 196 hectares (484 ac). Of these, 10% (21 ha/52 ac) of the area is associated with the Gila River riparian corridor, and 90% (175 ha/432 ac) with upland habitat or ephemeral drainages. The vast majority of the riparian corridor within the park was severely disturbed by the Miller Fire, with 95% (20 ha/49 ac) of riparian communities described as a post-fire, regenerating association. Within the upland communities, around 13% (22.4 ha/55 ac) was placed within a post-fire, regenerating association.

At the TJ unit, 13 polygons represent six associations (5 of which are common to the main unit) and some areas of Park Facilities, covering a total of 17 hectares (42 ac). Of these, 99% of the area is associated with upland communities, while less than one percent (0.08 ha/0.19 ac) is associated with the Gila River corridor. None of the upland polygons was placed within an association described as post-fire, regenerating community.

Six of the 16 final community types had accepted corollaries within the NVC at the time of report preparation. This number is expected to increase in future years as the NVC is refined and the inclusion of more data leads to new type descriptions. There were many similar associations documented within the NVC, but they were either not great fits for our associations or lacked detailed descriptions. The NVC "Elcodes" or SODN placeholder codes (for currently unaccepted types) are shown in Table 4-1 and included in the full community descriptions in Appendix D.

Following the map are one-page summaries of the 16 associations identified and mapped at Gila Cliff Dwellings National Monument during this project. These summaries are abridged versions of the full association descriptions provided in Appendix D. Each summary briefly describes the floristic and structural characteristics of the vegetation and shows (1) a representative photo of the association (top right), (2) its distribution across the park (bottom right), and (3) an example of the satellite imagery for one polygon (inset; area shown is indicated by red box in accompanying distribution figure). Readers may refer to the digital maps and databases accompanying this report for more detail.

Table 4-1. Final list of classified vegetation associations and map classes by formation type, Gila Cliff Dwellings National Monument.

#	Association[1]	Map class	NVC code	SODN code	Plots	Polygons	Area (hectares)			
							Main unit	TJ unit	Outside park	Project area
1	*Pinus ponderosa* Woodland and Tree Savanna (P)	(same as association)	–	NPSSODN036	8	30	53.4	0	94.84	148.2
2	*Pseudotsuga menziesii - Quercus gambelii* Forest	(same as association)	CEGL000452	–	15	13	17.9	0	41.36	59.3
3	*Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis* Tree Savanna (P)	*Pinus edulis - Juniperus monosperma* / Herbaceous Understory Open Woodland	–	NPSSODN087	1	8	10.5	2.65	70.64	83.77
4	*Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Open Woodland	*Pinus edulis - Juniperus monosperma* / Herbaceous Understory Open Woodland	CEGL002151	–	23	40	54.3	6.27	292.2	352.8
5	*Populus angustifolia / Salix irrorata* Riparian Woodland	(same as association)	CEGL002647	–	3	7	0.14	0.03	10.01	10.18
6	Regenerating *Populus angustifolia / Salix irrorata* Riparian Woodland (PS)	(same as association)	–	NPSSODN086	5	12	15.7	0	37.73	53.43
7	*Atriplex canescens* Shrubland	(same as association)	CGEL001281	–	0	1	0	0.46	0	0.46
8	*Cercocarpus montanus* Shrubby Rock Outcrop (P)	(same as association)	–	NPSSODN037	5	30	15.8	0	45.18	60.97
9	*Ericameria nauseosa* Shrubland	(same as association)	CEGL002713	–	3	10	0.89	0.004	25.53	26.42
10	*Quercus gambelii* (*Quercus grisea*) Shrubland and Shrub Savanna (PS)	(same as association)	–	NPSSODN0035	0	3	0.68	0	2.92	3.60
11	*Quercus grisea* / Mixed Perennial Grass (*Artemisia dracunculus)* Post-Fire Shrubland and Herbaceous (P)	*Quercus grisea* Regenerating Shrubland	–	NPSSODN040	2	11	6.24	0	27.76	33.99
12	*Quercus grisea / Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous (P)	*Quercus grisea* Regenerating Shrubland	–	NPSSODN041	7	11	15.5	0	92	107.5
13	*Robinia neomexicana* Shrubland (P)	(same as association)	–	NPSSODN038	2	6	1.04	0	1.83	2.87
14	Annual Forb - Mixed *Bouteloua* spp. Herbaceous (PS)	Mixed Riparian Herbaceous	–	NPSSODN043	3	3	0	0	21.86	21.86
15	Post-fire Riparian Mixed Herbaceous (PS)	Mixed Riparian Herbaceous	–	NPSSODN042	7	8	4.23	0.04	32.98	37.26
16	*Bouteloua gracilis* Grassland	(same as association)	CEGL001760	–	5	9	0	7.57	26.51	34.08

[1](P) = proposed" for entry into the NVC, (PS) = "park special," a unique assemblage found only in this park, resulting from disturbance or other factors.

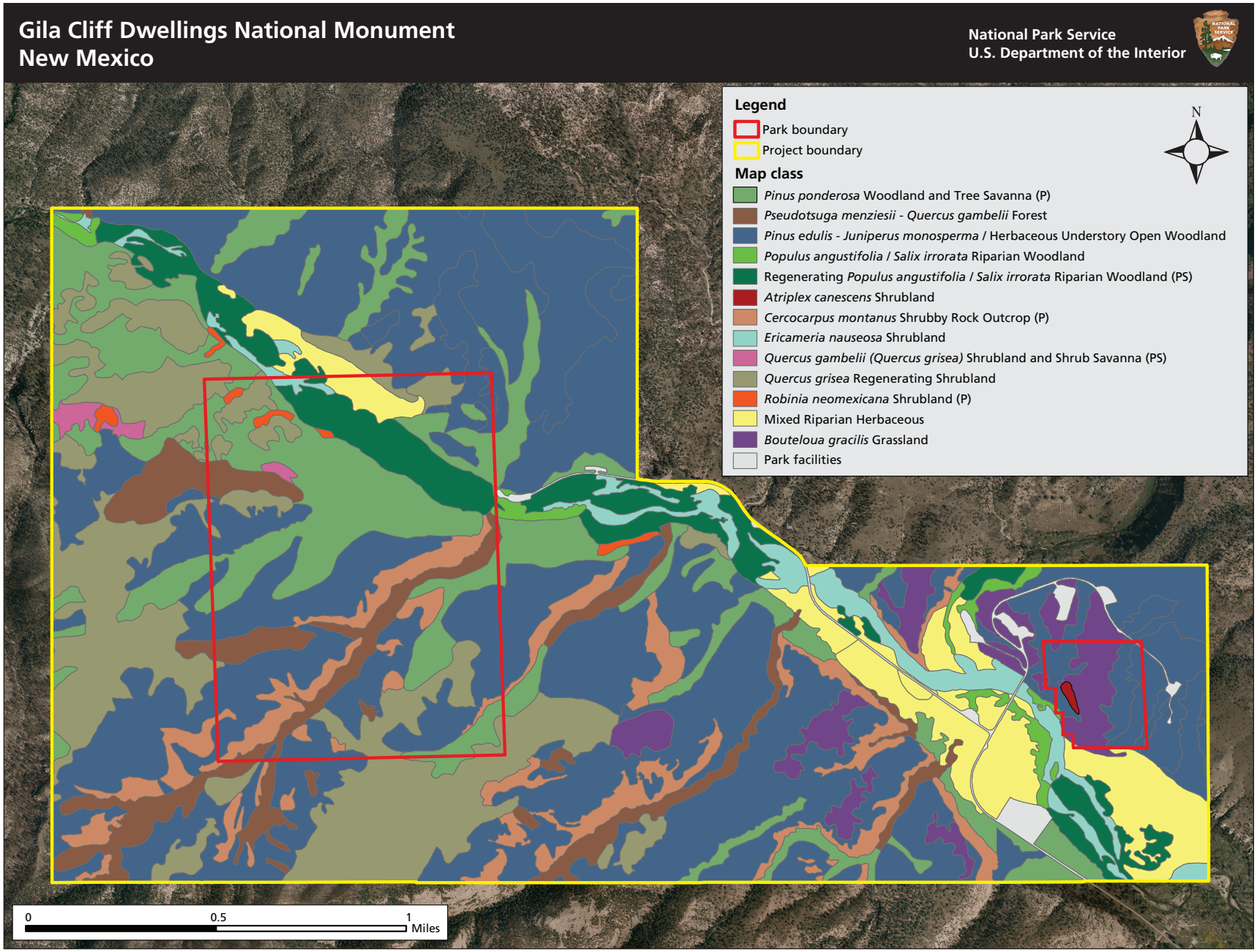


Figure 4-1. Final map graphic depicting classification at the map-class level (n=13).

1. *Pinus ponderosa* Woodland and Tree Savanna Association (P)

Ponderosa pine Woodland and Tree Savanna Association (P)

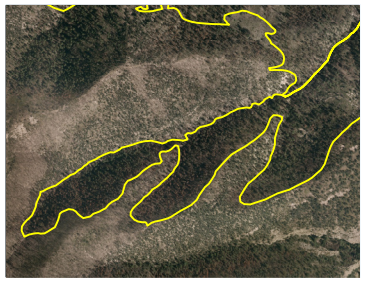
Common species

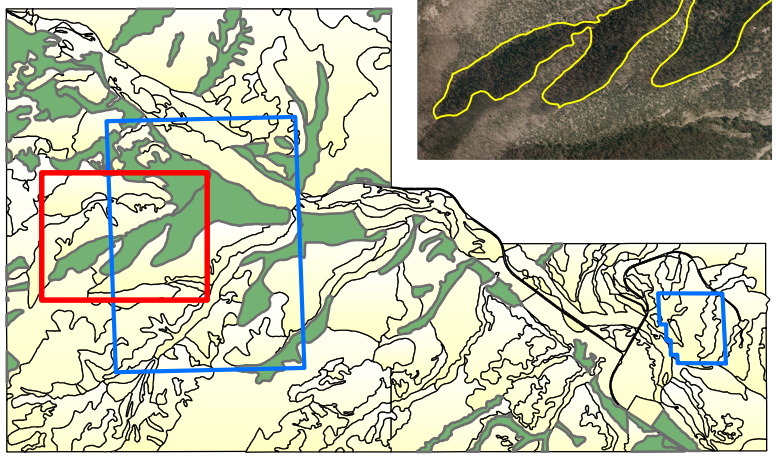
- *Pinus ponderosa*
- *Quercus grisea*
- *Bouteloua gracilis*
- *Juniperus scopulorum*
- *Poa fendleriana*

This community is characterized by an upper-canopy stratum (>5 m) dominated by ponderosa pine (*Pinus ponderosa*), with cover values from 15 to 28%. Tree height for this species is variable, ranging from 12 to 24 meters tall and averaging to 15.5 meters. On toeslopes and footslopes, this woodland is predominantly a pure stand of ponderosa pine (*P. ponderosa*), with scattered, tree-like gray oak (*Quercus grisea*) or, in areas disturbed by the Miller Fire, regenerating in the understory layers as a shrub. When restricted to drainages and their adjacent slopes, Rocky Mountain juniper (*Juniperus scopulorum*) can be a common associate, ranging in cover from 5% to 11% and occasionally becoming a second dominant. Douglas fir (*Pseudotsuga menziesii*) may also infrequently appear, standing 9–12 m tall with only 1–2% cover, mainly occupying secondary drainages and concave inclusions. Common but sparse understory species include common hoptree (*Ptelea trifoliata*), Carruth's artemisia (*Artemisia carruthii*), and New Mexico locust (*Robinia neomexicana*). The field stratum (<0.5) provides variable cover, ranging from 10–30%, that consists of blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), muttongrass (*Poa fendleriana*), sand dropseed (*Sporobolus cryptandrus*), dwarf stick-pea (*Calliandra humilis*), Wright's deervetch (*Lotus wrightii*), and tarragon (*Artemisia dracunculus*).

This woodland community occurs on steep- to moderate-gradient, generally north- to northwest-facing backslopes and toeslopes, and along steep-walled drainages from 1,676 to 1,828 meters (5,500–6,000 ft). Overall, this community covers 14.16% (148.21 ha/366.25 ac) of the project area and 25.0% (53.37 ha/131.87 ac) of the monument, exclusively in the main unit.







2. *Pseudotsuga menziesii - Quercus gambelii* Forest Association

Douglas fir - Gambel oak Forest Association

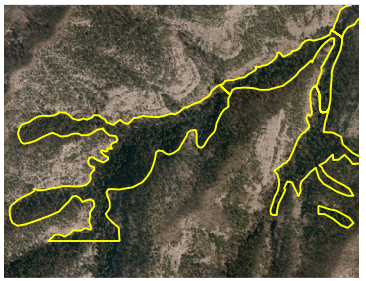
Common species

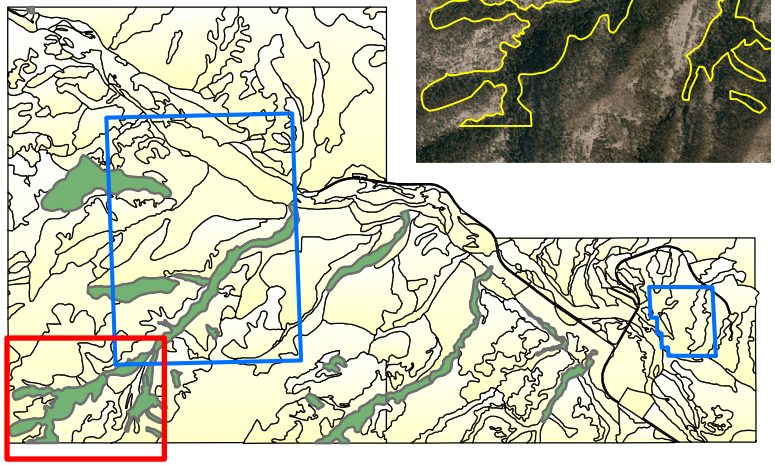
- *Pseudotsuga menziesii*
- *Quercus gambelii*
- *Juniperus scopulorum*
- *Pinus ponderosa*
- *Poa fendleriana*

This community is characterized by an upper tree canopy co-dominated by Douglas fir (*Pseudotsuga menziesii*) and Gambel oak (*Quercus gambelii*), with common associates Rocky Mountain juniper (*Juniperus scopulorum*) and ponderosa pine (*Pinus ponderosa*). Total cover in the upper canopy (>5 m) ranges from 25% to 60%, while the lower canopy (2–5 m) is sparser and often absent. Gambel oak (*Q. gambelii*) reaches heights of up to 14 meters, but is generally around 8 meters tall, with cover ranging from 8% to 45%. Douglas fir (*P. menziesii*) is a large-canopied tree, ranging from 12 to 25 meters in height and providing cover between 10% and 30%. Rocky Mountain juniper (*J. scopulorum*) averages 10 meters tall, with cover between 3% and 10%. Ponderosa pine (*P. ponderosa*) heights match those of the fir, while providing cover that fluctuates from 2% to 30%. Muttongrass (*Poa fendleriana*) and canyon grape (*Vitis arizonica*) are the two most common species in the field stratum (<0.5 m), at times being dominant, but with only a few percent cover. Where this community occupies canyon mouths, at the outskirts of the riparian zone and broader floodplain, other species typically associated with riparian systems are observed in moderate (but sometimes high) numbers, such as narrowleaf cottonwood (*Populus angustifolia*), Arizona walnut (*Juglans major*), boxelder (*Acer negundo*), and velvet ash (*Fraxinus velutina*). When this type occupies drier sites, higher on the north-facing backslopes above the drainage, ponderosa pine (*P. ponderosa*) may become the dominant canopy tree, contributing cover ranging from 12% to 23%. In these areas, Douglas fir (*P. menziesii*) is either co-dominant or subdominant to ponderosa pine (*P. ponderosa*), with cover around 15%.

This community occupies deep canyon drainages from 1,737 to 1,820 meters (5,700–6,000 ft), primarily Cliff Dweller Canyon and its tributaries. It can also be present on north- or northwest-facing slopes above minor drainages throughout the project area. Overall, this community covers 5.6% (59.25 ha/146.41 ac) of the project area and 8.41% (17.94 ha/44.34 ac) of the monument, exclusively in the main unit.







3. *Pinus edulis - Juniperus monosperma* (*Quercus grisea*) / *Bouteloua gracilis* Tree Savanna Association (P)

Two-needle pinyon - Oneseed juniper (Gray oak) / Blue grama Tree Savanna Association (P)

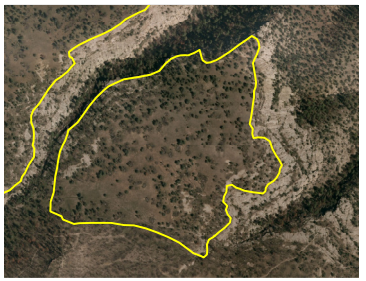
Common species

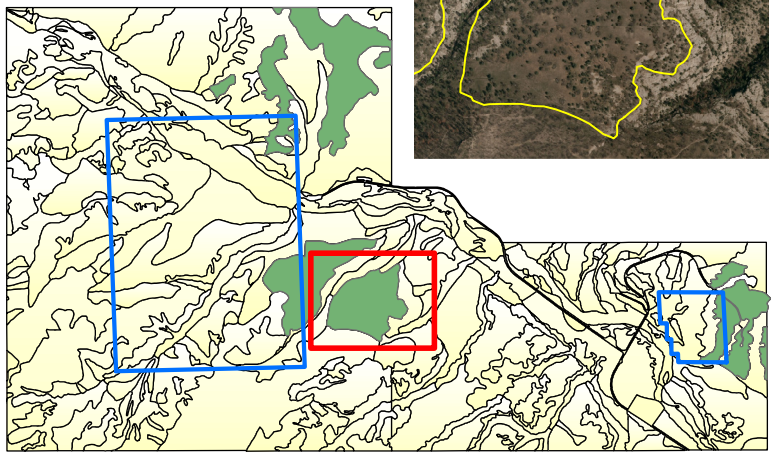
- *Pinus edulis*
- *Juniperus monosperma*
- *Quercus grisea*
- *Juniperus deppeana*
- *Bouteloua gracilis*

This association is characterized by a sparse tree canopy (5–18%), co-dominated by one-seed juniper (*Juniperus monosperma*) and two-needle pinyon (*Pinus edulis*), with two common associates, gray oak (*Quercus grisea*) and alligator juniper (*Juniperus deppeana*), and an herbaceous stratum (<0.5) dominated by blue grama (*Bouteloua gracilis*). Oneseed juniper (*J. monosperma*) is the clear canopy dominant, with cover averaging to 9%, compared to only 5% for two-needle pinyon (*P. edulis*). Gray oak (*Q. grisea*) and alligator juniper (*J. deppeana*) are common associates, each providing an average of 3–4% cover. Tree heights vary, with two-needle pinyon (*P. edulis*) ranging from 6 to 12 meters tall and averaging to 8 meters. Oneseed juniper (*J. monosperma*) is shorter, averaging 5 meters and rarely over 6 meters. The field stratum is characterized by a matrix of bunchgrasses primarily dominated by blue grama (*B. gracilis*), which provides a consistent cover ranging up to 30% and averaging to 20%. Other contributing bunchgrasses include bristly wolfstail (*Muhlenbergia alopecuroides*), sideoats grama (*Bouteloua curtipendula*), spidergrass (*Aristida ternipes*), squirreltail (*Elymus elymoides*), and hairy grama (*Bouteloua hirsuta*).

This association spans large areas, often covering and wrapping around entire hilltops. Elevation ranges from approximately 1,700–1,920 meters (5,600–6,300 ft). Typically, these communities are found on predominantly west-, southwest-, and southeast-facing slopes, covering 8.0% (83.72 ha/206.87 ac) of the project area and 6.15% (13.12 ha/32.43 ac) of the monument.







4. *Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Open Woodland Association

Two-needle pinyon - (Oneseed juniper, Alligator juniper) / Blue grama Open Woodland Association

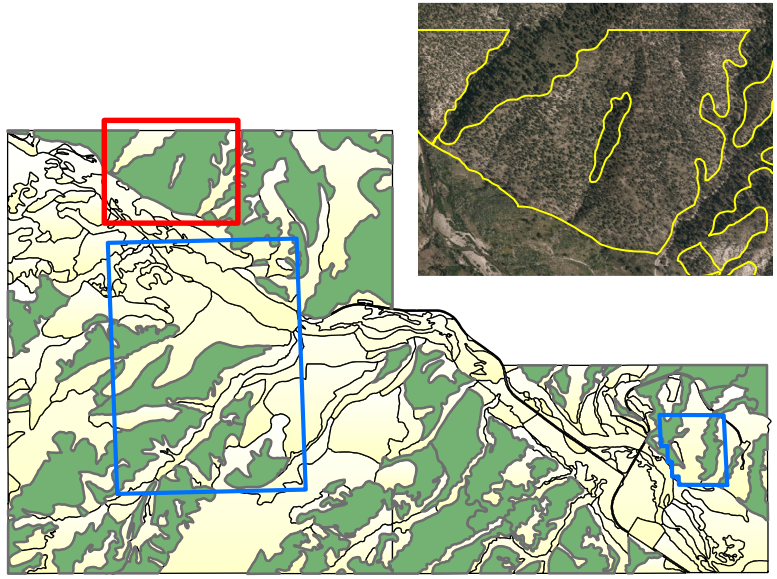
Common species

- *Pinus edulis*
- *Juniperus monosperma*
- *Quercus grisea*
- *Cercocarpus montanus*
- *Bouteloua gracilis*

This association is characterized by a moderately dense tree canopy (15–47%) co-dominated by two-needle pinyon (*Pinus edulis*) and oneseed juniper (*Juniperus monosperma*), with one common associate, gray oak (*Quercus grisea*), and an herbaceous stratum (<0.5) dominated by blue grama (*Bouteloua gracilis*). The dominant canopy trees, two-needle pinyon (*P. edulis*) and oneseed juniper *(J. monosperma*), both provide an average of 11% cover throughout the community, with values ranging above 30%. Tree heights vary, with two-needle pinyon (*P. edulis*) ranging from 6 to 12 meters tall and averaging to 8 meters. Oneseed juniper (*J. monosperma*) is shorter, averaging 5 meters tall and rarely over 6 meters. Gray oak (*Q. grisea*) is a common associate, providing an average of 7% cover and growing as a tree up to 6 meters tall (averaging 4 m) and occasionally as a shrub with heights less than 2 meters. Other trees, such as ponderosa pine (*Pinus ponderosa*), alligator juniper (*Juniperus deppeana*), and Rocky Mountain juniper (*Juniperus scopulorum*), are occasional, rarely covering more than 1 or 2%. Blue grama (*B. gracilis*) provides variable cover in the field stratum, with values ranging up to 18%, but averaging to only 5%. On occasion, sideoats grama (*Bouteloua curtipendula*) can appear co-dominant or even provide more cover than blue grama (*B. gracilis*), but not consistently across the landscape. The shrub layer is normally not well developed, with individuals scattered or growing beneath taller trees, and rarely providing much more than 3% cover. However, on the steeper, rockier, exposed hill crests, alderleaf mountain mahogany (*C. montanus*) can provide a few percent cover (up to 10%).

This association spans large areas, often covering and wrapping around entire hilltops. Elevation ranges from approximately 1,700 to 1,920 meters (5,600–6,300 ft). Typically, these communities are found on predominantly west-, southwest-, and southeast-facing slopes, covering 33.66% (352.31 ha/870.59 ac) of the project area and 28.40% (60.56 ha/150.00 ac) of the monument.





5. *Populus angustifolia / Salix irrorata* Riparian Woodland Association

Narrowleaf cottonwood / Dewystem willow Riparian Woodland Association

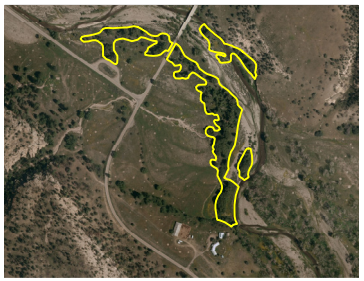
Common species

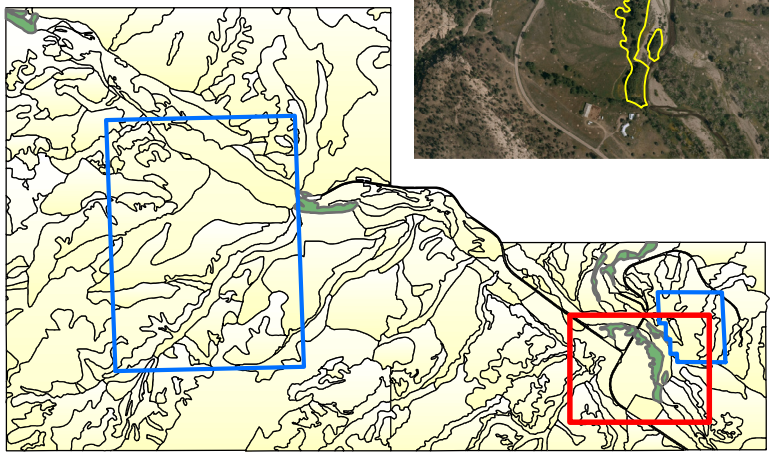
- *Populus angustifolia*
- *Salix irrorata*
- *Alnus oblongifolia*
- *Acer negundo*
- *Juglans major*

This riparian woodland and forest community is characterized by an upper canopy (>5 m) dominated by the facultative riparian tree, narrowleaf cottonwood (*Populus angustifolia*), and a lower canopy (2–5 m) dominated by the facultative riparian shrub, dewystem willow (*Salix irrorata*). Narrowleaf cottonwood (*P. angustifolia*) is generally present as a large tree (~16 m), with variable cover across the community, ranging from 6% to 63% and averaging to 37%. Arizona alder (*Alnus oblongifolia*) and boxelder (*Acer negundo*) are patchy associates with occasional areas of dominance or co-dominance with narrowleaf cottonwood (*P. angustifolia*). Arizona walnut (*Juglans major*) is a widespread, but low-cover associate. In the lower canopy, dewystem willow (*S. irrorata*) provides cover of 20–45%, predominately in dense bands at the margins of the river and along historical, abandoned river channels. The subcanopy (0.5–2 m) layer is characterized by a variable mix of riparian shrubs, subshrubs, new tree recruits, tall grasses, and large forbs. Rubber rabbitbrush (*Ericameria nauseosa*), Chihuahuan brickellbush (*Brickellia floribunda*), tarragon (*Artemisia dracunculus*), canyon grape (*Vitus arizonica*), and golden currant (*Ribes aureum*) are the most abundant and consistently occurring species. At the margins of the watercourse, a mix of large grasses and forbs often forms a dense band of vegetation commonly dominated by non-native forbs and grasses, including barnyardgrass (*Echinochloa crus-gallii*), sweetclover (*Melilotus albus*), spotted ladythumb (*Polygonum perisacaria*), and rice cutgrass (*Leersia oryzoides*).

This association is present across the floodplains and alluvial terraces adjacent to the Gila River, from 1,720 to 1,760 meters (5,643–5,772 ft). This area was heavily disturbed by the 2011 Miller Fire. The majority of the community is in a state of regeneration and is no longer classified as riparian woodland. Currently, this community covers 1.0% (10.18 ha/25.16 ac) of the project area, with only the margin of one occurrence falling within the monument.







6. Regenerating *Populus angustifolia / Salix irrorata* Riparian Woodland Association (PS)

Regenerating Narrowleaf cottonwood / Dewystem willow Riparian Woodland Association (PS)

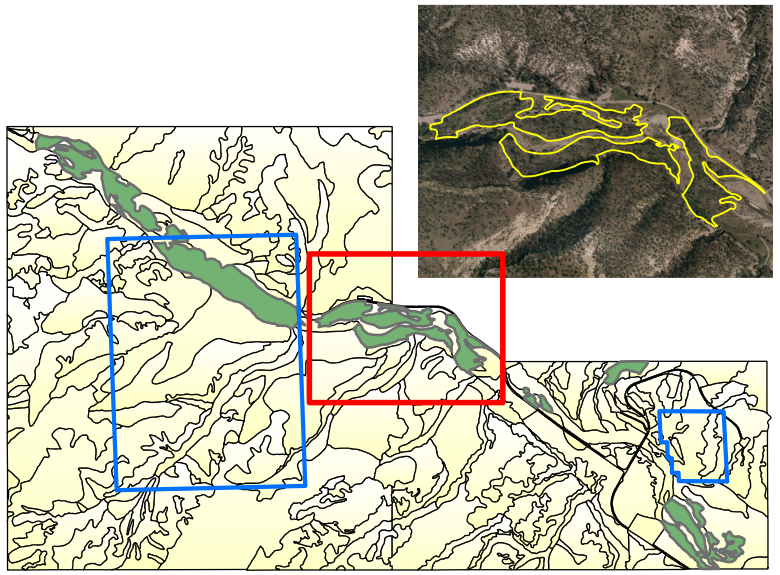
Common species

- *Populus angustifolia*
- *Salix irrorata*
- *Alnus oblongifolia*
- *Acer negundo*
- *Juglans major*

This regenerating riparian woodland community was severely damaged during the Miller Fire in 2011. It is currently characterized by a lower canopy (2–5 m) co-dominated by rapidly resprouting narrowleaf cottonwood (*Populus angustifolia*) and dewystem willow (*Salix irrorata*). In the worst-affected areas, most mature narrrowleaf cottonwoods (*P. angustifolia)* were killed, with scorch heights reaching 16 meters, leaving only standing blackened stumps and deep ash piles where flood debris had formerly accumulated on the ground. Dewystem willow (*S. irrorata*), Arizona walnut (*Juglans major*), Arizona alder (*Alnus oblongifolia*), and boxelder (*Acer negundo*) were all equally affected, leaving little living cover. Species composition was not seen to drastically change between the burned and unburned examples of this association, but cover values in the subcanopy increased dramatically, as the two dominant species boomed with fresh growth. In most cases, narrowleaf cottonwood (*P. angustifolia*) remains dominant, with average cover ranging from 25% to 30%, compared with 8–10% for dewystem willow (*S. irrorata*). Canyon grape (*Vitus arizonica*), Fendler's globemallow (*Sphaeralcea fendleri*), and common mullein (*Verbascum thapsus*) are still the most common subcanopy and field-layer associates in these regenerating areas.

This association is present across the floodplains and alluvial terraces adjacent to the Gila River, from 1,720 to 1,760 meters (5,643–5,772 ft). This area was heavily disturbed by the 2011 Miller Fire, and the majority of the community is in a state of regeneration. Currently, this community covers 5.10% (53.43 ha/132.02 ac) of the project area and 7.36% (15.69 ha/38.77 ac) of the monument, exclusively at the main unit.





7. *Atriplex canescens* Shrubland Association

Fourwing saltbush Shrubland Association

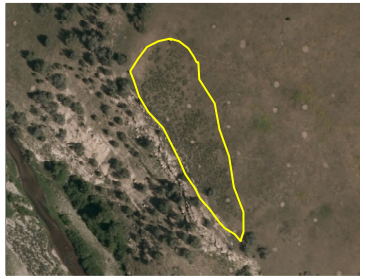
Common species

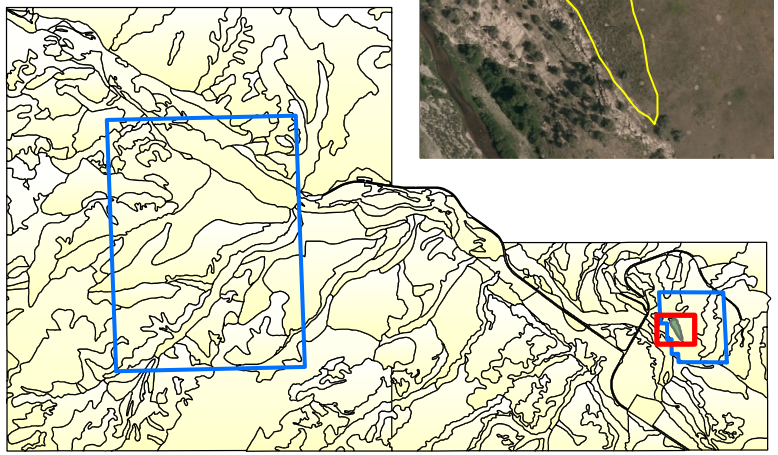
- *Atriplex canescens*
- *Bouteloua curtipendula*
- *Bouteloua gracilis*
- *Portulaca oleracea*
- *Sporobolus cryptandrus*

This shrubland community is characterized by a subcanopy stratum (0.5–2 m) dominated by fourwing saltbush (*Atriplex canescens*), which provides evenly distributed 25% cover throughout. No other shrub species are present within this single example type. The field stratum (<0.5 m) contributes around 13% cover, mainly consisting of sand dropseed (*Sporobolus cryptandrus*), Fendler's globemallow (*Sphaeralcea fendleri*), common purslane (*Portulaca oleracea*), sideoats grama (*Bouteloua curtipendula*), dwarf stickpea (*Calliandra humilis*), wild potato (*Solanum jamesii*), and blue grama (*Bouteloua gracilis*). None of these species provides more than 1% cover.

This shrubland is found at a single location in the TJ unit of Gila Cliff Dwellings National Monument, at 1,738 meters (5,704 ft). It covers 0.04% (0.46 ha/1.14 ac) of the project area and 0.2% (0.46 ha/1.14 ac) of the monument, exclusively in the TJ unit. The sole occurrence spans a low-angle summit and shoulder of a small mesa with dominant surface cover consisting of gravel and bare soil.







8. *Cercocarpus montanus* Shrubby Rock Outcrop Association (P)

Alderleaf mountain mahogany Shrubby Rock Outcrop Association (P)

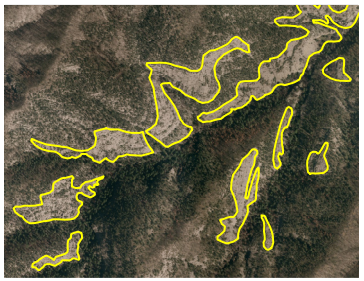
Common species

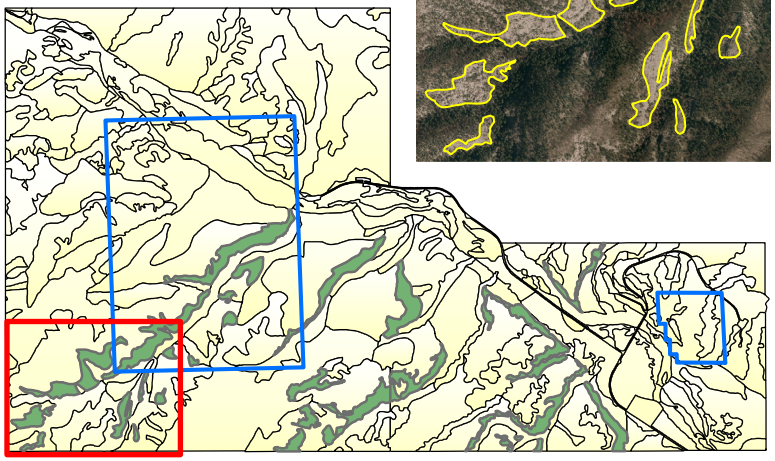
- *Cercocarpus montanus*
- *Juniperus monosperma*
- *Pinus edulis*
- *Quercus grisea*
- *Muhlenbergia polycaulis*

This shrubby rock outcrop community is characterized by dominant bedrock outcrops and the consistent presence of alderleaf mountain mahogany (*Cercocarpus montanus*), typically emerging as the dominant species in the subcanopy (0.5–2 m), with an estimated cover of 3–7%, but rarely as low as 1% and as high as 9%. Two-needle pinyon (*Pinus edulis*) and oneseed juniper (*Juniper monosperma*) are common in the 2–5 meter range and, to a lesser extent, in the subcanopy below 2 meters in height, but rarely at more than 1–2% cover. These trees are often stunted due to the exposure of the ridges and the poor water-holding capacity of the soils. They are more common along the crest of the hills. Gray oak (*Quercus grisea*) is an associated species, tending to occur in more shrubby form, not reaching much above 2 meters, and can be co-dominant with alderleaf mountain mahogany (*C. montanus*). Cliff muhly (*Muhlenbergia polycaulis*) and blue grama (*Bouteloua gracilis*) are the two most abundant and consistently occurring perennial grasses, with up to 3% cover, usually restricted to the small pockets of soil amongst the bedrock plains. Engelmann's prickly pear (*Opuntia engelmannii*), Fendler's globemallow (*Sphaeralcea fendleri*), muttongrass (*Poa fendleriana*), ragleaf bahia (*Amauriopsis dissecta* = *Bahia dissecta*), banana yucca (*Yucca baccata*), and Carruth's sagewort (*Artemisia carruthii*) are all common associates, each usually providing less than 1% cover (scattered individuals).

This community occurs along numerous drainages in the southern portion of the project area, south of the Gila River, and is restricted to the exposed mesa tops from 1,800–1,890 meters (5,900–6,200 ft), consisting of bedrock plains and rocky, sandstone-derived, shallow soils. Overall, this community covers 5.8% (60.87 ha/150.41 ac) of the project area and 7.5% (15.79 ha/39.01 ac) of the monument, exclusively in the main unit.







9. *Ericameria nauseosa* Shrubland Association (P)

Rubber rabbitbrush Shrubland Association

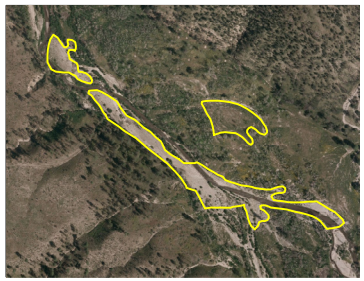
Common species

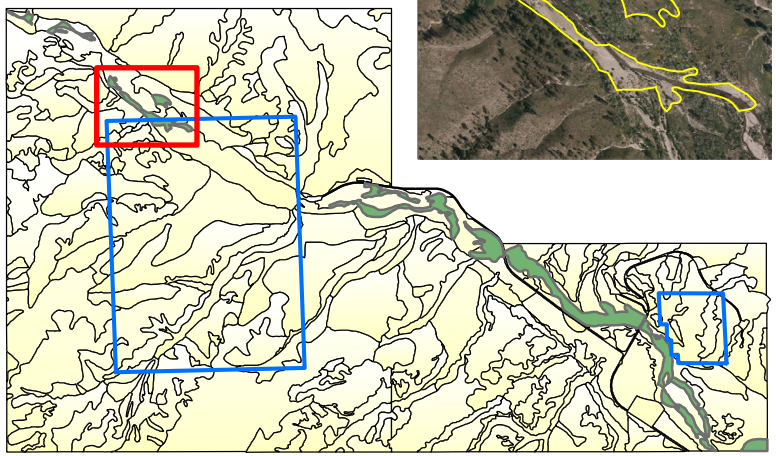
- *Ericameria nauseosa*
- *Artemisia dracunculus*
- *Amauriopsis dissecta*
- *Bouteloua gracilis*
- *Echinochloa crus-galli*

This shrubland community is characterized by a subcanopy (0.5–2 m) dominated by rubber rabbitbrush (*Ericameria nauseosa*), which provides approximately 15–30% cover throughout. Trees or canopy species are essentially absent; shrubs and herbaceous species define this type. Tarragon (*Artemisia dracunculus*) is often (but not consistently) a sub-dominant species, with 2–10% cover. Tarragon (*A. dracunculus*) prefers sandier areas and dry-wash side channels, while rabbitbrush (*Ericameria* spp.) prefers rockier sites. Other common associates include ragleaf bahia (*Amauriopsis dissecta* = *Bahia dissecta*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), barnyardgrass (*Echinochloa crus-galli*), Fendler's globemallow (*Sphaeralcea fendleri*), sand dropseed (*Sporobolus cryptandrus*), Dakota mock vervain (*Glandularia bipinnatifida*), and sacred thorn-apple (*Datura wrightii*). Due to the inherently disturbed nature of the floodplain communities, this type is subject to change as a result of natural flood or high-flow events. At times, these events are severe enough to scour these sandy, open areas, leaving them bereft of vegetation cover and more appropriately described as strands.

This association is found growing along the edges of the floodplain, on the cobbly, alluvial terraces adjacent to the Gila River, and in open areas between or next to the adjacent riparian woodland community. This community is dispersed along the entire length of the mapped riparian corridor, covering 2.5% (26.42 ha/65.28 ac) of the project area and just 0.41% (0.89 ha/2.20 ac) of the monument, exclusively along the north boundary of the main unit.







10. *Quercus gambelii* (*Quercus grisea*) Shrubland and Shrub Savanna Association (PS)

Gambel oak (Gray oak) Shrubland and Shrub Savanna Association (PS)

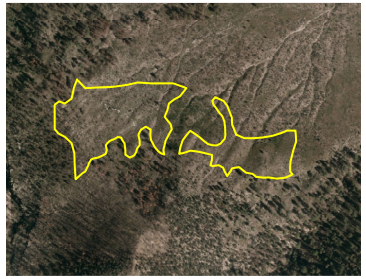
Common species

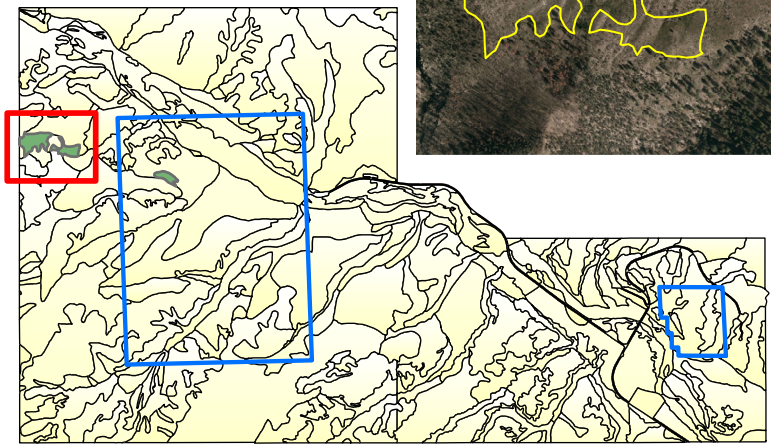
- *Quercus gambelii*
- *Quercus grisea*
- *Artemisia carruthii*
- *Bouteloua curtipendula*
- *Bouteloua gracilis*

This park-special association is described from only two small sites. Both appear to have burned or otherwise been previously disturbed, potentially from multiple events, leading to this seral stage of development. These sites are present within the much larger surrounding woodland associations dominated by ponderosa pine (*Pinus ponderosa*) and/or Douglas fir (*Pseudotsuga menziesii*), with a lower canopy of Gambel oak (*Quercus gambelii*). Within these sites, trees and tall shrubs are virtually absent—except along the boundaries, where canopy trees from the adjacent woodlands may be present. Instead, vegetation is characterized by a subcanopy (0.5–2 m) dominated by shrubby Gambel oak (*Q. gambelii*) with one common associate, gray oak (*Quercus grisea*). These species form a sparse subcanopy layer, with cover averaging 10% for Gambel oak (*Q. gambelii*) and 5% for gray oak (*Q. grisea*). Common hoptree (*Ptelea trifoliata*) and black cherry (*Prunus serotina*) are occasional associates in the stratum. The herbaceous stratum (<0.5 m) is defined by a diverse mix of perennial forbs, grasses, and subshrubs, including Carruth's sagewort (*Artemisia carruthii*), silvery lupine (*Lupinus argenteus*), plumed brickellbush (*Brickellia brachyphylla*), blue grama (*Bouteloua gracilis*), and sideoats grama (*Bouteloua curtipendula*). Where this community is present as a shrub savanna, blue grama (*B. gracilis*) may become an herbaceous stratum dominant, with cover approaching 8%.

This sparse shrubland is found on north/northeast-facing backslopes of hills on the south side of the river. Slope is approximately 40–60%. Ground cover has up to 40% gravel and rock, with around 45% bare ground. The community covers 0.34% (3.60 ha/8.90 ac) of the project area and 0.36% (0.67 ha/1.67 ac) of the monument, exclusively in the main unit.







11. *Quercus grisea* / Mixed Perennial Grass (*Artemisia dracunculus*) Post-Fire Shrubland and Herbaceous Association (P)

Gray oak / Mixed Perennial Grass (Tarragon) Post-Fire Shrubland and Herbaceous Association (P)

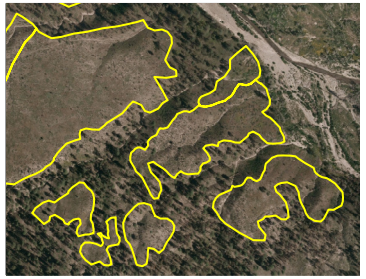
Common species

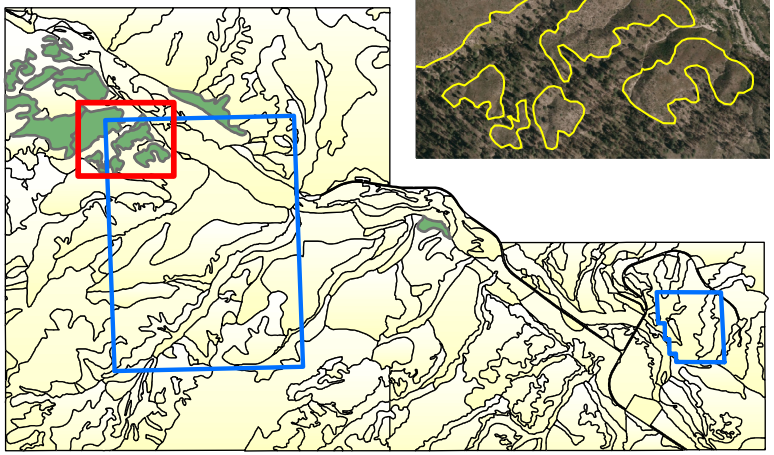
- *Quercus grisea*
- *Artemisia dracunculus*
- *Bouteloua gracilis*
- *Bouteloua curtipendula*
- *Muhlenbergia alopecuroides*

This community is in a seral stage of post-fire regeneration, occupying areas that were primarily oak shrublands or herbaceous-dominated communities before the fire. Vegetation is somewhat variable in terms of cover and associated species, but has consistent presence and dominance of gray oak (*Quercus grisea*) in the subcanopy (0.5–2 m) and field (<0.5 m) layers, along with the common associate, tarragon (*Artemisia dracunculus*). Cover of gray oak (*Q. grisea*) ranges from 2% to 8%, typically exhibiting a shrubby habit resprouting from the base of burned trunks. Pre-fire, most examples of this type were likely gray oak (*Q. grisea*) shrublands, with some individuals reaching almost 2 meters tall. Tarragon (*A. dracunculus*) is present in all but one example of this type, with cover ranging from 1% to 4%. Trees and other shrubs are accidental and uncommon. The field layer (<0.5 m) is dominated by perennial bunchgrasses, with average total cover around 20%, with many areas ranging up to 35%. Blue grama (*Bouteloua gracilis*), bristly wolfstail (*Muhlenbergia alopecuroides*), sand dropseed (*Sporobolus cryptandrus*), spidergrass (*Aristida ternipes*), and purple three-awn (*Aristida purpurea*) are the most common dominant or co-dominant species.

This type is found on low-gradient (<5% slope), north-facing foot- and toeslopes adjacent to the Gila River floodplain, predominantly on the south side of the river, from 1,737 to 1,761 meters (5,700–5,780 ft). These low-slope areas are essentially broad, flat, meadow-like openings surrounded by forest and woodland on the surrounding steeper slopes. This association covers 3.25% (34.00 ha/80.03 ac) of the project area and 2.93% (6.24 ha/15.41 ac) of the monument, exclusively in the northwest corner of the main unit.







12. *Quercus grisea / Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous Association (P)

Gray oak / Fendler's globemallow Post-fire Shrubland and Herbaceous Association (P)

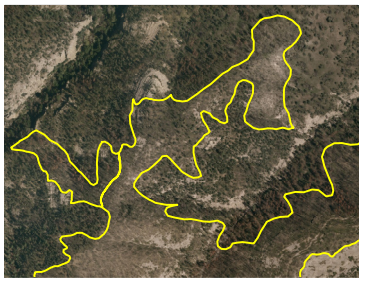
Common species

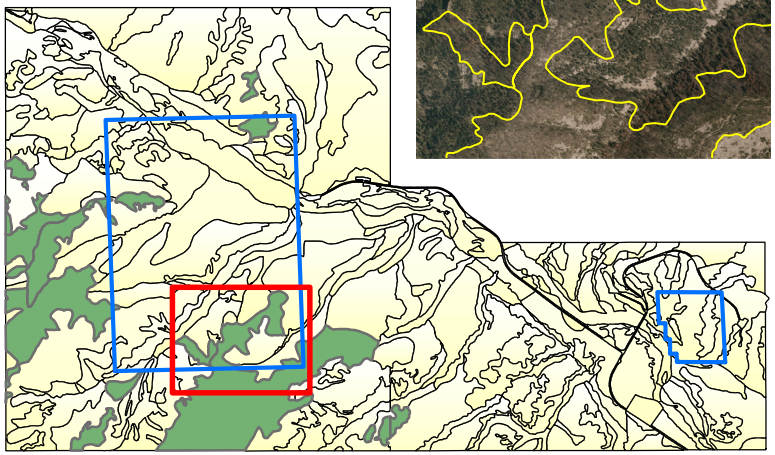
- *Quercus grisea*
- *Sphaeralcea fendleri*
- *Mirabilis multiflora*
- *Artemisia carruthii*
- *Bouteloua gracilis*

This community is in a seral stage of post-fire regeneration, occupying areas that were primarily pine woodlands and forests—specifically, ponderosa pine and pinyon-juniper types. Vegetation is somewhat variable in terms of cover and associated species, but has consistent presence and dominance of gray oak (*Quercus grisea*) in the subcanopy (0.5–2 m) and field (<0.5 m) layers, along with dominant Fendler's globemallow (*Sphaeralcea fendleri*), primarily in the field stratum. Cover of gray oak (*Q. grisea*) ranges from 1% to 3%, but can be higher (5–15%) in areas where pre-fire cover was elevated or fire intensity was less severe. This species typically exhibits a shrubby habit resprouting from the base of burned trunks. Fendler's globemallow (*S. fendleri*) is often, but not always, the dominant plant in the field (or subcanopy) layer, but can be absent or just an associate with cover values from ranging from <1% to 18%, with an average around 8%. Other species may have cover values approaching or exceeding that of Fendler's globemallow (*S. fendleri*), including Carruth's sagewort (*Artemisia carruthii*) and/or Colorado four o'clock (*Mirabilis multiflora*), usually with one or the other providing patchy, local dominance. These species might be replaced or found in lower abundance in later successional communities. In some map units, blue grama (*Bouteloua gracilis*) is a low-cover associate. Areas that did not burn completely have residual trees providing up to 2% cover; these can include ponderosa pine (*Pinus ponderosa*), two-needle pinyon (*Pinus edulis*), oneseed juniper (*Juniperus monosperma*), and alligator juniper (*Juniperus deppeana*). Depending on the pre-fire community, the regenerating oak species may be Gambel oak (*Quercus gambelii*), not gray oak (*Q. grisea*). This is typically only in drainages and on steep, north-facing slopes, where the pre-fire woodlands were more like the *Pseudotsuga menziesii - Quercus gambelii* Forest Association.

This type is found on north-facing backslopes and ridgelines above the Gila River floodplain, predominantly on the south side of the river from 1,828 to 1,920 meters (6,000–6,300 ft). This association covers 10.26 % (107.48 ha/265.61 ac) of the project area and 7.25% (15.5 ha/38.27 ac) of the monument, exclusively in the main unit.







13. *Robinia neomexicana* Shrubland Association (P)

New Mexico locust Shrubland Association (P)

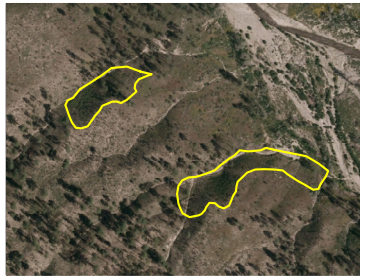
Common species

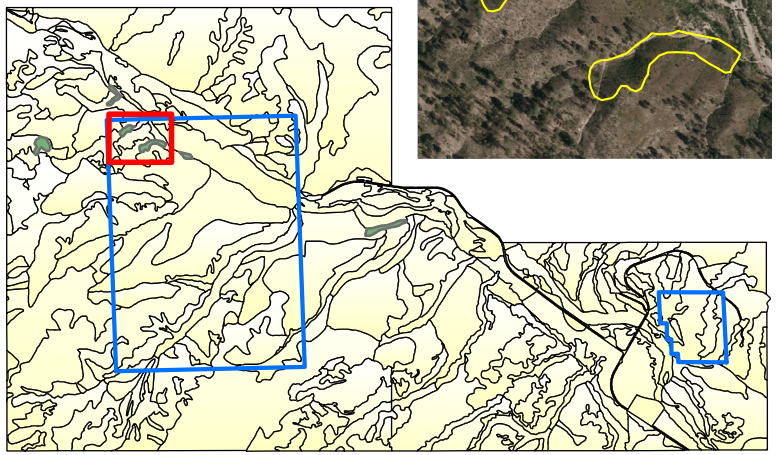
- *Robinia neomexicana*
- *Vitis arizonica*
- *Populus angustifolia*
- *Quercus gambelii*
- *Pinus ponderosa*

This shrubland association is characterized by a subcanopy stratum (0.5–2 m) dominated by New Mexico locust (*Robinia neomexicana*), with a sparse herbaceous understory and little to no tree cover. Cover of New Mexico locust (*R. neomexicana*) varies from a sparse 5% to a dense 50%, where it can be thicket-like and hard to move through. Other noteworthy but sparse shrubs and small trees include trumpet gooseberry (*Ribes leptanthum*) and common hoptree (*Ptelea trifoliata*). Tarragon (*Artemisia dracunculus*) is an inconsistent subshrub that occasionally provides cover approaching that of New Mexico locust (*R. neomexicana*). Vines are common throughout the subshrub/shrub layer, including canyon grape (*Vitis arizonica*), common hop (*Humulus lupulus*), western white clematis (*Clematis ligusticifolia*), and Virginia creeper (*Parthenocissus quinquefolia*). In general, this type occurs in areas with recent fire disturbance, where the canopy has been completely consumed or single ponderosa pine (*Pinus ponderosa*), narrowleaf cottonwood (*Populus angustifolia*), and/or Gambel oak (*Quercus gambelii*) remain.

This vegetation type is strongly associated with the riparian corridor. It is found growing on steep slopes immediately adjacent to the floodplain, and in canyon mouths. Aspect is generally north/northeast. Elevation ranges from 1,706 to 1,804 meters (5,600–5,920 ft). When present at the margins of the riparian corridor, surface cover is generally dominated by loose rock and gravel, with occasional patches of bedrock. Overall, this association covers 0.27% (2.87 ha/7.09 ac) of the project area and 0.49% (1.04 ha/2.57 ac) of the monument, exclusively in the main unit.







14. Annual Forb - Mixed *Bouteloua* spp. Herbaceous Association (PS)

Annual Forb - Mixed grama Grass Herbaceous Association (PS)

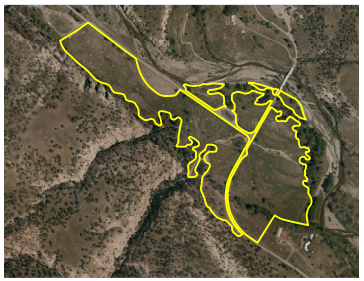
Common species

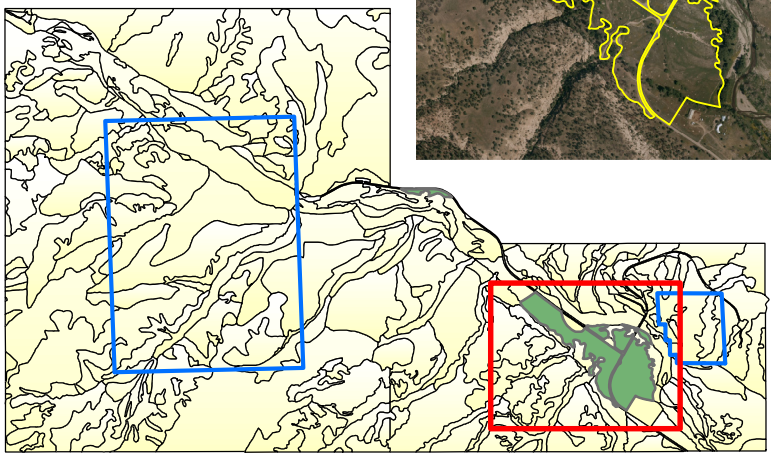
- Annual forbs
- *Ambrosia acanthicarpa*
- *Bouteloua gracilis*
- *Bouteloua curtipendula*

This herbaceous community is primarily composed of annual forbs, with an estimated 35–45% cover. During 2012 surveys (one year after the Miller Fire), pitseed goosefoot (*Chenopodium berlandieri*) was clearly dominant. During 2013 surveys, it was all but absent, replaced by flatspine burr ragweed (*Ambrosia acanthicarpa*). Other commonly occurring, low-cover annuals include carelessweed (*Amaranthus palmeri*), golden crownbeard (*Verbesina encelioides*), prickly Russian thistle (*Salsola tragus*), and melonleaf nightshade (*Solanum heterodoxum*). Blue grama (*Bouteloua gracilis*) is the second-most consistently distributed species, averaging 7% cover but occurring more or less in patches, due to its sod-forming nature. Hairy grama (*Bouteloua hirsuta*), sideoats grama (*Bouteloua curtipendula*), and sand dropseed (*Sporobolus cryptandrus*) are also common and may be locally dominant, but not consistently so. Due to its position in the riparian corridor, occasional trees are seen along the edges of this type, including but not limited to narrowleaf cottonwood (*Populus angustifolia*), Arizona walnut (*Juglans major*), and boxelder (*Acer negundo*). These average 6–7 m tall with trace amounts of cover and are considered accidental inclusions.

This herbaceous community encompasses a stretch of flat, sandy floodplain at 1,697–1,706 meters (5,570–5,600 ft) that has clear evidence of historical use for agriculture and grazing. The surface cover is dominated by bare soil with noteworthy gravel, small rocks, and litter throughout. This association covers 2.0% (21.86 ha/54.02 ac) of the project area and does not occur within the monument.







15. Post-fire Riparian Mixed Herbaceous Association (PS)

Post-fire Riparian Mixed Herbaceous Association (PS)

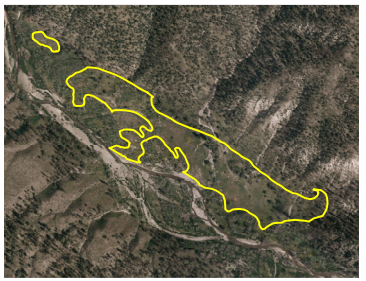
Common species

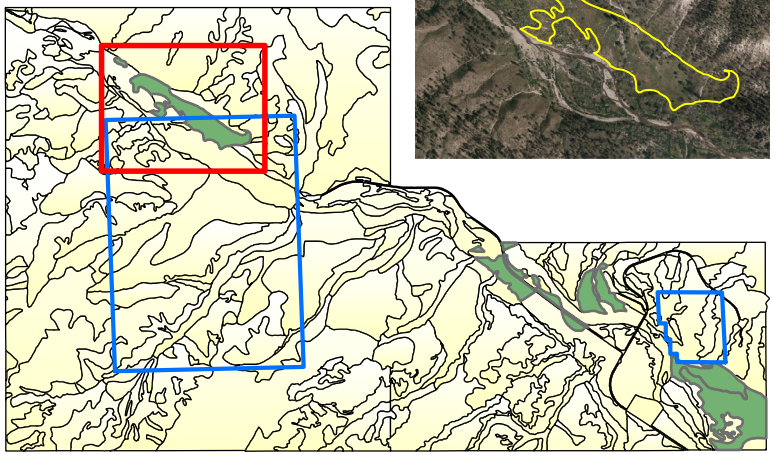
- Annual forbs
- *Sporobolus cryptandrus*
- *Sphaeralcea fendleri*
- *Bouteloua gracilis*
- *Artemisia dracunculus*

This variable vegetation type is characterized by dense herbaceous cover between 35% and 70%, primarily composed of sand dropseed (*Sporobolus cryptandrus*), Fendler's globemallow (*Sphaeralcea fendleri*), and annual forbs. Dominance switches between these species/lifeforms across the different examples of this type and can also have the common associates, golden crownbeard (*Verbesina encelioides*), blue grama (*Bouteloua gracilis*), and/or tarragon (*Artemisia dracunculus*), in abundances of 7–12%. Fendler's globemallow (*S. fendleri*) appears to be responding positively to the effects of the Miller Fire. It has consistent cover of 10% when estimated over large areas, but may start to decline over time. Sand dropseed (*S. cryptandrus*) usually averages around 11% but can provide upwards of 40% cover or be nearly absent. Shrubs are uncommon and subcanopy vegetation is not more than 5% in total. Riparian trees, such as narrowleaf cottonwood (*Populus angustifolia*), boxelder (*Acer negundo*), and Arizona walnut (*Juglans major*), as well as the more upland species, ponderosa pine (*Pinus ponderosa*) and gray oak (*Quercus grisea*), are sometimes present as scattered individuals but are not indicative of this type, occurring in isolated inclusions, on old terrace surfaces, or the edges of mapped polygons.

This community was mapped in very low-gradient floodplains and alluvial terraces associated with the Gila River. Bare ground and small-sized gravel are prolific and indicate the active nature of this floodplain, with scouring and deposition events. Litter and downed wood are rare. This community is associated more with the substrate and processes of the floodplain than with elevation and aspect (which is slight). Overall, this association covers 3.56% (37.25 ha/92.06 ac) of the project area and 2.00% (4.24 ha/10.50 ac) of the monument, predominately in the main unit.







16. *Bouteloua gracilis* Grassland Association

Blue grama Grassland Association

Common species

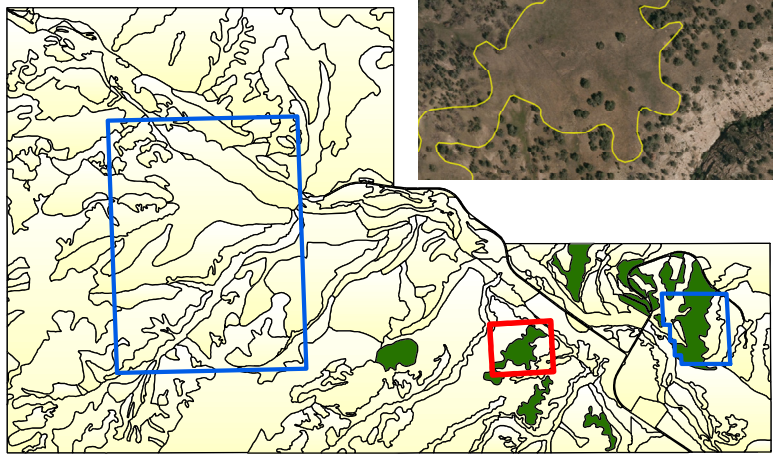
- *Bouteloua gracilis*
- *Portulaca oleracea*
- *Muhlenbergia alopecuroides*
- *Brickellia eupatorioides*
- *Aristida ternipes*

This herbaceous association is characterized by a moderately dense (20–55% cover) herbaceous layer (<0.5 m) solely dominated by the warm-season, perennial shortgrass, blue grama (*Bouteloua gracilis*). This species has a patchy to even distribution, with cover values ranging from 8% to 30% and averaging to 16%. This association is predominately present as an herbaceous opening surrounded by woodlands dominated by oneseed juniper (*Juniperus monosperma*) and two-needle pinyon (*Pinus edulis*). As a result, these species are often present in low cover (<1%), typically near the margins of this association. Other examples occur in areas where the Miller Fire burned severely enough to consume all tree species, rendering former pinyon-juniper savanna stands now dominated solely by blue grama (*B. gracilis*). Other associated species in the herbaceous layer include bristly wolfstail (*Muhlenbergia alopecuroides*), false boneset (*Brickellia eupatorioides*), little hogweed (*Portulaca oleracea*), Colorado four o'clock (*Mirabilis multiflora*), dwarf stickpea (*Calliandra humilis*), weeping lovegrass (*Eragrostis curvula*), spidergrass (*Aristida ternipes*), purple threeawn (*Aristida purpurea*), and ragleaf bahia (*Amauriopsis dissecta*).

This type occurs on flat-to-gently sloping mesa tops (1–6%) around the TJ unit of the monument and on the mesa tops south of Woody's Corral, at 1,700–1,800 meters (5,600–5,800 ft). Surface cover is generally dominated by a mix of gravel and bare soil. Overall, this association covers 3.3% (34.08 ha/82.21 ac) of the project area and 3.5% (7.57 ha/18.70 ac) of the monument, exclusively at the TJ unit.







5 Discussion

5.1 Vegetation characterization

The years before and after the vegetation classification effort were a time of great change at Gila Cliff Dwellings National Monument. The project was scheduled to begin in 2011, exactly one week after the Miller Fire ignited, and was thereby delayed for a year. Following the fire, a number of large flooding events altered the sinuosity of the river and decimated some stands of the associated vegetation communities (Figure 5-1). These events created a number of challenges for the classification and mapping phases, as the vegetation communities were responding post-fire with species mortality, short-lived changes in species dominance, and new early-succession species flushes that were not expected to last. Some changes to composition and dominance continued even into the accuracy assessment phase of the project, as trees suffered latent mortality. Postponing the project indefinitely to allow for full recovery would have been untenable, taking upwards of a decade for woody species to reestablish and more years thereafter to mature.



Figure 5-1. Ponderosa pine stand approximately one month post-fire in 2011. These trees are examples of canopies with some remaining green needles mixed with browned needles. Some of these trees would later die, while some brown-needled trees would revive. (NPS photo).

The fire burned the majority of the project area (Figure 5-2). During the classification phase, 67 plots (75%) were sampled in areas noted to have signs of recent fire disturbance. According to the burned area reflectance classification (BARC) map created by the US Forest Service (Figure 5-2), 665 hectares (64%) of the project area were affected by the fire, ranging in severity from low to a heavy. Based on our field observations, the severity and overall area covered by the fire appeared to be more severe and widespread than the BARC map indicates. The large area altered by the fire and short time between the fire and the start of the project led to a number of issues with initial classification—and accuracy assessment, several years later.

One of the primary difficulties during the initial classification was determining mortality of large conifers, such as ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*). In extreme cases, where canopies were completely consumed, this was an easy determination. However, many trees were more problematic, as their canopies were green, or half green, and appeared to be living following the fire event (see Figure 5-1). These trees were counted as alive during the classification and mapping phases. However, prior to the AA phase, many of these trees succumbed to their injuries or were potentially killed by associated bark-beetle infestations. A similar pattern has been documented following many fires in similar communities (Hood et al. 2010; Hood and Lutes 2017; Roccaforte et al. 2018). A study following the 1988 fires in Yellowstone National Park determined that up to one-third of Douglas fir (*P. menziesii*) that appeared alive after the fire eventually died (Ryan and Amman 1996). For our project, this caused many areas mapped as wooded/forested communities dominated by ponderosa pine (*P. ponderosa*) and/or Douglas fir (*P. menziesii*) to present as regenerating communities, typically dominated by one of the understory oaks, Gambel oak (*Quercus gambelii*), gray oak (*Quercus grisea*), and/or New Mexico locust (*Robinia neomexicana*). At least 10 mismatches between accuracy-assessment plots and the mapped polygons containing them could be directly attributed to post-mapping tree mortality.

Another difficulty we encountered was the

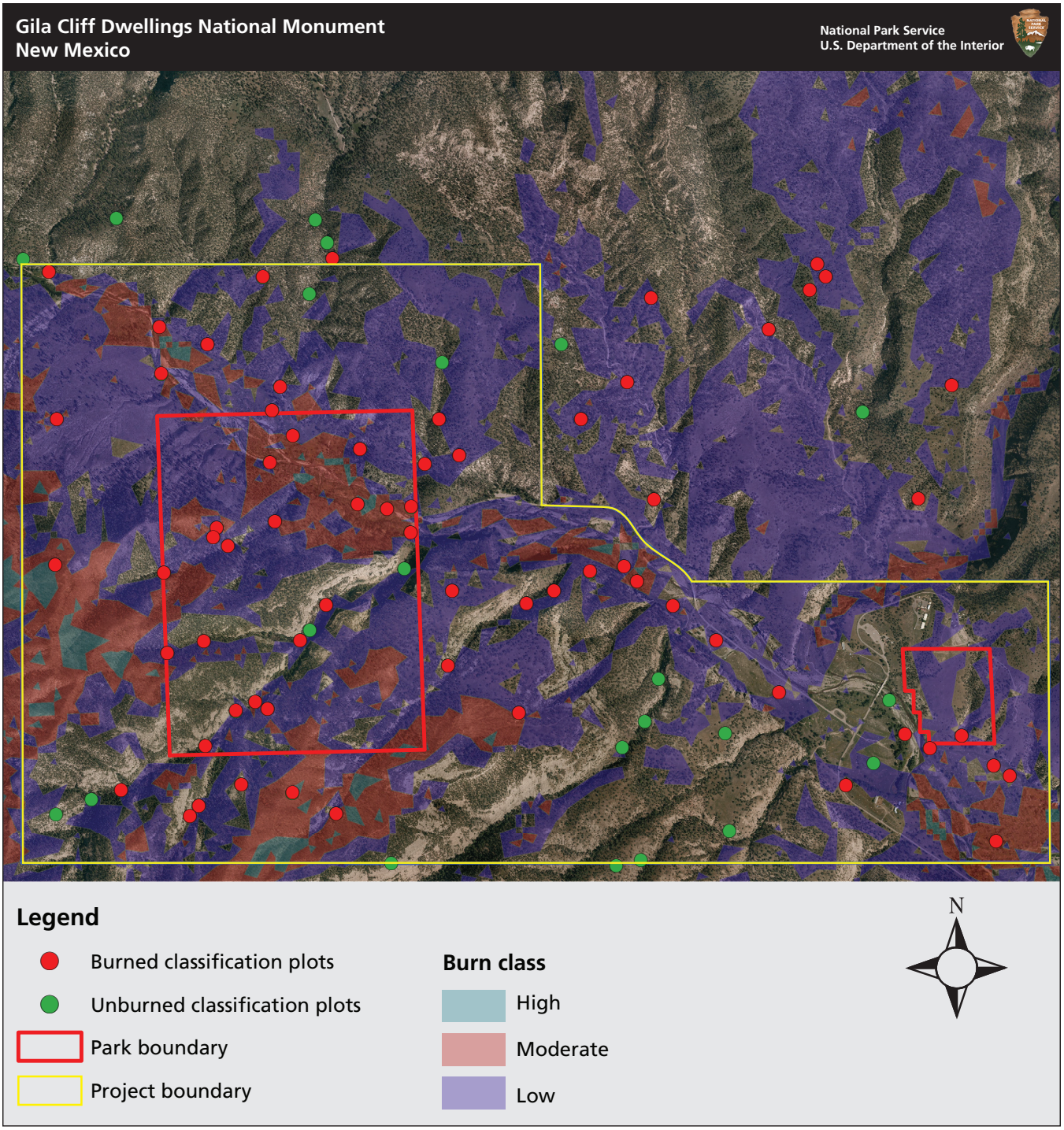


Figure 5-2. Burned Area Reflectance Classification (BARC) map, a satellite-derived data layer of post-fire vegetation condition. There are four classes: high, moderate, low, and unburned. Figure shows burn severity relative to the mapping project area and classification-plot locations.

patchy nature of the burn across the park. This was especially problematic within the pinyon-juniper woodland/tree savannas and the adjacent grama (*Bouteloua* sp.) -dominated communities. These communities form a broad gradient, ranging from grasslands to open woodland with a dominant understory of perennial grasses. Variable fire severity throughout these communities led to sporadic inclusions that presented more like one of the less-wooded versions. For example, a woodland version with tree mortality appeared as tree savanna, while high-severity areas presented as patchy grassland. While not all discrepancies between the map and the AA data can be attributed to fire effects, there were 12 (4%) mismatches within this gradient.

Two years after the Miller Fire, heavy rains, in concert with the recently burned hillslopes, led to an extreme flooding event (Figure 5-3). This event, in September 2013, caused the Gila River to rise by up to 15 feet, bringing with it considerable debris, including many of the trees killed during the Miller Fire (NWS 2013). The flooding led to the closure of the park for a number of days and damaged one of the bridges that crosses the river. In many places, the river changed course and scoured adjacent vegetation, leaving behind barren areas of sand and gravel. All this occurred between the mapping and accuracy-assessment phases, causing issues with the accuracy of some riparian communities. Due to their occurrence across gravel bars and adjacent floodplains, the rubber rabbitbrush (*Ericameria nauseosa*) Shrubland and Post-fire Riparian Mixed Herbaceous communities were the most heavily influenced by flooding. Areas that were recorded as these types during the classification phase were largely stripped of vegetation or contained only minimal annual cover following the flood. Two plots were so drastically altered by the flooding that they were removed from the accuracy assessment.

Despite these issues, overall accuracy remained high (84.2%), with most map classes close to 80% accuracy. If mapping had preceded the fire, the difficulty and time required would have been significantly reduced and the accuracy values would likely have been higher. However, we likely would have experienced the added difficulty of trying to map communities that were classified pre-burn. We would have needed either to describe the vegetation as it currently stood or devise "burned variations," which is ultimately what our team decided to do. Overall, the project team felt confident that its classifications will have longevity, as the fire burned at varying severities across the project area; some areas were untouched. The team used data from multiple years post-fire to validate the classification results. Communities drastically altered by fire, which will remain in a post-fire regenerating status for many years, were described separately from their unburned or lightly burned counterparts (e.g., the Regenerating *Populus angustifolia* / *Salix irrorata* Riparian Woodland Association) and mapped separately, allowing for the greatest flexibility in making future mapping or thematic updates to the map as the system recovers.



Figure 5-3. Middle fork of the Gila River during the September 2013 flash flood event where the channel was severely scoured. (NPS-SODN photo).

5.2 The natural role of fire on the landscape

The Miller Fire had immediate, lasting effects on vegetation at the park and within the larger project area. Wildfire in many ecosystem types is an important natural process, helping to maintain landscape-scale vegetation community patterns, reduce biomass, and shape forest stand structure and com-

position (Parks et al. 2013). In the last century, fire suppression reduced the number of fires and overall acreage that was allowed to burn, which is thought to have contributed to increased stand densities and fuel build-up in many western forests (Hunter et al. 2014). However, the Gila and Aldo Leopold Wilderness Complex, which surrounds Gila Cliff Dwellings NM, has begun to adopt more flexible polices that "allow fire to play a more natural role" (Hunter et al. 2014). The Miller Fire was a naturally ignited fire that was allowed to burn with limited suppression other than to protect human life and structures. This type of management practice is becoming more widely accepted and is often called "wildland fire use" or "wildfire use for resource benefit."

The two associations covering the greatest area within the main unit of Gila Cliff Dwellings NM are pinyon-juniper woodlands (~53 hectares) and the ponderosa pine forests (~53 hectares). These are the two most widespread communities within the larger project area, as well. Fires in pinyon-juniper savannas historically are thought to have occurred every 10–30 years, and usually would have burned as low-intensity, widespread fires that maintain open, grassy areas with scattered trees. However, pinyon-juniper woodlands are now more common in the U.S. Southwest. These communities often burn large areas as crown fires, leading to high overstory mortality (Bock and Block 2005; Hunter et al. 2011). Similarly, healthy, open stands of ponderosa pine are in large part maintained by multiple lower-intensity fires over time, which help reduce surface fuels and density of small trees while maintaining large trees (Hunter et al. 2014; Hunter et al. 2011). Both of these important communities at Gila Cliff Dwellings NM are adapted to fire and should naturally recover and reap other, shorter-term benefits from fire—for example, nutrient cycling to stimulate sprouting, and residual snags to provide habitat for cavity-nesting birds (Bock and Block 2005). Some research shows that fire severity is significantly lower in areas that have recently burned (up to 22 years between events) compared to areas that have not (Parks et al. 2013). This suggests that fire severity may diminish as normal fire cycles are restored.

Table 5-1. New species records collected during inventory fieldwork at Gila Cliff Dwellings National Monument.

Family	Scientific name	Common name
Asteraceae	*Bidens frondosa*	devil's beggartick
Amaranthaceae	*Kochia scoparia**	burningbush
Woodsiaceae	*Woodsia oregana*	Oregon cliff fern

*Non-native species.

While fire in these communities is natural and even necessary for their maintenance on the landscape, fire in riparian areas is much less common and its effects are less well-documented. During the Miller Fire, the riparian area along the West Fork of the Gila River experienced moderate- and high-severity fire, in which many overstory trees were completely consumed or killed (Figure 5-4a, Figure 5-5a). Since then, the two primary species that were affected, narrowleaf cottonwood (*Populus angustifolia*) and dewystem willow (*Salix irrorata*), have vigorously sprouted from their bases and, after six years of growth, reached heights of 3–5 meters tall (Figures 5-4b, Figure 5-5b). Every five years, the Sonoran Desert Network samples permanent monitoring plots in both upland and riparian areas of the park. These sites were sampled in 2012 (one year after the fire) and again in 2017. After sampling in 2022, a trend report will document vegetation change over time, highlighting the effects of the 2011 fire.

5.3 Park flora

5.3.1 Species observations

Over the course of this project, a total of 310 species were observed on plots (256 outside the monument, 218 in the main unit, and 32 in the TJ unit). An additional 39 were observed during polygon-scale data collection, for a total of 349 species. During field-data collection, three new species were identified and added to the park plant checklist (Table 5-1). A full list of species recorded during this project can be found Appendix F.

5.3.2 Rarity

Based on the rarity ranking system originally developed by The Nature Conservancy (now managed by NatureServe), we evaluated all

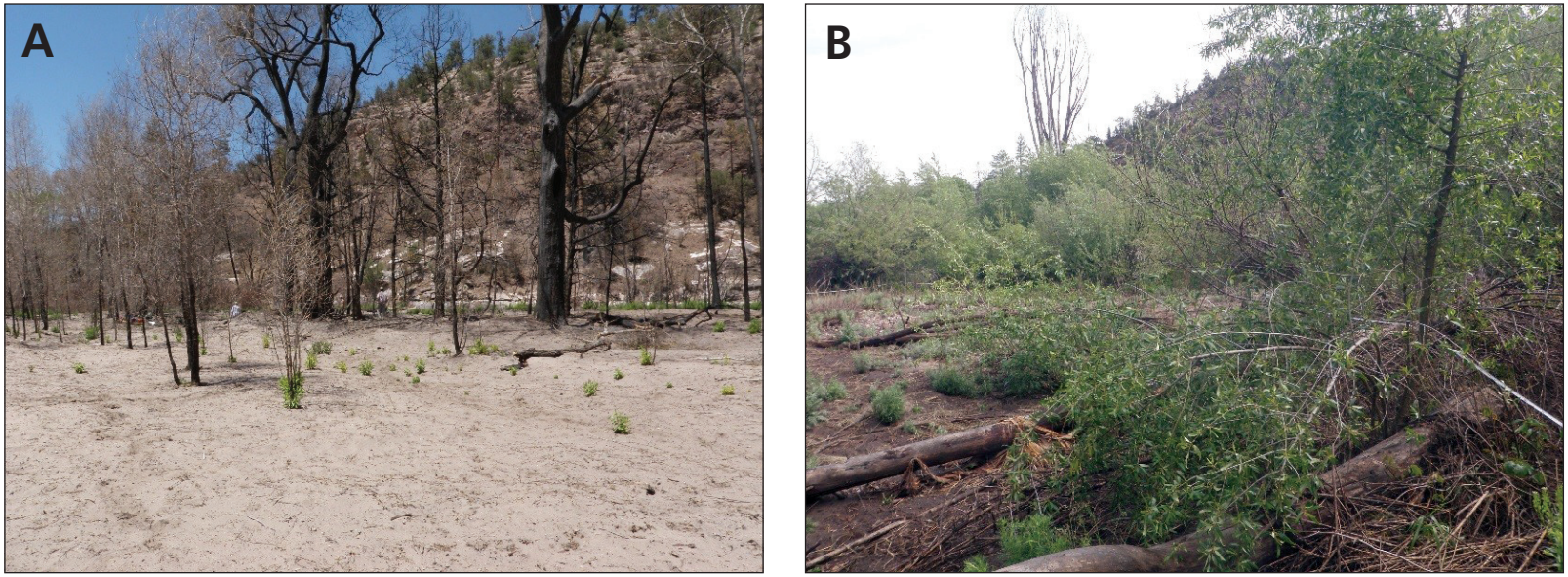


Figure 5-4. Cross-section F, density plot photo 2, June 24, 2011 (A) and June 2, 2017 (B).

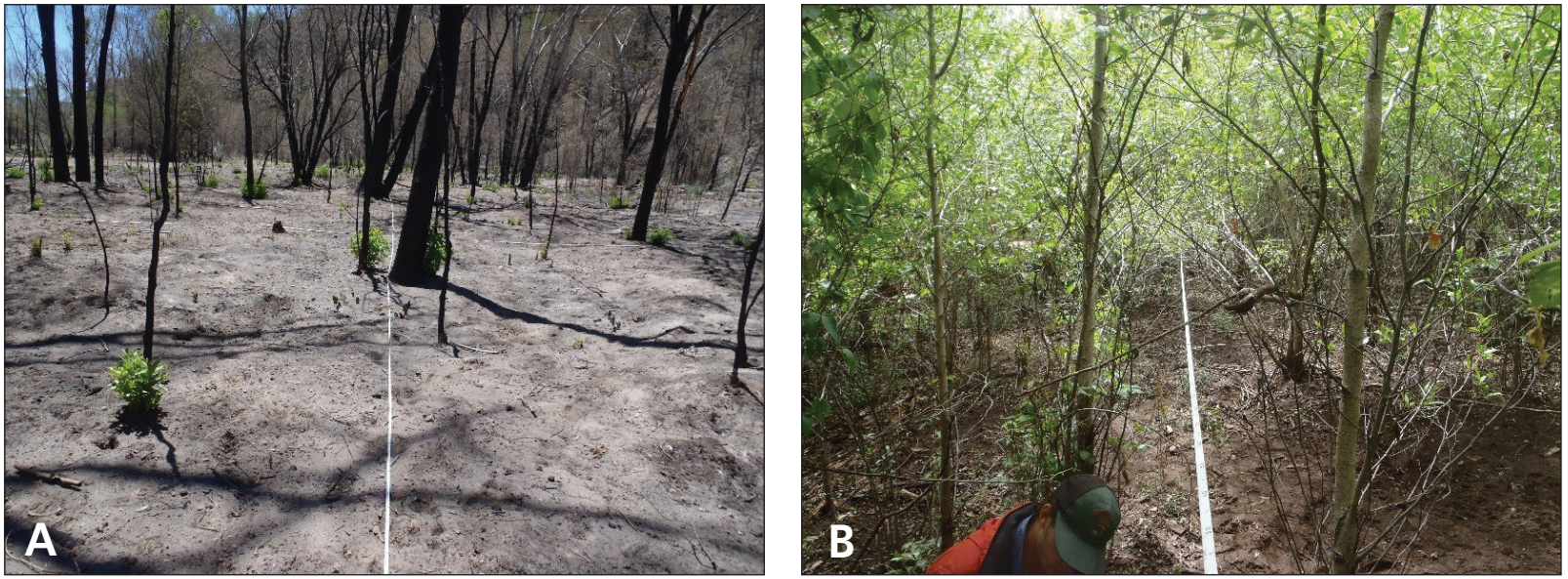


Figure 5-5. Cross-section G, plot 006, June 24, 2011 (A) and June 2, 2017 (B).

plants observed during this effort to see if any were considered rare or imperiled. The "global rank" describes each species's status globally and indicates the risk of extinction, with rank G1 being critically imperiled and G5 being secure. State ranks are also on a scale of 1–5, relative to distributions and abundances within state boundaries.

Fifteen species had a rank of G3 (Table 5-2), defined as "Vulnerable – At moderate risk of extinction due to a restricted range, relatively few populations, recent or widespread declines, or other factors" (natureserve.org). Of these, one species also had a comparable state ranking of S3. Two other species had a state ranking of S3 but a global ranking of G4 (defined as "Apparently secure"). These three species are listed first in the table. The remaining 12 species had state ranks of G3 but no state ranking. These are listed alphabetically by family then species. More details on these ranking systems are available from the NatureServe website, http://www.natureserve.org/biodiversity-science/publications/natureserve-conservation-status-assessments-methodology-assigning.

5.4 Final products and geodatabase delivery

Both spatial and tabular data collected during this project were input into a geodatabase designed to support relationships between the different data sources. This geodatabase contains all final map data, including photographs from plots and polygon locations, and pdf versions of the type descriptions. Each spatial feature in the database (points and polygons) can be selected such that data listing species and their associated cover classes is displayed. Searches can be performed both forward and backward in this format, so the user can browse data by species and see all the locations, or by location and see all the species. A description of the geodatabase structure and attachment formats is given in Appendix G.

All final products, including this report and the geodatabase, are available for download and viewing from the NPS data store (https://irma.nps.gov/Portal/) and the NPS Vegetation Mapping Inventory website (https://www.nps.gov/im/vegetation-inventory.htm). Spatial map data products can also be viewed in Internet Explorer (http://science.nature.nps.gov/ im/inventory/veg/mapviewer/mapviewer. html) by searching by park or geographic area. Data can also be requested direct from the SODN offices or accessed via the SODN website at https://www.nps.gov/im/sodn/inventories-assessments.htm.

Table 5-2. Species observed during project field work with either global or New Mexico state rarity rankings.

Scientific name	Common name	Family	Global rank/ State rank	Units
Draba mogollonica	Mogollon mountain draba	Brassicaceae	G3/S3	Location withheld
Aquilegia chrysantha	golden columbine	Ranunculaceae	G4/S3	Main unit
Penstemon virgatus	upright blue beardtongue	Plantaginaceae	G4/S3	Main unit
Brickellia floribunda	Chihuahuan brickellbush	Asteraceae	G3/SNR	Main unit; Project area
Brickellia rusbyi	stinking brickellbush	Asteraceae	G3/SNR	Project area
Hymenopappus mexicanus	Mexican woollywhite	Asteraceae	G3/SNR	Main unit; Project area
Stephanomeria thurberi	Thurber's wire-lettuce	Asteraceae	G3/SNR	Main unit
Alnus oblongifolia	Arizona alder	Betulaceae	G3/SNR	Main unit; Project area
Phaseolus ritensis	Santa Rita Mountain bean	Fabaceae	G3/SNR	Main unit; Project area
Hedeoma oblongifolia	oblong-leaf false pennyroyal	Lamiaceae	G3/SNR	Main unit; Project area
Oenothera neomexicana	New Mexico evening primrose	Onagraceae	G3/SNR	Main unit; Project area
Oxalis alpina	alpine wood-sorrel	Oxalidaceae	G3/SNR	Main unit; Project area
Ipomopsis macombii	Macomb's ipomopsis	Polemoniaceae	G3/SNR	Project area
Argyrochosma fendleri	Fendler's false cloak fern	Pteridaceae	G3/SNR	Project area
Galium fendleri	Fendler's bedstraw	Rubiaceae	G3/SNR	Main unit
Galium wrightii	Wright's bedstraw	Rubiaceae	G3/SNR	Main unit; Project area
Potentilla thurberi	scarlet cinquefoil	Rosaceae	G3/SNR	Main unit

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Appendix A. Exotic Plant Species

Table A-1. Exotic plant species documented during focused exotic plant early detection surveys, 2012 and 2013.

Family	Scientific name	Common name	Growth habit	Duration	2012	2013	Incidental
Amaranthaceae	*Salsola tragus*	prickly Russian thistle	Forb/Herb	Annual	✓	✓	✓
Asteraceae	*Lactuca serriola*	prickly lettuce	Forb/Herb	Annual	✓	✓	✓
Asteraceae	*Sonchus asper*	spiny sowthistle	Forb/Herb	Annual	✓	✓	✓
Asteraceae	*Taraxacum officinale*	common dandelion	Forb/Herb	Perennial	✓	✓	–
Asteraceae	*Tragopogon dubius*	yellow salsify	Forb/Herb	Annual	✓	✓	–
Brassicaceae	*Nasturtium officinale*	watercress	Forb/Herb	Perennial	✓	–	–
Chenopodiaceae	*Kochia scoparia*	Mexican-fireweed	Forb/Herb	Annual	–	✓	–
Convolvulaceae	*Ipomoea hederacea*	ivyleaf morning-glory	Vine	Annual	✓	–	–
Convolvulaceae	*Ipomoea purpurea*	tall morning-glory	Vine	Annual	–	✓	–
Crassulaceae	*Portulaca oleracea*	little hogweed	Forb/Herb	Annual	–	✓	–
Fabaceae	*Macroptilium gibbosifolium*	variableleaf bushbean	Forb/Herb	Perennial	✓	✓	–
Fabaceae	*Medicago lupulina*	black medick	Forb/Herb	Annual	✓	✓	–
Fabaceae	*Melilotus alba*	white sweetclover	Forb/Herb	Annual	✓	✓	–
Fabaceae	*Melilotus officinalis*	yellow sweetclover	Forb/Herb	Annual	✓	–	–
Fabaceae	*Trifolium repens*	white clover	Forb/Herb	Perennial	✓	–	–
Lamiaceae	*Marrubium vulgare*	horehound	Subshrub	Perennial	✓	✓	–
Lamiaceae	*Mentha spicata*	spearmint	Forb/Herb	Perennial	✓	–	–
Plantaginaceae	*Plantago major*	common plantain	Forb/Herb	Perennial	–	✓	–
Poaceae	*Agrostis stolonifera*	creeping bentgrass	Graminoid	Perennial	–	✓	–
Poaceae	*Bothriochloa ischaemum*	yellow bluestem	Graminoid	Perennial	–	✓	–
Poaceae	*Bromus inermis*	smooth brome	Graminoid	Perennial	✓	✓	–
Poaceae	*Bromus tectorum*	cheatgrass	Graminoid	Annual	✓	–	–
Poaceae	*Echinochloa crus-galli*	barnyardgrass	Graminoid	Annual	✓	–	–
Poaceae	*Eragrostis curvula*	weeping lovegrass	Graminoid	Perennial	✓	✓	–
Poaceae	*Hordeum murinum*	mouse barley	Graminoid	Annual	–	✓	–
Poaceae	*Poa pratensis*	Kentucky bluegrass	Graminoid	Perennial	–	✓	–
Poaceae	*Polypogon monspeliensis*	annual rabbitsfoot grass	Graminoid	Annual	✓	–	–
Poaceae	*Setaria viridis*	green bristlegrass	Graminoid	Annual	–	✓	–
Polygonaceae	*Polygonum convolvulus*	black bindweed	Vine	Annual	✓	✓	–
Polygonaceae	*Polygonum persicaria*	spotted ladysthumb	Forb/Herb	Annual	✓	–	–
Polygonaceae	*Rumex acetosella*	common sheep sorrel	Forb/Herb	Perennial	✓	–	–
Polygonaceae	*Rumex crispus*	curly dock	Forb/Herb	Perennial	✓	–	–
Scrophulariaceae	*Verbascum thapsus*	common mullein	Forb/Herb	Biennial	✓	✓	✓
Tamaricaceae	*Tamarix chinensis*	fivestamen tamarisk	Tree	Perennial	✓	✓	✓
Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	Vine	Perennial	✓	✓	–
Zygophyllaceae	*Tribulus terrestris*	punctureVine	Forb/Herb	Annual	✓	✓	–

Appendix B. Data Sheets

Sonoran Desert Network
Inventory and Monitoring Program

National Park Service
U.S. Department of the Interior

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USGS-NPS Vegetation Mapping Program Field Data Sheet: **Intermediate Plot Vegetation** Version: 0.054

Location and Event Information Proofread by: _____ Copied by: _____ Entered by: _____ Verified by: _____ Plot ID: _____

Park:	Sub-Map #:	Date (mm/dd/yyyy):		Plot ID:
Poly ID(s):		Field Poly ID:		Keyed Formation:
Observer(s):	Recorder:	Tentative Formation:		Protocol Name: VegMap
UTM NAD83: E 0 __ __ __ __ __ __ N __ __ __ __ __ __ __		____m Bearing:	____m Bearing:	Protocol Version: 0.05.3

List top three dominant species by stratum. Rank (R) 1=dominant or co-dominant, 2=second dominant, 3=least dominant.
Record species cover class (C) and average height (H, in meters to nearest tenth) by stratum. Record LF, lifeform (T or S).

1 = < 1% 2 = 1-5% 3 = 6-10% 4 = 11-25% 5 = 26-33% 6 = 34-50% 7 = 51-75% 8 = 76-95% 9 = 96-100%

Canopy >5m	LF	R	C	H	Canopy 2 – 5m	LF	R	C	H	Sub-canopy 0.5 – 2m	LF	R	C	Field 0 – 0.5m	R	C
Total Cover All Species					Total Cover All Spp					Total Cover All Spp				Total Cover All Spp		

List other common associates

_____	LF	C	H	_____	LF	C	Canopy 2 – 5m	LF	C	H	Sub-canopy 0.5 – 2m	LF	C	Field 0 – 0.5m	C	Field 0 – 0.5m	C

Association name: Use "—" within strata, "/" between strata and "( )" to denote minor species

If you find this datasheet completed, please call (520) 343-8845

Disturbance Types

Camera Name	IP Photo and Bearing	4 photos (N, E, S, W)

GPS Unit Name & HDOP

(X)	Plot Homogeneity
	Homogeneous
	Compositional trend
	Conspicuous inclusions
	Irregular
	Pattern mosaic

(X)	Stand Maturity
	Young/ regenerating
	Even age/ aggrading
	Mature/ even-age
	Transition/ break up
	Old growth/ senescent
	Uneven age
	Other:
	NA

NOTES: Describe the overall vegetative community, especially noting differences from other similar communities.

If you find this datasheet completed, please call (520) 343-8845

Sonoran Desert Network
Inventory and Monitoring Program

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U.S. Department of the Interior

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USGS-NPS Vegetation Mapping Program Field Data Sheet: **Intermediate Plot Soil/Landscape** Version: 0.05.4

Location and Event Information Proofread by: _____ Copied by: _____ Entered by: _____ Verified by: _____ Plot ID: _____

Park:	Sub-Map #:	Date (mm/dd/yyyy):	Plot ID:
Poly ID(s):		Field Poly ID:	Keyed Formation:
Observer(s):	Recorder:	Tentative Formation:	Protocol Name: VegMap
UTM NAD83: E 0 ___ ___ ___ ___ ___ ___		N ___ ___ ___ ___ ___ ___ ___	Protocol Version: 0.05.3

Soil/Landscape Parameters

#	Topographic Position (Rank all that apply)
	Crest/summit
	Shoulder
	Backslope
	Footslope
	Toeslope
	N/A
	Other:

#	Landform Rank all that apply
	Upper Alluvial Fan
	Lower Alluvial Fan
	Floodplain
	Alluvial Terrace
	Wash
	Arroyo
	Mountain
	Hill
	Colluvial Talus
	Outcrop
	Drainage (IFW/IFF)

Slope Class (Rank all that apply #)			
	0-1%		15 – 35%
	1-6%		35 – 50%
	6-15%		50+ %

Aspect (circle dominant aspect)

N NE E SE

S SW W NW

X	Parent Material (Select One)
	Intrusive Igneous Bedrock
	Extrusive Igneous Bedrock
	Volcanic Ash Bedrock
	Metamorphic Bedrock
	Non-calcareous sedimentary rock
	Calcareous sedimentary rock
	Colluvium
	Old Alluvium
	New Alluvium
	Aeolian - Windblown

Area Surface Cover (circle one class per feature)

Feature	Class				
Bare Soil	None	Sparse (<1-15%)	Medium (16-35%)	Common (36-60%)	Dominant (>60%)
Gravel: 2-75 mm	None	Sparse (<1-15%)	Medium (16-35%)	Common (36-60%)	Dominant (>60%)
Rock: 75 + mm	None	Sparse (<1-15%)	Medium (16-35%)	Common (36-60%)	Dominant (>60%)
Bedrock Outcrops	None	Sparse (<1-15%)	Medium (16-35%)	Common (36-60%)	Dominant (>60%)
Physical Crust	None	Sparse (<1-15%)	Medium (16-35%)	Common (36-60%)	Dominant (>60%)
Biological Crust	None	Sparse (<1-15%)	Medium (16-35%)	Common (36-60%)	Dominant (>60%)
Down Wood	None	Sparse (<1-15%)	Medium (16-35%)	Common (36-60%)	Dominant (>60%)
Litter	None	Sparse (<1-15%)	Medium (16-35%)	Common (36-60%)	Dominant (>60%)

Erosion Features (circle one class per feature)

Tunneling	None	Rare (<1 – 15%)	Common (16 – 60%)	Prolific (>60%)
Sheet	None	Rare (<1 – 15%)	Common (16 – 60%)	Prolific (>60%)
Rill	None	Rare (<1 – 15%)	Common (16 – 60%)	Prolific (>60%)
Gully	None	Rare (<1 – 15%)	Common (16 – 60%)	Prolific (>60%)
Pedestals	None	Rare (<1 – 15%)	Common (16 – 60%)	Prolific (>60%)
Terracettes	None	Rare (<1 – 15%)	Common (16 – 60%)	Prolific (>60%)
Burrowing	None	Rare (<1 – 15%)	Common (16 – 60%)	Prolific (>60%)
Wash	None	Rare (<1 – 15%)	Common (16 – 60%)	Prolific (>60%)

If you find this datasheet completed, please call (520) 343-8845

NOTES: 1) Write a short descriptive paragraph on the major soil type, slope position, and geomorphic features.
2) Sketch any soil or geologic features within the plot; *e.g.*, arroyos, changes in soils, rock outcrops.

Nail Location:

Appendix C. Plant Association Key

1a The community is characterized by dominant, mature and regenerating riparian trees and shrubs, often including narrowleaf cottonwood (*Populus angustifolia*), boxelder (*Acer negundo*), Arizona walnut (*Juglans major*) with dewystem willow (*Salix irrorata*) dominating the lower canopies. . . . . **(2)**

1b Vegetation not as above. . . . . **(3)**

2a The community is characterized by large, facultative riparian trees and shrubs, primarily dominated by narrowleaf cottonwood (*Populus angustifolia*) and dewystem willow (*Salix irrorata*). Arizona Alder (*Alnus oblongifolia*), Arizona walnut (*Juglans major*), and boxelder (*Acer negundo*) are patchy associate tree species. . . . . ***Populus angustifolia / Salix irrorata*** **Riparian Woodland**

2b The community is characterized by shrubby and regenerating, facultative riparian trees and shrubs, primarily dominated by Narrowleaf willow (*Populus angustifolia*) and dewystem willow (*Salix irrorata*). As a result of high severity fire effects, these species are vigorously regenerating in the sub-canopy and low canopy, forming dense thickets averaging 3m in height. Occasional mature trees survived the fire, but most are standing dead. Arizona Alder (*Alnus oblongifolia*), Arizona walnut (*Juglans major*), and boxelder (*Acer negundo*) are occasional, regenerating associates. . . . . **Regenerating *Populus angustifolia / Salix irrorata* Riparian Woodland**

3a The community is characterized by a sparse to moderately closed woodland/tree savanna dominated by twoneedle pinyon (*Pinus edulis*) and/or oneseed juniper (*Juniperus monosperma*), with a perennial grass layer of blue grama (*Bouteloua gracilis*). If present, ponderosa pine (*Pinus ponderosa*) provides only trace cover. . . . . **(4)**

3b Vegetation not as above. . . . . **(5)**

4a The community is characterized by a woodland dominated by twoneedle pinyon (*Pinus edulis*) and oneseed juniper (*Juniperus monosperma*), with one common associate, gray oak (*Quercus grisea*). Herbaceous cover is predominantly composed of blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), and mixed forbs. On the steeper and rockier exposed hill crests, alderleaf mountain mahogany (*Cercocarpus montanus*) may become a common associate. . . . . ***Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis*** **Open Woodland**

4b The community is characterized by a tree savanna dominated by perennial grass, mainly blue grama (*Bouteloua gracilis*), with a low-cover over story of twoneedle pinyon (*Pinus edulis*) and oneseed juniper (*Juniperus monosperma*). Alligator juniper (*Juniperus deppeana*) is often present as a common associate. . . . . ***Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis*** **Tree Savanna**

5a The community is characterized by a woodland/forest dominated by mature ponderosa pine (*Pinus ponderosa*) and/or Douglas fir (*Pseudotsuga menziesii*). . . . . **(6)**

5b Vegetation not as above. . . . . **(7)**

6a The community is characterized by a woodland/forest dominated by ponderosa pine (*Pinus ponderosa*) with patchy and low-cover, shrub to tree-like gray oak (*Quercus grisea*) in the understory. Douglas fir (*Pseudotsuga menziesii*) may be present, but shouldn't provide more than a few percent cover, and is never a dominant. . . . . ***Pinus ponderosa*** **Woodland and Tree Savanna**

6b The community is characterized by a woodland/forest co-dominated by Douglas fir (*Pseudotsuga menziesii*) and Gambel's oak (*Quercus gambelii*), with common associates Rocky mountain juniper (*Juniperus scopulorum*) and ponderosa pine (*Pinus ponderosa*). Near canyon exits or on the outskirts of the riparian zone, cover of other trees, such as, narrowleaf cottonwood (*Populus angustifolia*), Arizona walnut (*Juglans major*), and

boxelder (*Acer negundo*) may increase and provide local dominance……..***Pseudotsuga menziesii - Quercus gambelii*** **Forest**

7a The community is characterized by perennial vegetation dominated by shrubs (can be very low cover), with or without scattered trees……..... **(8)**

7b The community is characterized by dominant herbaceous species, annual and perennial, with or without scattered trees or low shrubs……....**(14)**

8a The community is characterized by a shrubland dominated by low-cover, resprouting gray oak (*Quercus grisea*), with either sparse herbaceous cover or moderate perennial grass cover…..**(9)**

8b Vegetation not as above…….. **(10)**

9a The community is characterized by a shrub layer dominated by low-cover, regenerating gray oak (*Quercus grisea*) that was recently subjected to high fire severity. Typically, tree mortality in the canopy layers is at or close to 100%, with standing blackened snags a unifying feature. Carruth's sagewort (*Artemisia carruthii*), Colorado four o'clock (*Mirabilis multiflora*), and blue grama (*Bouteloua gracilis*) are associate that may provide patches of local dominance……....***Quercus grisea / Sphaeralcea fendleri*** **Post-fire Shrubland and Herbaceous**

9b The community is characterized by a shrub layer dominated by low-cover, regenerating gray oak (*Quercus grisea*) with common associates tarragon (*Artemisia dracunculus*) and Fendler's globemallow (S*phaeralcea fendleri*), as well as, a field layer dominated by perennial grasses……..…..***Quercus grisea / M*****ixed Perennial Grass (*Artemisia dracunculus)* Post-fire Shrubland & Herbaceous**

10a The community is characterized by a shrubland dominated by rubber rabbitbrush (*Ericameria nauseosa*) or New Mexico locust (*Robinia neomexicana*)*;* usually in or adjacent to riparian habitats or canyon mouths ……..**(11)**

10b Vegetation not as above……....**(12)**

11a The community is characterized by a shrubland dominated by rubber rabbitbrush (*Ericameria nauseosa*). Tarragon (*Artemisia dranunculus*) is often but not consistently the sub-dominant species, preferring the sandier areas and dry wash side channels. Following flood events, these areas may be scoured of vegetation……..***Ericameria nauseosa*** **Shrubland**

11b The community is characterized by a shrubland dominated by New Mexico Locust (*Robinia neomexicana*), usually on N/NE facing hills. Canyon grape *Vitis arizonica* and common hop (*Humulus lupulus*) vines are common……..***Robinia neomexicana*** **Shrubland**

12a The community is characterized by a sparse rock outcrop dominated by bedrock and patchy, low-cover alderleaf mountain mahogany (*Cercocarpus montanus*)……***Cercocarpus montanus Shrubby Rock Outcrop***

12b Vegetation not as above. **(13)**

13a The community is characterized by a shrubland dominated by fourwing saltbush (*Atriplex canescens*)……..…….***Atriplex canescens*** **Shrubland**

13b The community is characterized by a shrub savanna dominated by low cover, resprouting Gambel's oak (*Quercus gambelii*) with resprouting gray oak (*Quercus grisea*) as a common associate……....……..***Quercus gambelii (Quercus grisea)*** **Shrubland and Shrub Savanna**

14a The community is characterized by an herbaceous layer dominated by blue grama (*Bouteloua gracilis*). Tree and shrub species are present on outskirts of these areas, usually with less than 2% cover……..…….***Bouteloua gracilis*** **Grassland**

14b Vegetation not as above……..**15**

15a The community is characterized by an herbaceous layer dominated by annual forbs with patchy blue grama (*Bouteloua gracilis*). Annual species vary based on the season and weather conditions, but typically consists of flatspine burr ragweed (*Ambrosia acanthicarpa*), carelessweed (*Amaranthus palmeri*), golden crownbeard (*Verbesina encelioides*), Prickly Russian thistle *(Salsola tragus*), and melonleaf nightshade (*Solanum heterodoxum*)…….. ……..**Annual Forb - Mixed *Bouteloua* spp. Herbaceous**

15b The community is characterized by an herbaceous layer dominated by sand dropseed (*Sporobolus cryptandrus*), Fendler's globemallow (*Sphaeralcea fendleri*), and annual forbs. Dominance switches between these species/lifeform across the different examples of this type and may include common associates golden crownbeard (*Verbesina encelioides*), blue grama (*Bouteloua gracilis*), and tarragon (*Artemisia dracunculus*)……..**Post-fire Riparian Mixed Herbaceous**

Appendix D. Vegetation Type Descriptions

This appendix includes information on the 16 vegetation types that were identified and mapped at Gila Cliff Dwellings National Monument (NM) between 2012 and 2013. All information not identified as specific to Gila Cliff Dwellings NM was collected from NatureServe Explorer (http://www.natureserve.org/explorer/) or from the U.S. National Vegetation Classification website, http://usnvc.org/. This includes the NatureServe or USNVC codes, global descriptions, vegetation hierarchy, ecological systems placement, and references.

Woodands/Forests/Tree Savannas

1. *Pinus ponderosa* Woodland and Tree Savanna Association (P)
2. *Pseudotsuga menziesii - Quercus gambelii* Forest Association
3. *Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis* Tree Savanna Association (P)
4. *Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Open Woodland Association
5. *Populus angustifolia / Salix irrorata* Riparian Woodland Association
6. Regenerating *Populus angustifolia / Salix irrorata* Riparian Woodland Association (PS)

Shrublands and Shrub Savannas

7. *Atriplex canescens* Shrubland Association
8. *Cercocarpus montanus* Shrubby Rock Outcrop Association (P)
9. *Ericameria nauseosa* Shrubland Association
10. *Quercus gambelii* (*Quercus grisea*) Shrubland and Shrub Savanna Association (PS)
11. *Quercus grisea* / Mixed Perennial Grass (*Artemisia dracunculus)* Post-Fire Shrubland and Herbaceous Association (P)
12. *Quercus grisea / Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous Association (P)
13. *Robinia neomexicana* Shrubland Association (P)

Herbaceous

14. Annual Forb - Mixed *Bouteloua* spp. Herbaceous Association (PS)
15. Post-fire Riparian Mixed Herbaceous Association (PS)
16. *Bouteloua gracilis* Grassland Association

1. *Pinus ponderosa* Woodland and Tree Savanna Association (P)

Translated name: Ponderosa pine Woodland and Tree Savanna Association (P)
NVC name: Not available
Identifier: NPSSODN036

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Alliance: Southern Rocky Mountain Ponderosa Pine / Grass Open Woodland [A3419]
Association: *Pinus ponderosa* Woodland and Tree Savanna

DISTRIBUTION

Gila Cliff Dwellings National Monument

This woodland occurs on steep- to moderate-gradient, generally north- to northwest-facing backslopes, toeslopes, and along steep-walled drainages. The largest and most characteristic stands are located on the expansive, north-facing slopes south of the Gila River and west of Cliff Dweller Canyon. Areas north of the river are generally smaller and found more commonly on steep, north- and northwest-facing drainage walls.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This association occurs on steep (25–55%), generally north- to northwest-facing backslopes, down onto toeslopes where the hills meet the greater floodplain, and along steep-walled drainages. This association is present from 1,676 to 1,828 m (5,500–6,000 ft). The ground surface is characterized by dominant bare soil and gravel cover, with occasional areas of dense pine litter where fire severity was low.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This association is found across the mapping area in multiple forms, as it is seen to intergrade strongly with other associations, forming ecotonal gradients. Overall, this woodland association is characterized by 10–33% total upper-canopy tree cover, dominated by ponderosa pine (*Pinus ponderosa*) ranging in cover from 15% to 28%. Tree height for this species is variable, ranging from 12 to 24 m tall and averaging 15.5 m.

On toeslopes and footslopes, these woodlands are predominantly pure stands of ponderosa pine (*P. ponderosa*) with cover averaging to 25%, and scattered, tree-like gray oak (*Quercus grisea*). In areas disturbed by the Miller Fire, gray oak (*Q. grisea*) is regenerating in the understory layers as a shrub. Herbaceous cover varies across these stands, ranging from 10% to 30%, dominated by perennial grasses sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), and sand dropseed (*Sporobolus cryptandrus*), and subshrubs dwarf stickpea (*Calliandra humilis*), Wright's deervetch (*Lotus wrightii*), and tarragon (*Artemisia dracunculus*) mixing and combining in patchwork. In these more-expansive, lower-gradient areas, other trees are considered accidental and are usually very low in cover. Shrubs other than re-sprouting gray oak (*Q. grisea*) and succulents are rare.

In areas where this association is restricted to drainages and their adjacent slopes, it typically occupies the west- or northwest-facing, steep backslopes. Rocky Mountain juniper (*Juniperus scopulorum*) can be a common associate, ranging in cover from 5% to 11% and occasionally becoming a second dominant. Douglas fir (*Pseudotsuga menziesii*) may also infrequently appear, standing 9–12 m tall with only 1–2% cover, mainly occupying secondary drainages and concave inclusions. Gray oak (*Q. grisea*) is occasional, often as a mature tree, with up to 7% cover and heights of 2.5–6 m. Other common but occasional understory species include common hoptree (*Ptelea trifoliata*), Carruth's sagewort (*Artemisia carruthii*), and New Mexico locust (*Robinia neomexicana*). The herbaceous community has no clear dominant, but blue grama (*B. gracilis*), sideoats grama (*B. curtipendula*), and muttongrass

(*Poa fendleriana*) are the most common. Shrub-layer cover is generally low, averaging about 4%.

This association can also be seen on steep slopes (35–50%) above drainages bordering pinyon-juniper woodlands, where two-needle pinyon (*Pinus edulis*), alligator juniper (*Juniperus deppeana*), oneseed juniper (*Juniperus monosperma*), and gray oak (*Q. grisea*) become more common and intergrade with the ponderosa pine (*P. ponderosa*) to become co-dominant in the lower canopy layers. These species are usually accidental in this type, but increase with proximity to and influence of these neighboring pinyon-juniper communities. Cover of these species ranges from 2% to 6%, with heights normally below 5 m, but two-needle pinyon (*P. edulis*) and gray oak (*Q. grisea*) occasionally reach 7 m. The herbaceous layer is characterized by a 10–30%, diverse cover of perennial grasses and forbs, including blue grama (*B. gracilis*), sideoats grama *(B. curtipendula*), muttongrass (*P. fendleriana*), and deergrass (*Muhlenbergia rigens*). Ground cover is sparse, with lots of bare ground, litter, and rock with relatively unstable soils.

At times, this association may present as a tree savanna, defined by decreased ponderosa pine (*P. ponderosa*) cover with a more consistent and pronounced perennial grass layer, mainly dominated by blue grama (*B. gracilis*). These areas appear to be the result of a complex fire and grazing history. Overall species composition is consistent across both the woodland and tree savanna variations, but cover values are noticeably different. These areas tend to occupy low angle-to-flat toeslopes.

This association was variably disturbed by the 2011 Miller Fire, with some areas showing substantial canopy mortality and others only field-layer damage. Where gray oak (*Q. grisea*) was present and burned, it is commonly re-sprouting from the base, providing trace amounts of subcanopy cover.

GLOBAL TYPE CONCEPT DESCRIPTION

This association is thought by the authors to fall under the *Pinus ponderosa* / Grass Understory Southern Rocky Mountain Open Woodland Alliance [A3419]. However, it does not match exactly to any of the currently described associations, and more classification work is needed to expand the range. At the alliance level, it is described as follows:

> These woodlands are characterized by widely spaced canopies primarily dominated by *Pinus ponderosa* in association with other conifers, including *Juniperus* spp., *Pinus discolor, Pinus edulis*, and *Pseudotsuga menziesii*. The typically moderately dense herbaceous layer has greater cover than the shrub layer and is dominated by graminoids. The most common dominant graminoids include *Andropogon gerardii, Bouteloua gracilis, Festuca arizonica, Muhlenbergia montana, Muhlenbergia virescens*, and *Schizachyrium scoparium*. These woodlands occur from the central and southern Rocky Mountains, extending south to the mountains of western Texas, escarpments of the Great Plains and west to the Mogollon Rim and Colorado Plateau. Stands occur on bottomlands, elevated plains, cinder cones, piedmont slopes, mesas, foothills, and mountains at elevations ranging from 1700-2900 m.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Pinus ponderosa*
Canopy (2–5 m)	*Quercus grisea*
Subcanopy (0.5–2 m)	*Quercus grisea*
Field (0–0.5 m)	*Bouteloua gracilis*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Juniperus scopulorum, Quercus gambelii*
Canopy (2–5 m)	*Juniperus monosperma, Pinus edulis*
Subcanopy (0.5–2 m)	*Sphaeralcea fendleri, Robinia neomexicana*
Field (0–0.5 m)	*Bouteloua curtipendula, Poa fendleriana, Muhlenbergia rigens*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This association is similar to a few described types present in the greater Gila Wilderness Area, including *Pinus ponderosa* / *Poa fendleriana* Woodland (CEGL005507), *Pinus ponderosa* / *Bouteloua gracilis* Woodland (CEGL000848), and *Pinus ponderosa* / Sparse Understory Woodland (CEGL002384). This association differs from the first two, high-confidence associations by not having a consistent herbaceous dominant. Although both muttongrass (*P. fendleriana*) and blue grama (*B. gracilis*) are present in this association, they provide little cover and are not dominant in any of the polygons. This is possibly a result of recent disturbance from the 2011 Miller Fire.

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP011, IP018, IP026, IP040, IP045, IP049, IP050, IP197
Gila Cliff Dwellings National Monument, Polygons: 24 polygons
Local Description Authors: J. Galvin, S. Studd

2. *Pseudotsuga menziesii - Quercus gambelii* Forest Association

Translated name: Douglas fir - Gambel oak Forest Association
NVC name: CEGL000452
Identifier: N/A

NVC CLASSIFICATION

Division:	Rocky Mountain Forest & Woodland [1.B.2.Nb]
Macrogroup:	Southern Rocky Mountain Lower Montane Forest [M022]
Group:	Southern Rocky Mountain White Fir - Douglas-fir Dry Forest [G226]
Association:	*Pseudotsuga menziesii - Quercus gambelii* Forest [CEGL000452]

DISTRIBUTION

Gila Cliff Dwellings National Monument

This type is found in deep canyon drainages at Gila Cliff Dwellings National Monument, primarily Cliff Dweller canyon and its tributaries. It can also be seen growing on north- or northwest-facing slopes above minor drainages throughout the mapping area.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This community is found growing in deep canyon drainages that have a generally northeast flow direction, and opposing southeast- and northwest-facing canyon hillsides. Elevation ranges from 1,737 to 1,830 m (5,700–6,000 ft). The drainages are relatively low gradient, and the type occurs predominantly on the toeslopes and footslopes, surrounding sandy-bottomed drainage courses. Bedrock outcrops are common higher on the slopes and in some instances signal the shift to a different community.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This type can be highly variable, depending on slope position and location in the canyon system. In deep drainages of the canyon reach, the *Pseudotsuga menziesii - Quercus gambelii* variant of this type dominates, but where it occupies more shallow sections or further up the canyon, ponderosa pine (*Pinus ponderosa*) becomes dominant and Douglas fir (*Pseudotsuga menziesii*, Gambel oak (*Q. gambelii*), and Rocky Mountain juniper (*Juniperus scopulorum*) are reduced to associates. Both variants are described below.

This forest community is characterized by an upper tree canopy co-dominated by Douglas fir (*P. menziesii*) and Gambel oak (*Q. gambelii*), with common associates Rocky mountain juniper (*J. scopulorum*) and ponderosa pine (*P. ponderosa*). Total cover of the canopy (>5) species varies between 25% and 60%, with lower canopy (2–5 m) being more sparse and often absent. Understory vegetation cover of both shrubs and herbaceous species is usually around 20% combined, but can be upwards of 45% in areas that either support more shrubs or are vigorously re-sprouting in response to the 2011 Miller Fire. Gambel oak (*Quercus gambelii*) reaches heights of up to 14 m but is generally around 8 m tall. It can range in cover from 8% to 45% but is most commonly seen between 12% and 20%. Douglas fir (*P. menziesii*) ranges from 12 to 25 m, and are mostly large, canopied, mature individuals rising above the gray oak (*Quercus grisea*) subcanopy. These large trees occupy 10–30% of the canopy. Both of the common tree associates, Rocky mountain juniper (*J. scopulorum*) and ponderosa pine (*P. ponderosa*), are consistently present in all but a few of the plots sampled, and cover can be quite high. Rocky mountain juniper (*J. scopulorum*) averages 10 m tall, with cover between 3% and 10%. Ponderosa pine (*P. ponderosa*) heights match those of the fir, averaging 19 m with a range of 16–27 m, and cover fluctuating from 2% to 30%. These drainages are ephemeral and do not have a great number of springs or pool systems. However, they are narrow and deep enough to provide plentiful shade, rich understory diversity, and duff and soil development.

Muttongrass (*Poa fendleriana*) and canyon grape (*Vitis arizonica*) are the two most common species in the field

layer, at times being dominant, but with only ever a few percent cover. Annual forbs and common mullein (*Verbascum thapsus*) are also a consistent part of the communities. Common forbs and grasses, each usually having less than 1% cover, include Fendler's globemallow (*Sphaeralcea fendleri*), mock-pennyroyal (*Hedeoma nana*), alpine woodsorrel (*Oxalis alpina*), Bigelow's tansyaster (*Dieteria bigelovii*), Arizona brome (*Bromus carinatus*), Wright's deervetch (*Lotus wrightii*), manyflower stickseed (*Hackelia floribunda*), New Mexico evening primrose (*Oenothera neomexicana*), pineywoods geranium (*Geranium caespitosum*), poison oak (*Toxicodendron diversilobum*) and scrambled eggs (*Corydalis aureum*). Other common associates include the shrubs/subshrubs Fendler's meadow-rue (*Thalictrum fendleri*), New Mexico locust (*Robinia neomexicana*), tasselflower brickellbush (*Brickellia grandiflora*) and plumed brickellbush (*B. brachyphylla*), and less commonly occurring stretchberry (*Forestiera pubescens*), beechleaf frangula (*Frangula betulifolia*), and the occasional black cherry tree (*Prunus serotina*).

Where these communities reach the canyon exits at the outskirts of the riparian zone and broader floodplain, other species typically associated with riparian systems are observed in moderate (but sometimes high) numbers, such as narrowleaf cottonwood (*Populus angustifolia*), Arizona walnut (*Juglans major*), boxelder (*Acer negundo*), and velvet ash *(Fraxinus velutina*). Arizona walnut (*J. major*) is the most common of these species and may be locally dominant. This species grows in both the upper canopy, providing cover around 7% with heights up to 8 m, and also in the lower canopy, in trace amounts below 4 m tall. Common understory species in these more mesic sections include Fendler's meadowrue (*T. fendleri*), canyon grape (*V. arizonica*), beechleaf frangula (*F. betulifolia*), New Mexico locust (*R. neomexicana*), tarragon (*Artemisia dracunculus*), and Wright's goldenrod (*Solidago wrightii*).

When this type occupies drier sites, higher on the north-facing backslopes above the drainage, ponderosa pine (*P. ponderosa*) may become the dominant canopy tree, contributing cover ranging from 12% to 23%. In these areas, Douglas fir (*P. menziesii*) is either co-dominant or subdominant to ponderosa pine (*P. ponderosa*), with cover around 15%. On average, heights for both species are lower on these backslopes range from 12 to 16 m. Abundance of Gambel oak (*Q. gambelii*) and Rocky Mountain juniper (*J. scopulorum*) is much lower in these areas, averaging only 4% and 3% cover, respectively. This variant can intergrade with the *Pinus ponderosa* Woodland and Tree Savanna Association, especially when it's adjacent to large backslopes. These two associations are closely related and both have ecotonal expressions or inclusions that may seem hard to distinguish.

GLOBAL TYPE CONCEPT DESCRIPTION

Information from NatureServe:

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

Koeleria macrantha, *Muhlenbergia straminea (= Muhlenbergia virescens)*, *Poa fendleriana*, *Lathyrus lanszwertii* var. *leucanthus*, *Thalictrum fendleri*, and *Vicia americana*. The shrub layer has equal or greater cover than graminoids.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Quercus gambelii, Pseudotsuga menziesii, Juniperus scopulorum, Pinus ponderosa*
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Quercus gambelii, Verbascum thapsus, Thalictrum fendleri*
Field (0–0.5 m)	*Vitus arizonica, Poa fendleriana*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Juglans major*, *Acer negundo*
Canopy (2–5 m)	*Fraxinus velutina*
Subcanopy (0.5–2 m)	*Robinia neomexicana*
Field (0–0.5 m)	*Sphaeralcea fendleri*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This type has been described solely from data collected at Gila Cliff Dwellings NM during this project. This includes 17 polygons and 17 classification plots.

Global

Data not available.

Classification confidence: High
NatureServe conservation status: Data not available
Global status: G5
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP001, IP002, IP005, IP013, IP016, IP017, IP029, IP031, IP042, IP043, IP065, IP070, IP124, IP125, IP154
Gila Cliff Dwellings National Monument, Polygons: 17 polygons
Local Description Authors: J. Galvin, S. Studd
Global Description Citation: K.A. Shultz. 2010. *Pseudotsuga menziesii–Quercus gambelii* Forest, 21May2010. United States National Vegetation Classification. Federal Geographic Data Committee, Washington, D.C. Accessed 09/26/2018.

3. *Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis* Tree Savanna Association (P)

Translated name: Two-needle pinyon - Oneseed juniper (Gray oak) / Blue grama Tree Savanna Association (P)
NVC name: Not available
Identifier: NPSSODN087

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis* Tree Savanna (P)

DISTRIBUTION

Gila Cliff Dwellings National Monument

This widespread type occurs across all hillslopes in the large local area. Within the mapping area, it is restricted to the upper backslopes, shoulders, crests, and summits of the mesas.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This woodland type spans large areas, often covering and wrapping around entire hilltops. Elevation ranges from approximately 1,700 to 1,920 m (5,600–6,300 ft). Typically, these communities are found on predominantly west-, southwest-, and southeast-facing slopes. Often, these areas are drier, rockier, and have poorly developed soils. This type intergrades with other communities present on backslopes and in drainages.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This tree-savanna association is characterized by a sparse tree canopy (5–15 [20]%), co-dominated by oneseed juniper (*Juniperus monosperma*) and two-needle pinyon (*Pinus edulis*), with two common associates, gray oak (*Quercus grisea*) and alligator juniper (*Juniperus deppeana*), and an herbaceous stratum (<0.5) dominated by blue grama (*Bouteloua gracilis*). In all examples of this variation, oneseed juniper (*J. monosperma*) is the clear canopy dominant, with cover averaging to 9%, compared to only 5% for two-needle pinyon (*P. edulis*). Gray oak (*Q. grisea*) and alligator juniper (*J. deppeana*) are common associates, providing an average of 3–4% cover each. Tree heights are quite consistent across both the woodland and tree savanna variations.

The shrub layer is normally not well developed, with individuals scattered or growing beneath taller trees, and rarely providing much more than 3% cover.

The herbaceous layer is characterized by a matrix of bunchgrasses primarily dominated by blue grama (*B. gracilis*), which provides a consistent cover that typically ranges from 20% to 30%, with some areas reaching up to 50%. Other contributing bunchgrasses include bristly wolfstail (*Muhlenbergia alopecuroides*), sideoats grama (*Bouteloua curtipendula*), spidergrass (*Aristida ternipes*), squirreltail (*Elymus elymoides*), and hairy grama (*Bouteloua hirsuta*). Overall, the combined cover of perennial grasses is greater than that of trees, often by a wide margin (≥10%). Other noteworthy field components include little hogweed (*Portulaca oleracea*), Fendler's globemallow (*Sphaeralcea fendleri*), Colorado four o'clock (*Mirabilis multiflora*), and bastardsage (*Eriogonum wrightii*).

This is a variable community at Gila Cliff Dwellings NM—partly due to environmental constraints, such as aspect, elevation and slope position, but also due to the effects of the 2011 Miller Fire. Where fire burned severely, much of the canopy cover was completely consumed, leaving only blackened stems. Oneseed juniper (*J. monosperma*) were particularly badly affected, as their low, dense branches allowed fire to frequently consume all aboveground biomass, leaving only a blackened circle of soil. Neither two-needle pinyon (*P. edulis*) nor juniper (*Juniperus* spp.)

readily sprouts from root stock after severe burns and will usually only recolonize from seed, whereas gray oak (*Q. grisea*), an associate throughout this type, sprouts readily post-fire.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Pinus edulis, Juniperus monosperma, Quercus grisea*
Canopy (2–5 m)	*Pinus edulis, Juniperus monosperma, Quercus grisea*
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	*Bouteloua gracilis, Bouteloua curtipendula*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Juniperus deppeana*
Canopy (2–5 m)	*Juniperus deppeana*
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	*Aristida ternipes, Elymus elymoides, Bouteloua hirsuta, Portulaca oleracea, Sphaeralcea fendleri, Mirabilis multiflora, Eriogonum wrightii*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This association was described from one classification plot and seven classification polygons. This association is similar to another described woodland community that was placed within an accepted NVC association, *Pinus edulis* - (*Juniperus monosperma*, *Juniperus deppeana*) / *Bouteloua gracilis* Open Woodland Association (CEGL002151). While they exhibit very similar species composition and a broad gradient exists between them, we decided to maintain them as separate associations based on formation (woodland vs. tree savanna).

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP190
Gila Cliff Dwellings National Monument, Polygons: 7 polygons
Local Description Authors: J. Galvin, S. Studd

4. *Pinus edulis - (Juniperus monosperma, Juniperus deppeana) / Bouteloua gracilis* Open Woodland Association

Translated name: Two-needle pinyon - (Oneseed juniper, Alligator juniper) / Blue grama Open Woodland Association
NVC name: CEGL002151
Identifier: N/A

NVC CLASSIFICATION

Division:	*Western North American Pinyon - Juniper Woodland & Scrub* [1.B.2.Nc]
Macrogroup:	Southern Rocky Mountain-Colorado Plateau Two-needle Pinyon - Juniper Woodland [M027]
Group:	Southern Rocky Mountain Pinyon-Juniper Woodland [G253]
Alliance:	Two-needle Pinyon- One-seed Juniper / Herbaceous understory Open Woodland [A3577]
Association: [CEGL002151]	*Pinus edulis* - (*Juniperus monosperma, Juniperus deppeana*) / *Bouteloua gracilis* Open Woodland

DISTRIBUTION

Gila Cliff Dwellings National Monument

This widespread type occurs across all hillslopes in the large local area. Within the mapping area, it is restricted to the upper backslopes, shoulders, crests, and summits of the mesas.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This woodland type spans large areas, often covering and wrapping around entire hilltops. Elevation ranges from approximately 1,700 to 1,920 m (5,600–6,300 ft). Typically, these communities are found on predominantly west-, southwest-, and southeast-facing slopes. Often, these areas are drier, rockier, and have poorly developed soils. This type intergrades with other communities present on backslopes and in drainages.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This woodland association is characterized by a moderately dense tree canopy (15–47%), co-dominated by two-needle pinyon (*Pinus edulis*) and oneseed juniper (*Juniperus monosperma*), with one common associate, gray oak (*Quercus grisea*), and an herbaceous stratum (<0.5) dominated by blue grama (*Bouteloua gracilis*). The dominant canopy trees, two-needle pinyon (*P. edulis*) and oneseed juniper (*J. monosperma*), both provide an average of 11% cover throughout the community, with values ranging above 30%. Tree heights vary, with two-needle pinyon ranging from 6 to 12 m tall and averaging to 8 m. Oneseed juniper is shorter, averaging 5 m and rarely over 6 m. Gray oak (*Q. grisea*) is a common associate, providing an average of 7% cover and growing as a tree up to 6 m (average of 4 m) and occasionally as a shrub with heights less than 2 m. Other trees, such as ponderosa pine (*Pinus ponderosa*), alligator juniper (*Juniperus deppeana),* and Rocky Mountain juniper (*Juniperus scopulorum*) are occasional, rarely covering more than 1 or 2%. Blue grama (*B. gracilis*) provides variable cover in the field stratum, with values ranging up to 18%, but averaging to only 5%. On occasion, sideoats grama (*Bouteloua curtipendula*) can appear co-dominant or even provide more cover than blue grama (*B. gracilis*), but not consistently across the landscape.

Ponderosa pine (*P. ponderosa*) is most common on north/northwest and west aspects, especially above steep drainages and at canyon mouths. These are most often tall, mature individuals with heights averaging to 12 m and cover <1%, but occasionally up to 8%. As with all ecotonal areas, some expressions of this association are pure mixes between communities. Woodlands dominated by ponderosa pine (*P. ponderosa*), Douglas fir (*Pseudotsuga menziesii*), and/or Gambel oak (*Quercus gambelii*) can occasionally intergrade with this association or appear as small inclusions.

The shrub layer is normally not well developed, with individuals scattered or growing beneath taller trees, and rarely providing much more than 3% cover. However, on the steeper, rockier, exposed hillcrests, alderleaf mountain mahogany (*Cercocarpus montanus*) can provide a few percent cover (up to 10%). Often, when this species is present, especially on western aspects, cover of Wright's silktassel (*Garrya wrightii*) and shrubby gray oak (*Q. grisea*) tends to increase. As these shrubs increase, blue grama (*B. gracilis*) tends to drop out and other grasses, such as cliff muhly (*Muhlenbergia polycaulis*), start to appear. Other shrubs that may be present in low abundance include Apache plume (*Fallugia paradoxa*), banana yucca (*Yucca baccata*), dwarf stickpea (*Calliandra humilis*), bastardsage (*Eriogonum wrightii*), tulip prickly pear (*Opuntia phaeacantha*), walking stick cactus (*Opuntia spinosior*), plumed brickellbush (*Brickellia brachyphylla*), white sagebrush (*Artemisia ludoviciana*), Carruth's sagewort (*Artemisia carruthii*), threadleaf snakeweed (*Gutierrezia microcephala*), and kingcup cactus (*Echinocereus triglochidiatus*). Forbs have low cover in this type, with no clear dominants or diagnostic species.

The field stratum is characterized by the presence and occasional dominance of blue grama (*B. gracilis*), with a mix of associate perennial grasses. Blue grama (*B. gracilis*) provides highly variable cover, with average cover around 5%, and uncommon instances of cover up to 18%. On occasion, sideoats grama (*B. curtipendula*) can appear co-dominant or even provide more cover than blue grama (*B. gracilis*), but not consistently across the landscape. Other documented field associates include muttongrass (*Poa fendleriana*), Carruth's sagewort (*A. carruthii*), plumed brickellbush (*B. brachyphylla*), and Fendler's globemallow (*Sphaeralcea fendleri*).

GLOBAL TYPE CONCEPT DESCRIPTION

Information from NatureServe:

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

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Pinus edulis, Juniperus monosperma, Quercus grisea*
Canopy (2–5 m)	*Pinus edulis, Juniperus monosperma, Quercus grisea*
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	*Bouteloua gracilis, Bouteloua curtipendula*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Juniperus scopulorum, Pinus ponderosa, Juniperus deppeana*
Canopy (2–5 m)	*Juniperus deppeana, Juniperus scopulorum*
Subcanopy (0.5–2 m)	*Cercocarpus montanus, Garrya wrightii*
Field (0–0.5 m)	*Poa fendleriana, Artemisia carruthii, Brickellia brachyphylla, Sphaeralcea fendleri*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

The local description for this association was described from 23 classification plots and 32 classification polygons.

Global

Information from NatureServe:

The two *Pinus edulis* / *Bouteloua gracilis* plant associations are treated as phases in Stuever and Hayden (1997a). In the USNVC we are including stands with southern Great Plains, Chihuahua Desert floristic affinities in *Pinus edulis - (Juniperus monosperma, Juniperus deppeana)* / *Bouteloua gracilis* Open Woodland (CEGL002151), and stands with the Colorado Plateau and Great Basin floristic affinities in *Pinus edulis - (Juniperus osteosperma)* / *Bouteloua gracilis* Woodland (CEGL000778). Both of these associations may include stands codominated by *Juniperus deppeana* in their southern extent. Stuever and Hayden (1997a) also described a *Juniperus deppeana* phase (recognized by the its (*sic*) 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 three species of *Juniperus*.

Classification confidence: Moderate
NatureServe conservation status: Data not available
Global status: G5?
Rounded global status: G5 - Secure
Global range: This widespread woodland association occurs in Wyoming, southern Colorado, western Oklahoma, New Mexico, and possibly Texas and east-central Arizona.

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP006, IP022, IP024, IP027, IP047, IP067, IP088, IP109, IP110, IP111, IP137, IP146, IP147, IP157, IP161, IP163, IP166, IP174, IP183, IP185, IP186, IP188, IP200
Gila Cliff Dwellings National Monument, Polygons: 32 polygons
Local Description Authors: J. Galvin, S. Studd
Global Description Citation: K.A. Shultz and K.S. King. 2010. *Pinus edulis* - (*Juniperus monosperma*, *Juniperus deppeana*) / *Bouteloua gracilis* Open Woodland Association, 21May2010. United States National Vegetation Classification. Federal Geographic Data Committee, Washington, D.C. Accessed 09/26/2018.

5. *Populus angustifolia / Salix irrorata* Riparian Woodland Association

Translated name: Narrowleaf cottonwood / Dewystem willow Riparian Woodland Association
NVC name: CEGL002647
Identifier: N/A

NVC CLASSIFICATION

Division:	Rocky Mountain-Great Basin Montane Flooded & Swamp Forest [1.B.3.Nc]
Macrogroup:	Rocky Mountain-Great Basin Montane Riparian & Swamp Forest [M034]
Group:	Rocky Mountain-Great Basin Montane Riparian & Swamp Forest [G506]
Association:	*Populus angustifolia* / *Salix irrorata* Riparian Woodland [CEGL002647]

DISTRIBUTION

Gila Cliff Dwellings National Monument

This association is found growing along the length of the floodplain and alluvial terraces adjacent to the Gila River. The most characteristic stands are found closer to the river. Those farther toward the upland mesa/canyon systems begin to intergrade with more xeric communities. This area of the park was disturbed by the 2011 Miller Fire that swept through the riparian area, causing severe damage. The stands of this association that did not burn provided the data for this description.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This association occurs along the drainage, bounded on both sides by steep canyon walls and drainages. This association occurs from 1,720 to 1,760 m (5,643–5,772 ft) in elevation, typically with a low gradient (2–4%), but may extend upslope along small drainages. Soils in the floodplain and terraces comprise new and old alluvial deposits from the adjacent Gila River. The ground surface is characterized by sand, gravel, and cobble in the drainage channel, with some patchy herbaceous cover along the terrace edges. Downed wood and leaf litter are common in unburned areas. The larger portion of the riparian floodplain that did burn is essentially free of debris.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This riparian woodland community is characterized by an upper canopy (>5 m) dominated by the facultative riparian tree, narrowleaf cottonwood (*Populus angustifolia*), and lower canopy (2–5 m) dominated by the facultative riparian shrub, dewystem willow (*Salix irrorata*). Narrowleaf cottonwood (*P. angustifolia*) is generally present as a large tree (~16 m) with variable cover across the community, ranging from 6% to 63% and averaging to 37%. Arizona alder (*Alnus oblongifolia*) and boxelder (*Acer negundo*) are patchy associates with occasional areas of dominance or co-dominance with narrowleaf cottonwood (*P. angustifolia*). Arizona walnut (*Juglans major*) is a widespread but low-cover associate. This association is often bounded by ponderosa pine (*Pinus ponderosa*) woodlands toward the canyon slopes. As such, ponderosa pine (*P. ponderosa*) and Rocky Mountain juniper (*Juniperus scopulorum*) are infrequently observed. In the lower canopy, dewystem willow (*S. irrorata*) provides cover of 20–45%, predominately in dense bands at the margins of the river and along historical, abandoned river channels.

The subcanopy (0.5–2 m) layer is characterized by a variable mix of riparian shrubs, subshrubs, new tree recruits, tall grasses, and large forbs. Rubber rabbitbush (*Ericameria nauseosa*), Chihuahuan brickellbush (*Brickellia floribunda*), tarragon (*Artemisia dracunculus*), canyon grape (*Vitus arizonica*), and golden currant (*Ribes aureum*) are the most abundant and consistently occurring species within the unburned areas. Often, at the margins of the watercourse, a mix of large grasses and forbs form a dense band of vegetation that is commonly dominated by non-native forbs and grasses, such as barnyardgrass (*Echinochloa crus-gallii*), sweetclover (*Melilotus albus*), spotted ladythumb (*Polygonum persicaria*), and rice cutgrass (*Leersia oryzoides*).

The herbaceous layer (<0.5 m) is characterized by sparse cover of 5–30%, primarily dominated by forbs. This was by far the most diverse layer, with ~20–25 species recorded in each plot. The non-native invasive, common mullein (*Verbascum thapsus*), is very widely distributed throughout the floodplain, but usually in low cover. Virginia creeper (*Parthenocissus quinquefolia*) was seen in almost every example of this type, and was the dominant forb in several areas, providing up to 7% cover. Other common associates include Fendler's globemallow (*Sphaeralcea fendleri*), Fendler's meadow-rue (*Thalictrum fendleri*), sweetclover (*Melilotus alba*), Bigelow's tansyaster (*Dieteria bigelovii*), Hooker's evening primrose (*Oenothera elata*), shining willow (*Salix lucida*), sacred thorn-apple (*Datura wrightii*), wild mint (*Mentha arvensis*), Kentucky bluegrass (*Poa pratensis*), and Mexican muhly (*Muhlenbergia mexicana*).

Variants of this type may include stands where dewystem willow (*S. irrorata*) is sparse to absent. In some cases, shrub species, such as rubber rabbitbush (*E. nauseosa*) and tarragon (*A. dracunculus*), which dominate the cobbly terraces, can be present and locally abundant, especially in transitional areas between communities. Due to the inherently disturbed nature of the floodplain communities, this type is subject to change as a result of natural flood or high-flow events. This is especially true for the narrow bands of vegetation found along steep-walled and sinuous sections of the river floodplain, where high flows produce forces capable of uprooting dewystem willow (*S. irrorata*) and other woody species.

GLOBAL TYPE CONCEPT DESCRIPTION

Information from NatureServe:

> This riparian woodland association is a new, tentative type representing young, early-seral stands of *Populus angustifolia* occurring in the transition zone between *Populus angustifolia* and *Populus deltoides* in Colorado and the San Francisco River watershed in southwestern New Mexico. Stands are found at or below the high-water mark on streambanks, point bars and sidebars of meandering low-gradient rivers that are flooded perhaps every five years at mid elevations (1700-2200 m). Soils have been reported as sandy-skeletal Oxyaquic Ustifluvents. The association is characterized by 5-40% cover of all age classes of *Populus angustifolia*, but may include significant cover (4-58%) of *Populus deltoides* ssp. *monilifera* in stands in the upper South Platte River Basin of Colorado. *Populus x acuminata* and *Salix amygdaloides* may also be present. In New Mexico stands, *Populus angustifolia* and *Populus fremontii* codominate a dense tree canopy (>75% cover). *Salix irrorata* and *Salix exigua* codominate the shrubby understory. The shrub canopy consists of thick bands of willow along the streambank, mostly *Salix irrorata* but may include *Salix exigua, Salix monticola*, and *Alnus incana*. Herbaceous undergrowth is sparse; however, invasive annual species can be abundant, including *Agrostis stolonifera, Poa pratensis, Bromus inermis, Ambrosia artemisiifolia, Chenopodium fremontii, Salsola kali, Sisymbrium altissimum*, and *Xanthium strumarium*. Native species present may include *Rudbeckia laciniata, Carex nebrascensis, Glyceria grandis, Schoenoplectus acutus*, and *Epilobium* spp. Native wetland indicators that have been recorded for the type are *Schoenoplectus pungens* (= *Scirpus pungens*) and *Equisetum arvense*.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Populus angustifolia, Alnus oblongifolia, Acer negundo*
Canopy (2–5 m)	*Salix irrorata*
Subcanopy (0.5–2 m)	*Ericameria nauseosa, Brickellia floribunda, Artemisia dracunculus, Vitus arizonica, Ribes aureum*
Field (0–0.5 m)	*Parthenocissus quinquefolia*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Juglans major*
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Salix exigua*, *Polygonum perisacaria, Xanthium strumarium, Echinochloa crus- galli, Leersia oryzoides, Carex lenticularis, Rumex crispus*
Field (0–0.5 m)	None

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This association was described from six classification plots and six classification polygons.

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: G2 (30Dec2000)
Rounded global status: G2 - Imperiled
Global range: Data not available
Reasons: This plant association has been documented only from the Rio Grande Valley in New Mexico and along the Colorado Front Range. Although both dominant tree species have wide ranges and ecological amplitudes, the overlap is restricted to fairly specific areas. There are 10–15 occurrences estimated for the Colorado Front Range, plus the New Mexican stands. This riparian woodland is likely impacted by flood control, improper livestock grazing, development, and exotic species invasion, but more survey is needed to document threats and locate unreported occurrences.

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP014, IP071, IP170
Gila Cliff Dwellings National Monument, Polygons: 5 polygons
Local Description Authors: J. Galvin, S. Studd
Global Description Citation: A.E. Black. 1998. *Populus angustifolia* / *Salix irrorata* Riparian Woodland, 09Apr1998. United States National Vegetation Classification. Federal Geographic Data Committee, Washington, D.C. Accessed 09/26/2018.

6. Regenerating *Populus angustifolia / Salix irrorata* Riparian Woodland Association (PS)

Translated name: Regenerating Narrowleaf cottonwood / Dewystem willow Riparian Woodland Association (PS)
NVC name: Not available
Identifier: NPSSODN086

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: Regenerating *Populus angustifolia* / *Salix irrorata* Riparian Woodland (PS)

DISTRIBUTION

Gila Cliff Dwellings National Monument

This association is found growing along the length of the floodplain and alluvial terraces adjacent to the Gila River. The most characteristic stands are found closer to the river. Those farther toward the upland mesa/canyon systems begin to intergrade with more xeric communities. This area of the park was disturbed by the 2011 Miller Fire that swept through the riparian area, causing severe damage. This description describes its regenerating form.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This association occurs along the drainage, bounded on both sides by steep canyon walls and drainages. This association occurs from 1,720 to 1,760 m (5,643–5,772 ft) in elevation, typically with a low gradient (2–4%), but may extend upslope along small drainages. Soils in the floodplain and terraces comprise new and old alluvial deposits from the adjacent Gila River. The ground surface is characterized by sand, gravel, and cobble in the drainage channel, with some patchy herbaceous cover along the terrace edges.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This riparian woodland and forest community was severely damaged during the 2011 Miller Fire. In the worst-affected areas, most mature narrrowleaf cottonwoods (*Populus angustifolia*) were killed, with scorch heights reaching 16 m, leaving only standing, blackened stumps and deep ash piles where flood debris had formerly accumulated on the ground. Dewystem willow (*Salix irrorata*), Arizona walnut (*Juglans major*), Arizona alder (*Alnus oblongifolia*), and boxelder (*Acer negundo*) were all equally affected, leaving little living cover. During the summer 2012 mapping effort, these areas were seen to be rapidly regenerating, with narrowleaf cottonwood (*P. angustifolia*) and dewystem willow (*S. irrorata*) re-sprouting from root stock and already attaining heights of 3 m or more. Occasional Arizona walnut (*J. major*) and boxelder (*A. negundo*) were also seen regenerating in the subcanopy (<2 m). Species composition was not seen to drastically change between the burned and unburned examples of this association, but cover values in the subcanopy increased dramatically, as the two dominant species boomed with fresh growth. In most cases, narrowleaf cottonwood (*P. angustifolia*) remained dominant, with average cover ranging from 25% to 30% compared with 8–10% for dewystem willow (*S. irrorata*). These (currently) shrubby narrowleaf cottonwoods (*P. angustifolia*) were seen re-sprouting from all sides of dead stumps and snags. It's unlikely that all stems will remain viable, and in coming years, the stumps and snags will likely fall and allow for the main stems of re-sprouts to take dominance. Due to the often patchy fire damage, some stands are almost impenetrable while others are mixed, having some old trees that survived the fire and some re-sprouting.

Canyon grape (*Vitus arizonica*), Fendler's globemallow (*Sphaeralcea fendleri*), and common mullein (*Verbascum thapsus*) are still the most common subcanopy and field layer associates in these regenerating areas.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	*Populus angustifolia, Salix irrorata*
Subcanopy (0.5–2 m)	*Ericameria nauseosa, Brickellia floribunda, Artemisia dracunculus, Vitus arizonica, Ribes aureum*
Field (0–0.5 m)	*Parthenocissus quinquefolia*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	*Juglans major, Alnus oblongifolia, Acer negundo*
Subcanopy (0.5–2 m)	*Salix exigua*, *Polygonum perisacaria, Xanthium strumarium, Echinochloa crus- galli, Leersia oryzoides, Carex lenticularis, Rumex crispus*
Field (0–0.5 m)	None

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This association was described from five classification plots and four classification polygons. This park-special association is a heavily burned version of a *Populus angustifolia* / *Salix irrorata* Woodland and Forest Association (CEGL002647). While species composition is similar across both associations, the overall structure of the community was so drastically altered by the Miller Fire that we decided to keep them as separate associations.

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP004, IP012, IP028, IP041, IP046
Gila Cliff Dwellings National Monument, Polygons: 4 polygons
Local Description Authors: J. Galvin, S. Studd

7. *Atriplex canescens* Shrubland Association

Translated name: Fourwing saltbush Shrubland Association
NVC name: CEGL001281
Identifier: N/A

NVC CLASSIFICATION

Division:	Western North American Cool Semi-Desert Scrub & Grassland [3.B.1.Ne]
Macrogroup:	Great Basin Saltbush Scrub [M093]
Group:	Intermountain Shadscale - Saltbush Scrub [G300]
Alliance:	*Atriplex canescens* Scrub [A0869]
Association:	*Atriplex canescens* Shrubland [CEGL001281]

DISTRIBUTION

Gila Cliff Dwellings National Monument

This shrubland is found at a single location in the TJ unit of Gila Cliff Dwellings National Monument.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This association is located on a south/southwest-facing shoulder and summit of a hill, at an elevation of 1,738 m (5,704 ft). This low-angle hill has low slope of 1–15%. Surface covers are dominated by gravel and bare ground, with patchy rock and litter.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This shrubland type is characterized by a subcanopy stratum (0.5–2 m) dominated by fourwing saltbush (*Atriplex canescens*), providing evenly distributed 25% cover throughout. No other shrub species are present within this single example type. The field stratum (<0.5 m) contributes around 13% cover, mainly consisting of sand dropseed (*Sporobolus cryptandrus*), Fendler's globemallow (*Sphaeralcea fendleri*), common purslane (*Portulaca oleracea*), sideoats grama (*Bouteloua curtipendula*), dwarf stickpea (*Calliandra humilis*), wild potato (*Solanum jamesii*), and blue grama (*Bouteloua gracilis*). None of these species provides more than 1% cover.

GLOBAL TYPE CONCEPT DESCRIPTION

Information from NatureServe:

> This shrubland association is known from the Great Basin north into the southern Columbia Basin, east into Wyoming, the Colorado Plateau and northern Chihuahuan Desert, and west into the Mojave Desert of California. The vegetation is characterized by a sparse short-shrub layer (10-35% cover) dominated or codominated by *Atriplex canescens*, typically with a variable and often sparse herbaceous layer. Notable codominants in the shrub layer include *Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ephedra nevadensis, Eriogonum nummulare* (= *Eriogonum kearneyi*), *Grayia spinosa, Gutierrezia sarothrae, Lycium pallidum*, or several species of *Psorothamnus*. The herbaceous layer includes low cover of species such as *Achnatherum hymenoides, Aristida purpurea, Elymus elymoides, Pleuraphis jamesii*, and *Sporobolus cryptandrus*. Introduced species, especially *Bromus tectorum, Bromus diandrus*, and *Salsola kali*, are common on disturbed sites and can create an herbaceous layer much denser than on undisturbed sites. Winter annual forb cover is variable depending on annual precipitation. It is common at middle elevations on alluvial fans and toeslopes in deep, sandy soils but will occur at lower elevations along alluvial benches where soils are often finer-textured and possibly saline/alkaline. Parent materials are variable.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Atriplex canescens*
Field (0–0.5 m)	*Atriplex canescens*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	*Boutleoua curtipendula*, *Bouteloua gracilis*, *Portulaca oleracea*, *Sporobolus cryptandrus*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This type has been described solely from data collected during this project at Gila Cliff Dwelling NM. Data were from a single mapped classification polygon.

Global

Data not available.

Classification confidence: High
NatureServe conservation status: G5
Global status: Data not available
Rounded global status: Data not available
Global range: This shrubland occurs from the southern Columbia Basin and Great Basin east into Wyoming and south into the Mojave Desert, Colorado Plateau, and northern Chihuahuan Desert. This shrubland association occurs throughout much of the interior western U.S.
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: None
Gila Cliff Dwellings National Monument, Polygons: 1 polygon
Local Description Authors: J. Galvin, S. Studd
Global Description Citation: K.A. Shultz. 2016. *Atriplex canescens* shrubland, 12Jul2016. United States National Vegetation Classification. Federal Geographic Data Committee, Washington, D.C. Accessed 09/26/2018.

8. *Cercocarpus montanus* Shrubby Rock Outcrop Association (P)

Translated name: Alderleaf mountain mahogany Shrubby Rock Outcrop Association (P)
NVC name: Not available
Identifier: NPSSODN037

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Cercocarpus montanus* Shrubby Rock Outcrop (P)

DISTRIBUTION

Gila Cliff Dwellings National Monument

This vegetation community is mainly restricted to the rocky, exposed outcrops above most major drainages south of the Gila River, from Cliff Dweller Canyon east to Heart Bar Ranch.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

Mapped areas are predominantly west- or southeast-facing, lying on steep (30–60% slope) bedrock shelves of non-calcareous sedimentary sandstone conglomerates. Elevation ranges from 1,800 to 1,890 m (5,900–6,200 ft). Total vegetation cover is low and widely spaced, as bedrock outcrops account for an average of 40% of the surface cover. Soils are shallow and rocky. These sparse shrublands occur on the backslopes, highest shoulders, and crests of the canyon edges. This type is bounded by topographic and edaphic factors, with decreases in bedrock and slope in adjacent areas supporting woodland and forest communities.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This vegetation community is characterized by the consistent presence of the shrub, alderleaf mountain mahogany (*Cercocarpus montanus*), typically emerging as the dominant species in the subcanopy stratum (0.5–2 m height) with an estimated cover of 3–7% but rarely as low as 1% and as high as 9%. It occurs along many of the drainages of the southern portion of the mapping area, south of the Gila River, and is restricted to the exposed mesa tops consisting of bedrock plains and rocky sandstone-derived shallow soils. Two-needle pinyon (*Pinus edulis*) and oneseed juniper (*Juniper monosperma*) are common in the 2–5 m range and, to a lesser extent, in the subcanopy below 2 m in height, but rarely with more than 1–2% cover. These trees are often stunted due to the exposure of the ridges and the poor water-holding capacity of the soils, and are more common along hillcrests. Gray oak (*Quercus grisea*) is an associated species, tending to occur in more shrubby form, not reaching much above 2 m. It can be co-dominant with alderleaf mountain mahogany (*C. montanus*). Ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*) were observed in one mapped area at less than 1%, and are considered accidental in this type, emerging from neighboring communities. This type could be considered an environmental variant of the pinyon-juniper woodland type, as it often borders these woodlands and the differences are driven by the high bedrock content and exposure of the slope positions. It is not uncommon, therefore, that some polygons representing this shrubby *Cercocarpus*-dominant type often contain vegetated islands (<0.5 ha) of the woodland type.

Cliff muhly (*Muhlenbergia polycaulis*) and blue grama (*Bouteloua gracilis*) are the two most abundant and consistently occurring perennial grasses, with up to 3% cover, usually restricted to the small pockets of soil amongst the bedrock plains. Engelmann's prickly pear (*Opuntia engelmannii*), Fendler's globemallow (*Sphaeralcea fendleri*), muttongrass (*Poa fendleriana*), ragleaf bahia (*Amauriopsis dissecta* = *Bahia dissecta*), banana yucca (*Yucca baccata*), and Carruth's sagewort (*Artemisia carruthii*) are all common associates, each usually providing less than 1% cover (scattered individuals).

The 2011 Miller Fire did not affect all examples of this type. Those affected were subject to low-to-medium intensity burn as the predominance of bedrock prevented rapid spread. Alderleaf mountain mahogany (*C. montanus*) is well adapted to fire, burning less readily than many other shrubs. When severely burned, it will vigorously resprout from the root crown.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	*Pinus edulis, Juniperus monosperma*
Subcanopy (0.5–2 m)	*Cercocarpus montanus, Quercus grisea*
Field (0–0.5 m)	None

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Opuntia engelmannii, Yucca baccata, Artemisia carruthii*
Field (0–0.5 m)	*Muhlenbergia polycaulis, Bouteloua gracilis, Bouteloua curtipendula, Sphaeralcea fendleri, Poa fendleriana, Amauriopsis dissecta*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This type is very similar to the *Cercocarpus montanus* Rock Pavement Sparse Vegetation type described from Zion National Park (CEGL002978). It also bears floristic resemblance to the *Juniperus monosperma* / Rockland Woodland type (CEGL005369) described from Bandelier NM, but has much lower cover and fewer trees. More classification efforts are needed, as most of these types currently have low confidence and will likely be revised as more data become available.

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP036, IP065, IP106, IP115, IP119
Gila Cliff Dwellings National Monument, Polygons: 16 polygons
Local Description Authors: J. Galvin, S. Studd

9. *Ericameria nauseosa* Shrubland Association

Translated name: Rubber rabbitbrush Shrubland Association
NVC name: CEGL002713
Identifier: N/A

NVC CLASSIFICATION

Division:	Western North American Cool Semi-Desert Scrub & Grassland [3.B.1.Ne]
Macrogroup:	Great Basin-Intermountain Dry Shrubland & Grassland [M171]
Group:	Intermountain Semi-Desert Steppe & Shrubland [G310]
Alliance:	*Ericameria nauseosa* Steppe & Shrubland [A3196]
Association:	*Ericameria nauseosa* Shrubland [CEGL002713]

DISTRIBUTION

Gila Cliff Dwellings National Monument

This association is found growing along the edges of the floodplain and cobbly alluvial terraces adjacent to the Gila River, in open areas between or next to the *Populus angustifolia* / *Salix irrorata* woodlands. This type is found along the entire length of the riparian corridor at Gila Cliff Dwellings NM.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This association occurs along the riparian corridor, often bounded or entwined by riparian woodlands and forests. These shrublands are typically found growing on relatively flat alluvial terraces, sandbars, and plains, with an average low-gradient slope of only 3%. Elevation was recorded in the field within the range of 1,696–1,735 m (5,565–5,691 ft). Soils in the floodplain and terraces comprise new and old alluvial deposits from the adjacent Gila River. The ground surface is usually dominated by rocks and cobble, providing up to 75% cover but averaging 45%. In two stands, bare soil is prevalent and much lower cover is provided by rocks (~15%). Litter and downed wood are sparse throughout all examples of this type as a result of the 2011 Miller Fire, which consumed most litter and flood debris.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

These riparian shrublands are characterized by a short (<2 m) subcanopy layer dominated by rubber rabbitbrush (*Ericameria nauseosa*) with approximately 15–30% cover. Some of these stands were clearly burned during the 2011 Miller Fire, so typical cover values may be higher (or lower, since fire often triggers increases in growth). Trees or canopy species are essentially absent; shrubs and herbaceous species define this type. Tarragon (*Artemisia dracunculus*) is often, but not consistently, the subdominant species, with 2–10% cover, preferring the sandier areas and dry wash side channels while rabbitbrush prefers the rockier sites. Other common associates include ragleaf bahia (*Amauriopsis dissecta* = *Bahia dissecta*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), barnyardgrass (*Echinochloa crus-galli*), Fendler's globemallow (*Sphaeralcea fendleri*), sand dropseed (*Sporobolus cryptandrus*), Dakota mock vervain (*Glandularia bipinnatifida*) and sacred thorn-apple (*Datura wrightii*). The non-natives, spotted ladysthumb (*Polygonum persicaria*) and common mullein (*Verbascum thapsus*), are occasional, although these species are common along the entire riparian corridor. Other, less-common herbaceous species include the obligate riparian, rice cutgrass (*Leersia oryzoides*), which occurs with spotted ladysthumb (*P. persicaria*) and barnyardgrass (*E. crus-galli*) to create dense bands when closer to the water's edge. Annual forbs and grasses contribute 3–5% cover combined in most of the areas sampled, but cover can be much higher in localized patches. Due to the inherently disturbed nature of the floodplain communities, this type is subject to change as a result of natural flood or high-flow events. At times, these events are severe enough to scour these sandy open areas, leaving the openings bereft of vegetation cover and more appropriately described as strand.

Both narrowleaf cottonwood (*Populus angustifolia*) and dewystem willow (*Salix irrorata*) are occasional with very low cover, indicative of the ecotonal relationship between this and the adjacent riparian woodlands. Arizona walnut (*Juglans major*), box elder (*Acer negundo*), or ponderosa pine (*Pinus ponderosa*) trees may also be present with less than 1% cover, as these creep in from neighboring communities.

In a few instances of this type, the diverse field layer (<0.5 m in height) had up to 26 species, with total cover approaching that of the subcanopy, making some mapped areas better described as a shrub herbaceous type, or shrub savanna. However, at the time of mapping, the longevity of these lifeform distributions was unclear, as the communities were still freshly responding to the post-fire environment. As such, and in keeping with the NVC guidelines, this type has been classified based on the dominant perennial species in the uppermost stratum, rather than based on potentially ephemeral herbaceous cover.

GLOBAL TYPE CONCEPT DESCRIPTION

Information from NatureServe:

> The vegetation is characterized by a moderate to dense (35-70% cover) shrub canopy dominated by *Ericameria nauseosa* shrubs 0.5-3 m tall, with a relatively sparse herbaceous layer. In Colorado, stands have low diversity. Additional associated short and dwarf-shrubs are *Artemisia frigida*, *Artemisia tridentata* ssp. *wyomingensis*, and *Rosa woodsii*. In Nevada, stands are more diverse, and several other shrubs, such as *Atriplex canescens*, *Psorothamnus polydenius*, *Sarcobatus vermiculatus*, and *Tetradymia tetrameres*, may be important. The sparse herbaceous layer is a mixture of grasses and forbs. Native grasses include *Achnatherum hymenoides*, *Distichlis spicata*, and *Elymus elymoides*. Common forbs may include the non-natives *Cirsium arvense*, *Descurainia incana* ssp. *incisa*, *Erodium cicutarium*, *Lepidium campestre*, *Iva axillaris*, *Salsola tragus*, and *Sisymbrium altissimum*, and the natives *Eriogonum hookeri*, *Rumex salicifolius*, and *Verbesina encelioides*. The introduced annual grass *Bromus tectorum* was observed to be prominent in one stand in Utah, although native grasses *Pseudoroegneria spicata* and *Sporobolus airoides* are typically absent or have low cover.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Ericameria nauseosa, Artemisia dracunculus, Echinochloa crus-galli*
Field (0–0.5 m)	*Bouteloua gracilis, Sporobolus cryptandrus, Amauriopsis dissecta, Glandularia bipinnatifida*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	*Salix irrorata*
Subcanopy (0.5–2 m)	*Populus angustifolia* (regenerating), *Forestiera pubescens*
Field (0–0.5 m)	*Sphaeralcea fendleri, Verbascum thapsus, Mirabilis linearis, Bouteloua hirsuta, Parthenocissus quinquefolia, Aristida ternipes, Physaria goodingii, Brickellia floribunda, Polygonum persicaria, Leersia oryzoides*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This association was described from three classification plots and five classification polygons.

Global

This type bears resemblance to *Ericameria nauseosa* Desert Wash Shrubland (CEGL002261), described from western Colorado and eastern Utah. It is also similar to *Ericameria nauseosa* Sand Deposit Sparse Shrubland (CEGL002980). Several other *E. nauseosa*-dominant or co-dominant associations have been described, all of which either have floristic, landscape position, or broad geographic differences from the type as seen at Gila Cliff Dwellings NM. More classification efforts are needed, as most of these types currently have low-to-medium confidence and will likely be revised as more data become available.

Classification confidence: Moderate
NatureServe conservation status: Data not available
Global status: G5
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP03, IP64, IP71
Gila Cliff Dwellings National Monument, Polygons: 5 polygons
Local Description Authors: J. Galvin, S. Studd
Global Description Citation: K.A. Schulz and G. Kittel. 2011. Ericameria nauseosa shrubland, 19Feb2011. United States National Vegetation Classification. Federal Geographic Data Committee, Washington, D.C. Accessed 09/26/2018.

10. *Quercus gambelii* (*Quercus grisea*) Shrubland and Shrub Savanna Association (PS)

Translated name: Gambel oak (Gray oak) Shrubland and Shrub Savanna Association (PS)
NVC name: Not available
Identifier: NPSSODN035

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Quercus gambelii (Quercus grisea)* Shrubland and Shrub Savanna (PS)

DISTRIBUTION

Gila Cliff Dwellings National Monument

This shrubland community occupies two small areas in the western section of the mapping area: one within the main unit of the park and one within the Gila National Forest, just west of the park. This community tends to occur in areas impacted by multiple historic fires.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This sparse shrubland is found on north/northeast-facing backslopes of hills on the south side of the river. Slope is approximately 40–60%. Ground cover has up to 40% gravel and rock, with around 45% bare ground.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This park-special association is described from only two small sites that appear to have burned or been otherwise previously disturbed, potentially from multiple events, leading to this seral stage of development. These sites are present within the much larger surrounding woodland associations dominated by ponderosa pine (*Pinus ponderosa*) and/or Douglas fir (*Pseudotsuga menziesii*), with a lower canopy of Gambel oak (*Quercus gambelii*). Within these sites, trees and tall shrubs are virtually absent, except along the boundaries, where canopy trees from the adjacent woodlands may be present. Instead, vegetation is characterized by a subcanopy (0.5–2 m) dominated by shrubby Gambel oak (*Q. gambelii*) with one common associate, gray oak (*Quercus grisea*). These species form a sparse subcanopy layer, with cover averaging 10% for Gambel oak (*Q. gambelii*) and 5% for gray oak (*Q. grisea*). Common hoptree (*Ptelea trifoliata*) and black cherry (*Prunus serotina*) are occasional associates in the stratum. The herbaceous stratum (<0.5 m) is defined by a diverse mix of perennial forbs, grasses, and subshrubs, including Carruth's sagewort (*Artemisia carruthii*), silvery lupine (*Lupinus argenteus*), plumed brickellbush (*Brickellia brachyphylla*), blue grama (*Bouteloua gracilis*), and sideoats grama (*Bouteloua curtipendula*). Where this community is present as a shrub savanna, blue grama (*B. gracilis*) may become an herbaceous stratum dominant, with cover approaching 8%.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Quercus gambelii*, *Quercus grisea*
Field (0–0.5 m)	*Artemisia carruthii, Bouteloua curtipendula*, *Bouteloua gracilis*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Pinus ponderosa*
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Ptelea trifoliata*, *Prunus serotina*
Field (0–0.5 m)	*Lupinus argenteus, Brickellia brachyphylla, Verbascum thapsus, Muhlenbergia alopecuroides*, *Sporobolus cryptandrus*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This association was drafted for two very small yet distinct areas. While these are considered different enough to separate from the larger woodlands that surround them, they are thought to be the result of fire disturbance and in successional stages. For this reason, this has been classified as a park special.

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: None
Gila Cliff Dwellings National Monument, Polygons: 2 polygons
Local Description Authors: J. Galvin, S. Studd

11. *Quercus* grisea / Mixed Perennial Grass (*Artemisia dracunculus)* Post-Fire Shrubland and Herbaceous Association (P)

Translated name: Gray oak / Mixed Perennial Grass (Tarragon) Post-fire Shrubland and Herbaceous Association (P)
NVC name: Not available
Identifier: NPSSODN040

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Quercus grisea* / Mixed Perennial Grass (*Artemisia dracunculus*) Post-fire Shrubland and Herbaceous (P)

DISTRIBUTION

Gila Cliff Dwellings National Monument

This type occurs in the northwestern corner of Gila Cliff Dwellings NM and extends further northwest outside the boundary, restricted to the older terrace surface above the immediate floodplain.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This type is found on low-gradient (<5% slope) foot and toeslopes adjacent to the Gila River floodplain, predominantly on the south side of the river. These low-slope areas are essentially broad, flat, meadow-like openings surrounded by forest and woodland on the surrounding steeper slopes. Aspect is north-facing, with slight easterly tendencies. Elevation ranges from 1,737 to 1,761 m (5,700–5,780 ft).

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This association is described from data collected at Gila Cliff Dwellings NM roughly one year after the 2011 Miller Fire. It was modified with additional data collected in summer 2013 to better estimate the continued response to the fire. This is considered a seral stage of post-fire regeneration in areas that were primarily oak shrublands or herbaceous-dominated communities before the fire. Several of the areas showed evidence of an earlier burn from which they were already recovering prior to the Miller Fire. Both oak (*Quercus* sp.) and pine (*Pinus* sp.) were regenerating as small poles, but most of these were destroyed in the Miller Fire. This type might also be seen in the ponderosa pine (*Pinus ponderosa*) post-fire woodlands, where fire severity was very high.

Vegetation is somewhat variable in terms of cover and associated species, but has consistent presence and dominance of gray oak (*Quercus grisea*) in the subcanopy (0.5–2 m) and field (<0.5 m) layers, along with the common associate, tarragon (*Artemisia dracunculus*). In the first year after the fire, Fendler's globemallow (*Sphaeralcea fendleri*) was very abundant, acting as an early successional species, but in 2013, cover was greatly reduced (averaging 2–3%) and less consistent. It is thought this species will remain over time as a common associate. Cover of gray oak (*Q. grisea*) ranges from 2% to 8%, typically exhibiting a shrubby habit re-sprouting from the base of burned trunks. Pre-fire, most examples of this type were likely gray oak (*Q. grisea*) shrublands, with some individuals reaching almost 2 m tall. Tarragon (*A. dracunculus*) is present in all but one example of this type, with cover ranging from 1% to 4%. Trees and other shrubs are accidental and uncommon.

The field layer (<0.5 m) is dominated by perennial bunchgrasses with average total cover around 20%, with many areas ranging up to 35%. Blue grama (*Bouteloua gracilis*), bristly wolfstail (*Muhlenbergia alopecuroides*), sand dropseed (*Sporobolus cryptandrus*), spidergrass (*Aristida ternipes*), and purple threeawn (*Aristida purpurea*) are the most common dominant or co-dominant species. While cover of each grass is variable across the commu-

nity, all of these species are typically present. In sites where ponderosa pine (*P. ponderosa*) stands are nearby, blue grama (*B. gracilis*) and sand dropseed (*S. cryptandrus*) become increasingly dominant over the other grass species. Other common field-layer species include dwarf stickpea (*Calliandra humilis*), ragleaf bahia (*Amauriopsis dissecta*), Chihuahuan brikellbush (*Brickellia floribunda*), false boneset (*Brickellia eupatorioides*), White Mountain sedge (*Carex geophila*), whiteflower prairie clover (*Dalea albiflora*), showy goldeneye (*Heliomeris multiflora*), four o'clock (*Mirabilis* sp.), single threeawn (*Aristida schiedeana*), hairy grama (*Bouteloua hirsuta*), Fendler's flatsedge (*Cyperus fendlerianus*), common mullein (*Verbascum thapsus*), and Texas bluestem (*Schizachyrium cirratum*). Annual forbs and grasses are a small component of this type.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Quercus grisea, Artemisia dracunculus*
Field (0–0.5 m)	*Bouteloua gracilis, Muhlenbergia alopecuroides, Sporobolus cryptandrus, Aristida ternipes, Aristida purpurea, Bouteloua curtipendula*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	*None*
Subcanopy (0.5–2 m)	*Brickellia floribunda, Brickellia eupatorioides, Sphaeralcea fendleri*
Field (0–0.5 m)	None

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This type is described solely from data collected at Gila Cliff dwellings NM during this project. Data from 11 mapped classification polygons were used.

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP021, IP057
Gila Cliff Dwellings National Monument, Polygons: 11 polygons
Local Description Authors: J. Galvin, S. Studd

12. *Quercus grisea / Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous Association (P)

Translated name: Gray oak / Fendler's globemallow Post-fire Shrubland and Herbaceous Association (P)
NVC name: Not available
Identifier: NPSSODN041

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Quercus grisea* / *Sphaeralcea fendleri* Post-fire Shrubland and Herbaceous (P)

DISTRIBUTION

Gila Cliff Dwellings National Monument

This is a widely distributed type covering large hillslopes and ridgetops primarily in the southern and western portions of the park. In general, areas covered by this association were subject to moderate or high burn severity as a result of the Miller Fire in summer 2011. This is a post-fire seral type and occupies areas formerly covered with woodland and forest.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This community is found mostly on slopes with a northerly component, but often large enough to encompass multiple aspects, including N, NE, NW, and, rarely, SW. Elevation ranges from 1,828 to 1,920 m (6,000–6,300 ft). This type was mapped as occurring mainly on backslopes and summits of hills. Litter and downed wood are uncommon due to the severity of the fire, but as dead trees fall these may increase again. Surface cover was often recorded as ashy, and the majority of the ground cover was either bare soil or gravel.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This association is described from data collected at Gila Cliff Dwellings NM roughly one year after the 2011 Miller Fire and from additional data collected in summer 2013 to better estimate the continued response to the fire. This is considered a seral stage of post-fire regeneration in areas that were primarily occupied by pine woodlands and forests—specifically, ponderosa pine (*P. ponderosa*) and pinyon-juniper (*Pinus/Juniperus* spp.) types.

These areas are currently sparse shrublands dominated by re-sprouting gray oak (*Quercus grisea*) in the subcanopy stratum (0.5–2 m), occasionally reaching up to 3 m, and a diverse mixture of grasses, forbs, and shrubs in the field stratum (<0.5 m). The most unifying feature of these variable examples is the presence of burned snags in the subcanopy and canopy (>2 m) strata and a regenerating understory community dominated by a mix of herbaceous species and shrubby oaks. In general, these snags were completely consumed (100% mortality) during the Miller Fire.

Cover of gray oak (*Q. grisea*) is low, ranging from 1% to 3% in most examples, but can be higher (5–15%) in areas where pre-fire cover was elevated or fire intensity was less severe. Alderleaf mountain mahogany (*Cercocarpus montanus*) is vigorously re-sprouting, usually along ridges and shoulders. Being highly fire tolerant, this species should become more prevalent as the community rebounds, and may serve as an important successional species. Typically, this species is most common in areas formerly occupied by pinyon-juniper woodlands.

Fendler's globemallow (*Sphaeralcea fendleri*) is often, but not always, the dominant plant in the field (or subcanopy) layer, but can be absent or just an associate, with cover values from ranging from <1 to 18%, and an average around 8%. Other species may have cover values approaching or exceeding that of Fendler's globemallow

(*S. fendleri*), including Carruth's sagewort (*Artemisia carruthii*) and/or Colorado four o'clock (*Mirabilis multiflora*), usually with one or the other providing patchy, local dominance. These species might be replaced or found in lower abundance in later successional communities. In some map units, blue grama (*Bouteloua gracilis*) is a low-cover associate. Other uncommon species and functional groups which may be present include but are not limited to annual forbs, annual grasses, fragrant snakeroot (*Ageratina herbacea*), plumed brikellbush (*Brickellia brachyphylla*), ragleaf bahia (*Amauriopsis dissecta*), re-sprouting banana yucca (*Yucca baccata*), spreading fleabane (*Erigeron divergens*), toothleaf goldeneye (*Viguiera dentata*), showy goldeneye (*Heliomeris multiflora*), California brickellbush (*Brickellia californica*), Bigelow's tansyaster (*Dieteria bigelovii*), Goodding's bladderpod (*Physaria gooddingii*), dwarf stickpea (*Calliandra humilis*), birdbill dayflower (*Commelina dianthifolia*), cactus apple (*Opuntia engelmannii*), Fendler's meadow-rue (*Thalictrum fendleri*), and Wright's milkpea (*Garrya wrightii*).

Areas that did not burn completely have residual trees providing up to 2% cover. These can include ponderosa pine (*P. ponderosa*), two-needle pinyon (*Pinus edulis*), oneseed juniper (*Juniperus monosperma*), and alligator juniper (*Juniperus deppeana*). Depending on the pre-fire community, the regenerating oak species may be Gambel oak (*Quercus gambelii*), not gray oak (*Q. grisea*). This is typically only in drainages and steep north-facing slopes, where the pre-fire woodlands were more like the *Pseudotsuga menziesii - Quercus gambelii* Forest Association.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Quercus grisea*
Field (0–0.5 m)	*Sphaeralcea fendleri, Mirabilis multiflora, Artemisia carruthii*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	*Pinus edulis*
Subcanopy (0.5–2 m)	*Cercocarpus montanus, Quercus gambelii*
Field (0–0.5 m)	*Bouteloua gracilis, Amauriopsis dissecta*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

Data from seven classification plots and 10 mapped classification polygons were used.

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP030, IP053, IP083, IP100, IP134, IP165, IP199
Gila Cliff Dwellings National Monument, Polygons: 10 polygons
Local Description Authors: J. Galvin, S. Studd

13. *Robinia neomexicana* Shrubland Association (P)

Translated name: New Mexico locust Shrubland Association (P)
NVC name: Not available
Identifier: NPSSODN038

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Robinia neomexicana* Shrubland (P)

DISTRIBUTION

Gila Cliff Dwellings National Monument

This type is found in small, scattered patches on the south side of the Gila River, both east and west of Cliff Dweller Canyon.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This vegetation type is strongly associated with the riparian corridor, and is found growing on steep slopes immediately adjacent to the floodplain and in canyon mouths. Aspect is generally north/northeast, and elevation ranges from 1,707 to 1,804 m (5,600–5,920 ft). When present at the margins or the riparian corridor, the surface cover is generally dominated by loose rock and gravel, with occasional patches of bedrock.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This shrubland association is characterized by a subcanopy stratum (0.5–2 m) dominated by New Mexico locust (*Robinia neomexicana*), with a sparse herbaceous understory and little to no tree cover. Cover of New Mexico locust (*R. neomexicana*) varies from a sparse 5% up to a dense 50%, where it can be thicket-like and hard to move through. Other noteworthy but sparse shrubs and small trees include trumpet gooseberry (*Ribes leptanthum*) and common hoptree (*Ptelea trifoliata*). Tarragon (*Artemisia dracunculus*) is an inconsistent subshrub that occasionally provides cover approaching that of New Mexico locust (*R. neomexicana*). Throughout the subshrub/shrub layer, vines, including canyon grape (*Vitis arizonica*), common hop (*Humulus lupulus*), western white clematis (*Clematis ligusticifolia*), and Virginia creeper (*Parthenocissus quinquefolia*), are common.

In general, this type occurs in areas with recent fire disturbance, where the canopy has been completely consumed or single ponderosa pine (*Pinus ponderosa*), narrowleaf cottonwood (*Populus angustifolia*), and/or Gambel oak (*Quercus gambelii*) remains. Except for ponderosa pine (*P. ponderosa*), these species are more commonly present as re-sprouts from a charred snag. Often, this community occupies a narrow band between an unburned ponderosa pine (*P. ponderosa*) woodland and a riparian corridor dominated by narrowleaf cottonwood (*P. angustifolia*) and dewystem willow (*Salix irrorata*).

The most frequently recorded species in the herbaceous layer are common mullein (*Verbascum thapsus*), narrowleaf four o'clock (*Mirabilis linearis*), Fendler's globemallow (*Sphaeralcea fendleri*), and Carruth's sagewort (*Artemisia carruthii*), but diversity can be quite high, with 22 species recorded in one example of this type.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Robinia neomexicana, Vitis arizonica*
Field (0–0.5 m)	*Artemisia dracunculus*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Pinus ponderosa*
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Populus angustifolia, Quercus gambelii, Humulus lupulus, Parthenocissus quinquefolia, Ribes leptanthum, Clematis ligusticifolia, Ptelea trifoliata*
Field (0–0.5 m)	*Verbascum thapsus, Mirabilis linearis, Artemisia carruthii, Sphaeralcea fendleri*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This type has been described based solely on data collected during this inventory project and is based on data from two classification plots and five mapped polygons.

Global

This type is similar to several described NVC types. *Robinia neomexicana* Shrubland (CEGL005505) is described from Grand Canyon National Park in Arizona, as occurring in areas that have experienced high-severity, stand-replacing fires, usually ponderosa pine (*P. ponderosa*) woodlands. More classification is needed to fully describe this type.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP015, IP048
Gila Cliff Dwellings National Monument, Polygons: 5 polygons
Local Description Authors: J. Galvin, S. Studd

14. Annual Forb - Mixed *Bouteloua* spp. Herbaceous Association (PS)

Translated name: Annual Forb - Mixed grama Herbaceous Association (PS)
NVC name: Not available
Identifier: NPSSODN043

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: Annual Forb - Mixed *Bouteloua* spp. Herbaceous (PS)

DISTRIBUTION

Gila Cliff Dwellings National Monument

This type is found in one map unit of the project area, southwest of and downslope from the TJ unit at Gila Cliff Dwellings National Monument. It is bisected by the entrance-road intersection.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This type encompasses a stretch of flat, sandy floodplain with negligible aspect. However, some parts of the mapped unit occur on slightly elevated alluvial terraces. Bare ground dominates and averages over 60% cover, with gravel, small rocks, and litter each contributing around 10–20%. Elevation ranges from 1,697 to 1,706 m (5,570–5,600 ft). This area clearly has a history of agricultural or grazing use, evidenced not only by vegetation composition but also the remaining fence lines and pasture structures.

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This vegetation type is primarily composed of annual forbs, with an estimated 35–45% cover. During 2012 surveys (one year post-fire), pitseed goosefoot (*Chenopodium berlandieri*) was clearly dominant, but during 2013 surveys it was all but absent and had been replaced by flatspine burr ragweed (*Ambrosia acanthicarpa*). Other commonly occurring, low-cover annuals include carelessweed (*Amaranthus palmeri*), golden crownbeard (*Verbesina encelioides*), prickly Russian thistle (*Salsola tragus*), and melonleaf nightshade (*Solanum heterodoxum*). Blue grama (*Bouteloua gracilis*) is the second-most consistently distributed species, averaging 7% cover but occurring more or less in patches, due to its sod-forming nature. Hairy grama (*Bouteloua hirsuta*), sideoats grama (*Bouteloua curtipendula*) and sand dropseed (*Sporobolus cryptandrus*) are also common and may be locally dominant, but not consistently so.

Perennial forbs, shrubs, and grass provide very patchy cover, totaling only a few percent, but are the same species found in much greater abundance in the adjacent perennial herbaceous communities: sand dropseed (*S. cryptandrus*), common wolfstail (*Muhlenbergia alopecuroides*), Fendler's globemallow (*Sphaeralcea fendleri*), southwestern pricklypoppy (*Argemone pleiacantha*), and tarragon (*Artemisia dracunculus*).

Due to its position in the riparian corridor, occasional trees are seen along the edges of this type, including but not limited to narrowleaf cottonwood (*Populus angustifolia*), Arizona walnut (*Juglans major*), and boxelder (*Acer negundo*). These average 6–7 m tall with trace amounts of cover, and are considered accidental inclusions.

Other less-common species recorded in the field layer (<0.5 m) are common mullein (*Verbascum thapsus*), squirreltail (*Elymus elymoides*), Bigelow's tansyaster (*Dieteria bigelovii*), Dakota mock vervain (*Glandularia bipinnatifida*), and possibly others.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	Annual forbs, *Ambrosia acanthicarpa , Bouteloua gracilis, Bouteloua curtipendula*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	*Populus angustifolia, Juglans major, Acer negundo*
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Artemisia dracunculus, Sphaeralcea fendleri*
Field (0–0.5 m)	*Sporobolus cryptandrus, Muhlenbergia alopecuroides, Verbascum thapsus, Elymus elymoides, Dieteria bigelovii, Glandularia bipinnatifida*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This type has been described solely from data collected at Gila Cliff Dwellings NM during this project. This includes three classification plots and one mapped classification polygon.

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP072, IP074, IP076
Gila Cliff Dwellings National Monument, Polygons: 1 polygon
Local Description Authors: J. Galvin, S. Studd

15. Post-fire Riparian Mixed Herbaceous Association (PS)

Translated name: Post-fire Riparian Mixed Herbaceous Association (PS)
NVC name: Not available
Identifier: NPSSODN042

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: Post-fire Riparian Mixed Herbaceous (PS)

DISTRIBUTION

Gila Cliff Dwellings National Monument

This type is distributed along the length of the river within the park and between the two units. It occurs in the broader areas of the floodplain (300–500 m across).

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This community was mapped in very low-gradient floodplains and alluvial terraces associated with the Gila River. Bare ground and small-sized gravel are prolific and indicate the active nature of this floodplain, with scouring and deposition events. Litter and downed wood are rare. This community is associated more with the substrate and floodplain processes than with elevation and aspect (which is slight).

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This variable vegetation type is characterized by dense herbaceous cover of 35–70%, primarily composed of sand dropseed (*Sporobolus cryptandrus*), Fendler's globemallow (*Sphaeralcea fendleri*), and annual forbs. Dominance switches between these species/lifeforms across the different examples of this type and can also have the common associates, golden crownbeard (*Verbesina encelioides*), blue grama (*Bouteloua gracilis*), and/or tarragon (*Artemisia dracunculus*), in abundances of 7–12%. The globemallow appears to be responding positively to the effects of the Miller Fire. It has consistent cover of 10% when estimated over large areas, but may start to decline as time since fire increases. Sand dropseed (*S. cryptandrus*) usually averages around 11% but can provide upwards of 40% cover or be nearly absent. Shrubs are uncommon and subcanopy vegetation is not more than 5% in total. Riparian trees, such as narrowleaf cottonwood (*Populus angustifolia*), boxelder (*Acer negundo*), and Arizona walnut (*Juglans major*), as well as the more upland species, ponderosa pine (*Pinus ponderosa*) and gray oak (*Quercus grisea*), are sometimes present as scattered individuals but are not indicative of this type, occurring in isolated inclusions, on old terrace surfaces, or the edges of mapped polygons.

Other common species found in the field layer include prickly poppy (*Argemone pleiacantha*), sacred thorn-apple (*Datura wrightii*), stinking gourd (*Cucurbita foetidissima*), Adonis blazingstar (*Mentzelia multiflora*), bristly wolfstail (*Muhlenbergia alopecuroides*), tarragon (*Artemisia dracunculus*), Russian thistle (*Salsola tragus*), common mullein (*Verbascum thapsus*), sweet four o'clock (*Mirabilis longiflora*), and canyon grape (*Vitis arizonica*). Burning bush (*Kochia scoparia*) is a very inconsistent, non-native associate that is primarily present in the vicinity of Woody's Corral. The perennial-to-annual ratio will vary throughout the year. The annual component of this type may change compositionally over time, but currently has a distinctly "weedy" slant, which is typical of disturbed riparian areas like this. While not always immediately adjacent to the river channel, these areas are still occasionally subject to severe disturbance in the form of flood scouring. This could substantially change the composition and abundance of the vegetation, albeit temporarily.

This type is similar to the Annual Forb - Mixed *Bouteloua* spp. Herbaceous type but differs in having much lower

and less consistent grama (*Bouteloua* spp.) cover, lower annual-forb cover, and much higher perennial-grass cover, specifically contributed from sand dropseed (*S. cryptandrus*). The presence and regular distribution of Fendler's globemallow (*S. fendleri*), at least in the years immediately post-fire, also differentiates this type.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	Annual forbs, *Sporobolus cryptandrus, Sphaeralcea fendleri*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Verbesina encelioides, Bouteloua gracilis, Artemisia dracunculus*
Field (0–0.5 m)	*Argemone pleiacantha, Datura wrightii, Cucurbita foetidissima, Mentzelia multiflora, Muhlenbergia alopecuroides, Kochia scoparia*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This type has been described solely from data collected at Gila Cliff Dwellings NM during this project. This includes seven classification plots and four mapped classification polygons.

Global

Data not available.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP009, IP020, IP033, IP034, IP035, IP075, IP181
Gila Cliff Dwellings National Monument, Polygons: 6 polygons
Local Description Authors: J. Galvin, S. Studd

16. *Bouteloua gracilis* Grassland Association

Translated name: Blue grama Grassland Association
NVC name: CEGL001760
Identifier: N/A

NVC CLASSIFICATION

Division:	Western North American Cool Semi-Desert Scrub & Grassland [3.B.1.Ne]
Macrogroup:	Great Basin & Intermountain Dry Shrubland & Grassland [M171]
Group:	Intermountain Semi-Desert Grassland [G311]
Alliance:	*Pleuraphis jamesii* Grassland [A1287]
Association:	*Bouteloua gracilis* Grassland [CEGL001760]

DISTRIBUTION

Gila Cliff Dwellings National Monument

This type occurs on flat-to-gently sloping mesa tops around the TJ unit of the park and on the mesa tops south of Woody's Corral.

ENVIRONMENTAL DESCRIPTION

Gila Cliff Dwellings National Monument

This grassland type spans flat-to-gently sloping (1–6%) mesa tops and shoulders with bare soil and gravel-dominated substrates. Typically, these communities span multiple aspects north and south of the Gila River, with an elevation ranging from 1,700 to 1,800 m (5,600–5,800 ft).

VEGETATION DESCRIPTION

Gila Cliff Dwellings National Monument

This association is characterized by a moderate (20–55% cover) herbaceous layer solely dominated by the warm-season, perennial shortgrass, blue grama (*Bouteloua gracilis*). This species has a patchy-to-even distribution, with cover values ranging from 8% to 30% and averaging to 16%. This association is predominately present as an herbaceous opening surrounded by woodlands dominated by oneseed juniper (*Juniperus monosperma*) and two-needle pinyon (*Pinus edulis*). As a result, these species are often present in low cover (<1%), typically near the margins of the blue grama (*B. gracilis*) herbaceous association. Other examples occur in areas where the Miller Fire burned severely enough to consume all tree species, rendering former pinyon-juniper savanna stands now solely dominated by blue grama (*B. gracilis*). Other associated species in the herbaceous layer include bristly wolfstail (*Muhlenbergia alopecuroides*), false boneset (*Brickellia eupatorioides*), little hogweed (*Portulaca oleracea*), Colorado four o'clock (*Mirabilis multiflora*), dwarf stickpea (*Calliandra humilis*), weeping lovegrass (*Eragrostis curvula*), spidergrass (*Aristida ternipes*), purple threeawn (*Aristida purpurea*), and ragleaf bahia (*Amauriopsis dissecta*). While these species are consistent across this association, they provide very low cover. This type is most reliably distinguished from the similar *Pinus ponderosa* Woodland and Tree Savanna type by the general lack of ponderosa pine (*Pinus ponderosa*).

GLOBAL TYPE CONCEPT DESCRIPTION

Information from NatureServe:

> This minor plant association is reported from Arizona, western Colorado, New Mexico, Utah and Wyoming. Elevation ranges from 1660-2780 m (5420-9115 feet). Sites are flat to moderately sloping and include plains, old lavaflows, kipukas, valley bottoms, sand and limestone hills, plateaus, and montane meadows and parks. Substrates are variable and range from coarse-textured soils derived from sand, gravel, granite or cinder to silty clay loam soils. This association 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 but may be diverse over the range of the type. Scattered *Ericameria nauseosa*, *Tetradymia canescens*, and *Gutierrezia sarothrae* shrubs and an occasional *Pinus edulis*, *Juniperus* spp., or *Pinus ponderosa* tree (in montane stands) may be present.

MOST ABUNDANT SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	*Bouteloua gracilis*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Gila Cliff Dwellings National Monument

Stratum	Species
Canopy (>5 m)	None
Canopy (2–5 m)	*Juniperus monosperma*
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	*Portulaca oleracea, Muhlenbergia alopecuroides, Brickellia eupatorioides, Aristida ternipes, Aristida purpurea, Amauriopsis dissecta, Eragrostis curvula*

CLASSIFICATION COMMENTS

Gila Cliff Dwellings National Monument

This association was described from six classification plots and six classification polygons.

Global

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 blue grama (*B. gracilis*)-dominated grasslands that lack other diagnostic species. Blue grama (*B. gracilis*) is often able to persist after other species are eliminated because it is an extremely drought- and grazing-tolerant species.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: G4Q
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Gila Cliff Dwellings National Monument, Inventory Notes: Data are not available.
Gila Cliff Dwellings National Monument, Plots: IP062, IP099, IP173, IP189, IP194
Gila Cliff Dwellings National Monument, Polygons: 8 polygons
Local Description Authors: J. Galvin, S. Studd
Global Description Citation: K.A. Schulz, J. Coles and M.E. Hall 2016. *Bouteloua gracilis* Grassland, 14Jul2016. United States National Vegetation Classification. Federal Geographic Data Committee, Washington, D.C. Accessed 09/26/2018.

Appendix E. Accuracy Assessment Documentation of Changes to Plot Attribution

Table E-1 provides a detailed listing of changes made to plot attributes post-accuracy assessment. Each case is treated individually and referenced using the plot ID and the associated polygon name in parenthesis.

Table E-1. Changes made to plot attributes following accuracy assessment.

AA plot(s)	Decision	Reason
239, 243, 249	Plots removed from analysis	As a result of flooding in 2013, all vegetation was scoured from the plots.
257, 259	Plot removed from analysis	Due to access difficulties, the plot was assessed from afar with the aid of binoculars. When compared to the imagery at the plot location, the assessors' placement of the plot does not make sense.
263, 267, 274, 278,	Plots changed from a *Pinus edulis - Juniperus monosperma (Quercus grisea) / Bouteloua gracilis* Woodland to a *Cercocarpus montanus* Shrubby Rock Outcrop	AA datasheets and imagery indicated the overwhelming dominance of exposed bedrock and the noteworthy presence of *Cercocarpus montanus*.
028	Plot removed from analysis	Assessors' used snags to key plot. Assessors' were supposed to assign plots based on current conditions and not what would have been there prior to the Miller Fire.
002	Plot removed from analysis	Location of survey was outside of plots boundary and within an adjacent type. No notes were made to explain this issue.
080, 081, 087	Plots changed from a *Quercus gambelii* (*Quercus grisea*) Shrub Savanna Association to a *Pseudotsuga menziesii - Quercus gambelii* Forest Association	One crew of assessors was consistently and incorrectly placing plots dominated by mature, unburned *Quercus gambelii* with the burned, regenerating *Q. gambelii* shrubland.
034, 067, 095, 097, 247, 288, 294	Plots changed to various communities	Based on imagery, photos, and listed dominant species we determined that these plots were incorrectly placed.

Appendix F. Species Lists

List of all plant species observed during intermediate plot data collection and polygon-scale data collection at Gila Cliff Dwellings National Monument from 2012 to 2013. The columns indicate which portion of the project is associated with a species observation and if it was documented at either park unit or across the broader project area (FS=U.S. Forest Service land). Non-native species are bolded.

Table F-1. All plant species observed during intermediate plot data collection and polygon-scale data collection, Gila Cliff Dwellings NM, 2012–2013.

			Intermediate plots			Pol✓gons		
Family	Scientific name	Common name	Main unit	TJ unit	FS	Main unit	TJ unit	FS
Amaranthaceae	*Amaranthus palmeri*	carelessweed	–	–	–	–	–	✓
Amaranthaceae	*Atriplex canescens*	fourwing saltbush	–	–	–	–	✓	✓
Amaranthaceae	*Chenopodium leptophyllum*	narrowleaf goosefoot	✓	✓	✓	–	✓	✓
Amaranthaceae	*Gomphrena caespitosa*	tufted globe amaranth	–	–	✓	–	–	–
Amaranthaceae	*Kochia scoparia*	burningbush	–	–	–	–	–	✓
Amaranthaceae	*Salsola tragus*	prickly Russian thistle	–	✓	✓	–	✓	✓
Amaryllidaceae	*Allium cernuum*	nodding onion	✓	–	✓	–	–	✓
Anacardiaceae	*Rhus aromatica*	fragrant sumac	–	–	✓	✓	✓	✓
Anacardiaceae	*Rhus microphylla*	littleleaf sumac	–	–	–	–	–	✓
Anacardiaceae	*Toxicodendron rydbergii*	western poison ivy	✓	–	✓	✓	–	✓
Apocynaceae	*Apocynum cannabinum*	Indianhemp	✓	–	–	–	–	–
Apocynaceae	*Asclepias nyctaginifolia*	Mojave milkweed	–	–	✓	✓	✓	✓
Apocynaceae	*Asclepias subverticillata*	horsetail milkweed	–	–	–	✓	–	✓
Apocynaceae	*Asclepias tuberosa*	butterfly milkweed	–	–	✓	–	–	
Asparagaceae	*Agave palmeri*	Palmer's century plant	✓	–	–	–	–	–
Asparagaceae	*Echeandia flavescens*	Torrey's craglily	–	–	✓	✓	–	✓
Asparagaceae	*Maianthemum racemosum*	feathery false lily of the valley	✓	–	✓	✓	–	✓
Asparagaceae	*Maianthemum stellatum*	starry false lily of the valley	✓	–	✓	✓	–	✓
Asparagaceae	*Nolina microcarpa*	sacahuista	–	–	–	–	–	✓
Asparagaceae	*Yucca baccata*	banana yucca	✓	–	✓	✓	✓	✓
Asparagaceae	*Yucca elata*	soaptree yucca	–	–	–	–	–	✓
Asteraceae	*Achillea millefolium*	common yarrow	✓	–	✓	✓	–	✓
Asteraceae	*Ageratina herbacea*	fragrant snakeroot	✓	–	✓	✓	–	✓
Asteraceae	*Amauriopsis dissecta*	ragleaf bahia	✓	✓	✓	✓	✓	✓
Asteraceae	*Ambrosia acanthicarpa*	flatspine bur ragweed	–	–	✓	–	–	–
Asteraceae	*Ambrosia confertiflora*	weakleaf bur ragweed	–	–	✓	–	–	✓
Asteraceae	*Artemisia carruthii*	Carruth's sagewort	✓	–	✓	✓	✓	✓
Asteraceae	*Artemisia dracunculus*	tarragon	✓	✓	✓	✓	✓	✓
Asteraceae	*Artemisia ludoviciana*	white sagebrush	✓	–	✓	✓	✓	✓
Asteraceae	*Baccharis brachyphylla*	shortleaf baccharis	–	–	✓	–	–	–
Asteraceae	*Baccharis pteronioides*	yerba de pasmo	–	–	✓	✓	–	✓
Asteraceae	*Bidens frondosa*	devil's beggartick	✓	–	–	✓	–	✓
Asteraceae	*Brickellia brachyphylla*	plumed brickellbush	✓	✓	✓	✓	✓	✓
Asteraceae	*Brickellia californica*	California brickellbush	–	–	✓	✓	–	✓
Asteraceae	*Brickellia eupatorioides*	false boneset	✓	✓	✓	✓	✓	✓

Table F-1. All plant species observed during intermediate plot data collection and polygon-scale data collection, Gila Cliff Dwellings NM, 2012–2013, cont.

			Intermediate plots			Pol✓gons		
Family	Scientific name	Common name	Main unit	TJ unit	FS	Main unit	TJ unit	FS
Asteraceae	*Brickellia floribunda*	Chihuahuan brickellbush	✓	–	✓	✓	✓	✓
Asteraceae	*Brickellia grandiflora*	tasselflower brickellbush	✓	–	✓	✓	–	✓
Asteraceae	*Brickellia rusbyi*	stinking brickellbush	–	–	✓	–	–	–
Asteraceae	*Chaetopappa ericoides*	rose heath	–	–	✓	✓	✓	✓
Asteraceae	*Cirsium neomexicanum*	New Mexico thistle	–	–	✓	–	–	–
Asteraceae	*Conyza canadensis*	Canadian horseweed	✓	–	✓	✓	–	✓
Asteraceae	*Dieteria bigelovii*	Bigelow's tansyaster	✓		✓	✓	✓	✓
Asteraceae	*Dieteria bigelovii* var. *bigelovii*	Bigelow's tansyaster	–	–	✓	✓	–	✓
Asteraceae	*Ericameria nauseosa*	rubber rabbitbrush	–	–	✓	–	–	–
Asteraceae	*Ericameria nauseosa* var. *bigelovii*	rubber rabbitbrush	–	–	✓	✓	✓	✓
Asteraceae	*Erigeron divergens*	spreading fleabane	–	–	✓	✓	–	✓
Asteraceae	*Erigeron flagellaris*	trailing fleabane	✓	–	✓	✓	–	✓
Asteraceae	*Erigeron formosissimus*	beautiful fleabane	✓	–	✓	✓	–	✓
Asteraceae	*Erigeron neomexicanus*	New Mexico fleabane	✓	–	✓	✓	–	✓
Asteraceae	*Erigeron oreophilus*	chaparral fleabane	✓	–	✓	✓	–	✓
Asteraceae	*Erigeron speciosus*	aspen fleabane	✓	–	✓	–	–	–
Asteraceae	*Erigeron tracyi*	running fleabane	✓	–	✓	–	–	✓
Asteraceae	*Erigeron vreelandii*	Vreeland's erigeron	✓	–	–	–	–	–
Asteraceae	*Geraea canescens*	hairy desertsunflower	✓	–	–	–	–	–
Asteraceae	*Gutierrezia microcephala*	threadleaf snakeweed	✓	–	✓	✓	✓	✓
Asteraceae	*Gutierrezia sarothrae*	broom snakeweed	–	–	✓	–	–	–
Asteraceae	*Heliomeris multiflora*	showy goldeneye	✓	✓	✓	✓	✓	✓
Asteraceae	*Hieracium fendleri*	yellow hawkweed	–	–	✓	–	–	–
Asteraceae	*Hymenopappus filifolius*	fineleaf hymenopappus	–	–	✓	–	–	–
Asteraceae	*Hymenopappus mexicanus*	Mexican woollywhite	✓		–	✓		✓
Asteraceae	*Hymenothrix wislizeni*	Trans-Pecos thimblehead	–	–	✓	✓	–	✓
Asteraceae	*Hymenothrix wrightii*	Wright's thimblehead	–	–	–	✓	–	–
Asteraceae	*Lactuca graminifolia*	grassleaf lettuce	✓	–	–	–	–	–
Asteraceae	*Lactuca serriola*	prickly lettuce	✓	–	✓	✓	✓	✓
Asteraceae	*Mulgedium oblongifolium*	blue lettuce	✓	–	✓	–	–	–
Asteraceae	*Packera neomexicana*	New Mexico groundsel	✓	–	✓	✓	–	✓
Asteraceae	*Porophyllum gracile*	slender poreleaf	–	–	–	✓	–	✓
Asteraceae	*Pseudognaphalium*	cudweed	✓	–	✓	✓	–	✓
Asteraceae	*Pseudognaphalium canescens*	Wright's cudweed	✓	–	✓	✓	✓	✓
Asteraceae	*Pseudognaphalium macounii*	Macoun's cudweed	✓	–	✓	–	–	–
Asteraceae	*Pseudognaphalium stramineum*	cottonbatting plant	✓	–	✓	–	–	–
Asteraceae	*Rudbeckia laciniata*	cutleaf coneflower	✓	–	✓	✓	–	✓
Asteraceae	*Senecio flaccidus*	threadleaf ragwort	–	–	✓	–	✓	✓

Table F-1. All plant species observed during intermediate plot data collection and polygon-scale data collection, Gila Cliff Dwellings NM, 2012–2013, cont.

Family	Scientific name	Common name	Intermediate plots			Pol✓gons		
			Main unit	TJ unit	FS	Main unit	TJ unit	FS
Asteraceae	*Solidago velutina*	threenerve goldenrod	–	–	✓	✓	–	✓
Asteraceae	*Solidago wrightii*	Wright's goldenrod	✓	–	✓	✓	–	✓
Asteraceae	*Sonchus asper*	spiny sowthistle	✓	–	✓	✓	–	✓
Asteraceae	*Stephanomeria thurberi*	Thurber's wirelettuce	✓	–	–	–	–	–
Asteraceae	*Taraxacum erythrospermum*	rock dandelion	✓	–	–	–	–	✓
Asteraceae	*Taraxacum officinale*	common dandelion	✓	–	–	✓	–	✓
Asteraceae	*Tragopogon dubius*	yellow salsify	✓	–	–	✓	–	✓
Asteraceae	*Verbesina encelioides*	golden crownbeard	–	–	✓	–	–	✓
Asteraceae	*Viguiera cordifolia*	heartleaf goldeneye	✓	–	✓	✓	✓	✓
Asteraceae	*Viguiera dentata*	toothleaf goldeneye	✓	✓	✓	✓	✓	✓
Asteraceae	*Xanthisma spinulosum*	lacy tansyaster	–	–	–	–	–	✓
Asteraceae	*Xanthium strumarium*	rough cocklebur	–	–	–	–	–	✓
Betulaceae	*Alnus oblongifolia*	Arizona alder	–	–	✓	✓	–	✓
Boraginaceae	*Hackelia floribunda*	manyflower stickseed	✓	–	✓	✓	–	✓
Boraginaceae	*Lappula occidentalis*	flatspine stickseed	–	–	✓	–	–	–
Boraginaceae	*Lithospermum macromeria*	giant trumpets	✓	–	–	✓	–	✓
Boraginaceae	*Lithospermum multiflorum*	manyflowered stoneseed	✓	–	✓	–	–	–
Brassicaceae	*Draba mogollonica*	Mogollon Mountain draba	✓	–	✓	✓	–	✓
Brassicaceae	*Erysimum capitatum*	sanddune wallflower	✓	✓	✓	✓	–	✓
Brassicaceae	*Hesperidanthus linearifolius*	slimleaf plainsmustard	✓	–	✓	✓	✓	✓
Brassicaceae	*Nasturtium officinale*	watercress	✓	–	–	–	–	–
Brassicaceae	*Noccaea fendleri* ssp. *glauca*	alpine pennycress	✓	–	✓	✓	–	✓
Brassicaceae	*Pennellia micrantha*	mountain mock thelypody	✓	–	✓	✓	–	✓
Brassicaceae	*Physaria gooddingii*	Goodding's bladderpod	✓	–	✓	–	–	–
Brassicaceae	*Physaria gordonii*	Gordon's bladderpod	✓	–	–	✓	✓	✓
Cactaceae	*Cylindropuntia spinosior*	walkingstick cactus	✓	–	✓	✓	✓	✓
Cactaceae	*Echinocereus*	hedgehog cactus	–	–	–	–	–	✓
Cactaceae	*Echinocereus coccineus*	scarlet hedgehog cactus	✓	–	✓	✓	✓	✓
Cactaceae	*Echinocereus fendleri*	pinkflower hedgehog cactus	✓	–	✓	✓	–	✓
Cactaceae	*Echinocereus triglochidiatus*	kingcup cactus	–	–	–	–	–	✓
Cactaceae	*Escobaria vivipara*	spinystar	–	–	✓	–	–	✓
Cactaceae	*Mammillaria*	globe cactus	–	–	✓	–	–	–
Cactaceae	*Opuntia engelmannii*	cactus apple	✓	–	✓	✓	–	✓
Cactaceae	*Opuntia phaeacantha*	tulip pricklypear	✓	–	✓	✓	✓	✓
Cannabaceae	*Humulus lupulus*	common hop	✓	–	✓	✓	–	✓
Caprifoliaceae	*Lonicera albiflora*	western white honeysuckle	✓	–	✓	–	–	✓
Caryophyllaceae	*Silene antirrhina*	sleepy silene	✓	–	–	–	–	–
Caryophyllaceae	*Silene laciniata*	cardinal catchfly	✓	–	–	–	–	✓
Commelinaceae	*Commelina dianthifolia*	birdbill dayflower	✓	–	✓	✓	✓	✓
Commelinaceae	*Commelina tuberosa*	commelina	–	–	–	–	–	✓
Convolvulaceae	*Convolvulus arvensis*	field bindweed	–	–	✓	–	–	–
Convolvulaceae	*Cuscuta indecora*	bigseed alfalfa dodder	–	–	✓	–	–	–

Table F-1. All plant species observed during intermediate plot data collection and polygon-scale data collection, Gila Cliff Dwellings NM, 2012–2013, cont.

			Intermediate plots			Pol✓gons		
Family	Scientific name	Common name	Main unit	TJ unit	FS	Main unit	TJ unit	FS
Convolvulaceae	*Evolvulus sericeus*	silver dwarf morning-glory	–	–	✓	–	✓	✓
Convolvulaceae	*Ipomoea hederifolia*	scarletcreeper	✓	✓	✓	–	✓	✓
Convolvulaceae	*Ipomoea purpurea*	tall morning-glory	–	–	–	–	–	✓
Cornaceae	*Cornus sericea*	redosier dogwood	–	–	–	✓	–	✓
Crassulaceae	*Sedum cockerellii*	Cockerell's stonecrop	–	–	–	✓	–	✓
Cucurbitaceae	*Cucurbita foetidissima*	Missouri gourd	✓	–	✓	✓	✓	✓
Cucurbitaceae	*Marah gilensis*	Gila manroot	✓	–	–	–	✓	✓
Cupressaceae	*Juniperus deppeana*	alligator juniper	✓	–	✓	✓	✓	✓
Cupressaceae	*Juniperus monosperma*	oneseed juniper	✓	–	✓	✓	✓	✓
Cupressaceae	*Juniperus scopulorum*	Rocky Mountain juniper	✓	–	✓	✓	✓	✓
Cyperaceae	*Carex geophila*	White Mountain sedge	✓	–	✓	✓	–	✓
Cyperaceae	*Carex lenticularis*	lakeshore sedge	–	–	–	–	–	✓
Cyperaceae	*Carex praegracilis*	clustered field sedge	✓	–	–	–	–	–
Cyperaceae	*Carex senta*	swamp carex	✓	–	–	✓	✓	✓
Cyperaceae	*Cyperus esculentus*	yellow nutsedge	✓	–	✓	✓	✓	✓
Cyperaceae	*Cyperus fendlerianus*	Fendler's flatsedge	✓	–	✓	✓	–	✓
Cyperaceae	*Cyperus rotundus*	nutgrass	✓	–	–	–	–	–
Cyperaceae	*Cyperus sphaerolepis*	Rusby's flatsedge	✓	–	–	–	–	–
Cyperaceae	*Schoenoplectus tabernaemontani*	softstem bulrush	–	–	–	✓	–	✓
Equisetaceae	*Equisetum laevigatum*	smooth horsetail	–	–	✓	–	–	–
Euphorbiaceae	*Euphorbia chamaesula*	mountain spurge	✓	–	✓	–	–	–
Euphorbiaceae	*Euphorbia esula*	leafy spurge	–	–	–	–	–	✓
Euphorbiaceae	*Tragia nepetifolia*	catnip noseburn	✓	–	✓	✓	–	✓
Euphorbiaceae	*Tragia ramosa*	branched noseburn	–	–	✓	–	✓	✓
Fabaceae	*Acmispon rigidus*	shrubby deervetch	✓	–	–	–	–	–
Fabaceae	*Acmispon wrightii*	Wright's deervetch	✓	–	✓	✓	✓	✓
Fabaceae	*Amorpha fruticosa*	false indigo bush	–	–	✓	–	–	–
Fabaceae	*Astragalus tephrodes*	ashen milkvetch	✓	–	✓	✓	–	✓
Fabaceae	*Calliandra humilis*	dwarf stickpea	✓	–	✓	✓	✓	✓
Fabaceae	*Cologania angustifolia*	longleaf cologania	✓	–	✓	–	✓	✓
Fabaceae	*Dalea albiflora*	whiteflower prairie clover	✓	–	✓	✓	–	✓
Fabaceae	*Dalea candida*	white prairie clover	✓	–	✓	✓	✓	✓
Fabaceae	*Dalea formosa*	featherplume	–	–	✓	–	–	✓
Fabaceae	*Dalea neomexicana*	downy prairie clover	✓	–	–	–	–	–
Fabaceae	*Lupinus arizonicus*	Arizona lupine	✓	–	–	–	–	–
Fabaceae	*Macroptilium gibbosifolium*	variableleaf bushbean	✓	–	✓	✓	✓	✓
Fabaceae	*Medicago lupulina*	black medick	–	–	–	✓	–	✓
Fabaceae	*Melilotus albus*	sweetclover	✓	–	✓	✓	–	✓
Fabaceae	*Melilotus officinalis*	sweetclover	✓	–	–	–	–	–
Fabaceae	*Oxytropis lambertii*	purple locoweed	–	–	✓	✓	–	✓
Fabaceae	*Phaseolus angustissimus*	slimleaf bean	✓	–	✓	✓	–	✓

Table F-1. All plant species observed during intermediate plot data collection and polygon-scale data collection, Gila Cliff Dwellings NM, 2012–2013, cont.

			Intermediate plots			Pol✓gons		
Family	Scientific name	Common name	Main unit	TJ unit	FS	Main unit	TJ unit	FS
Fabaceae	*Phaseolus ritensis*	Santa Rita Mountain bean	✓	–	✓	✓	–	✓
Fabaceae	*Psoralidium tenuiflorum*	slimflower scurfpea	–	–	–	–	–	✓
Fabaceae	*Rhynchosia senna*	Texas snoutbean	✓	–	✓	✓	✓	✓
Fabaceae	*Rhynchosia senna* var. *texana*	Texas snoutbean	✓	–	✓	✓	–	✓
Fabaceae	*Robinia neomexicana*	New Mexico locust	✓	–	✓	✓	–	✓
Fabaceae	*Vicia americana*	American vetch	✓	–	–	–	–	–
Fagaceae	*Quercus gambelii*	Gambel oak	✓	–	✓	✓	–	✓
Fagaceae	*Quercus grisea*	gray oak	✓	✓	✓	✓	✓	✓
Garryaceae	*Garrya wrightii*	Wright's silktassel	✓	–	✓	✓	–	✓
Gentianaceae	*Frasera speciosa*	elkweed	✓	–	✓	–	–	–
Geraniaceae	*Geranium caespitosum*	pineywoods geranium	✓	–	✓	✓	–	✓
Geraniaceae	*Geranium richardsonii*	Richardson's geranium	✓	–	–	–	–	–
Grossulariaceae	*Ribes aureum*	golden currant	✓	–	✓	✓	✓	✓
Grossulariaceae	*Ribes cereum*	wax currant	✓	–	✓	–	–	–
Grossulariaceae	*Ribes leptanthum*	trumpet gooseberry	✓	–	–	–	–	✓
Hydrangeaceae	*Fendlera rupicola*	cliff fendlerbush	–	–	✓	–	–	–
Hydrangeaceae	*Fendlera rupicola* var. *wrightii*	Wright's fendlerbush	–	–	✓	–	✓	✓
Juglandaceae	*Juglans major*	Arizona walnut	✓	–	✓	✓	✓	✓
Juncaceae	*Juncus saximontanus*	Rocky Mountain rush	✓	–	–	–	–	–
Lamiaceae	*Agastache pallidiflora* ssp. *neomexicana*	Bill Williams Mountain giant hyssop	✓	–	–	✓	–	✓
Lamiaceae	*Hedeoma nana*	dwarf false pennyroyal	✓	–	✓	–	–	–
Lamiaceae	*Hedeoma oblongifolia*	oblongleaf false pennyroyal	✓	–	✓	✓	–	✓
Lamiaceae	*Marrubium vulgare*	horehound	–	–	✓	–	✓	✓
Lamiaceae	*Mentha arvensis*	wild mint	✓	–	✓	✓	–	✓
Lamiaceae	*Monarda fistulosa*	wild bergamot	✓	–	✓	✓	–	✓
Linaceae	*Linum neomexicanum*	New Mexico yellow flax	✓	–	–	–	–	–
Loasaceae	*Mentzelia multiflora*	Adonis blazingstar	✓	✓	✓	✓	✓	✓
Malvaceae	*Malva parviflora*	cheeseweed mallow	–	–	✓	–	–	–
Malvaceae	*Sphaeralcea fendleri*	Fendler's globemallow	✓	✓	✓	✓	✓	✓
Montiaceae	*Phemeranthus aurantiacus*	orange fameflower	–	–	✓	–	–	–
Montiaceae	*Phemeranthus parviflorus*	sunbright	–	–	✓	–	–	–
Nyctaginaceae	*Allionia incarnata*	trailing windmills	–	–	✓	–	–	–
Nyctaginaceae	*Mirabilis albida*	white four o'clock	✓	–	✓	✓	–	✓
Nyctaginaceae	*Mirabilis coccinea*	scarlet four o'clock	✓	✓	✓	✓	–	✓
Nyctaginaceae	*Mirabilis linearis*	narrowleaf four o'clock	✓	–	✓	✓	–	✓
Nyctaginaceae	*Mirabilis longiflora*	sweet four o'clock	✓	✓	✓	✓	✓	✓
Nyctaginaceae	*Mirabilis multiflora*	Colorado four o'clock	✓	✓	✓	✓	✓	✓
Oleaceae	*Forestiera pubescens*	stretchberry	✓	–	✓	✓	✓	✓
Oleaceae	*Fraxinus velutina*	velvet ash	✓	–	✓	✓	✓	✓
Oleaceae	*Menodora scabra*	rough menodora	–	✓	✓	✓	✓	✓

Table F-1. All plant species observed during intermediate plot data collection and polygon-scale data collection, Gila Cliff Dwellings NM, 2012–2013, cont.

			Intermediate plots			Pol✓gons		
Family	Scientific name	Common name	Main unit	TJ unit	FS	Main unit	TJ unit	FS
Onagraceae	*Epilobium ciliatum*	fringed willowherb	✓	–	–	✓	–	✓
Onagraceae	*Oenothera cespitosa*	tufted evening primrose	✓	–	✓	✓	–	✓
Onagraceae	*Oenothera curtiflora*	velvetweed	–	–	✓	–	–	–
Onagraceae	*Oenothera elata*	Hooker's evening primrose	✓	–	✓	✓	–	✓
Onagraceae	*Oenothera hexandra*	harlequinbush	–	–	✓	–	–	–
Onagraceae	*Oenothera hexandra* ssp. *gracilis*	harlequinbush	–	–	✓	–	–	–
Onagraceae	*Oenothera laciniata*	cutleaf evening primrose	–	–	✓	–	–	–
Onagraceae	*Oenothera neomexicana*	New Mexico evening primrose	✓	–	✓	✓	–	✓
Orobanchaceae	*Castilleja integra*	wholeleaf Indian paintbrush	–	✓	✓	✓	–	✓
Oxalidaceae	*Oxalis albicans*	radishroot woodsorrel	✓	–	–	–	–	–
Oxalidaceae	*Oxalis alpina*	alpine woodsorrel	✓	–	✓	✓	–	✓
Oxalidaceae	*Oxalis corniculata*	creeping woodsorrel	–	–	✓	–	–	–
Oxalidaceae	*Oxalis decaphylla*	tenleaf woodsorrel	–	–	✓	–	–	–
Papaveraceae	*Argemone pleiacantha*	southwestern pricklypoppy	✓	✓	✓	✓	✓	✓
Papaveraceae	*Corydalis aurea*	scrambled eggs	✓	–	✓	✓	–	✓
Phrymaceae	*Mimulus guttatus*	seep monkeyflower	✓	–	–	✓	–	✓
Pinaceae	*Pinus discolor*	border pinyon	–	–	✓	–	–	✓
Pinaceae	*Pinus edulis*	twoneedle pinyon	✓	–	✓	✓	✓	✓
Pinaceae	*Pinus ponderosa*	ponderosa pine	✓	✓	✓	✓	✓	✓
Pinaceae	*Pseudotsuga menziesii*	Douglas-fir	✓	–	✓	✓	–	✓
Plantaginaceae	*Maurandella antirrhiniflora*	roving sailor	–	–	✓	–	–	–
Plantaginaceae	*Penstemon*	beardtongue	–	–	✓	✓	–	✓
Plantaginaceae	*Penstemon barbatus*	beardlip penstemon	✓	–	✓	✓	–	✓
Plantaginaceae	*Penstemon virgatus*	upright blue beardtongue	✓	–	–	–	–	–
Plantaginaceae	*Plantago major*	common plantain	✓	–	✓	–	–	–
Plantaginaceae	*Veronica peregrina*	neckweed	–	–	–	–	–	✓
Platanaceae	*Platanus wrightii*	Arizona sycamore	–	–	✓	–	–	✓
Poaceae	*Agrostis gigantea*	redtop	–	–	–	–	–	✓
Poaceae	*Agrostis stolonifera*	creeping bentgrass	–	–	✓	–	–	–
Poaceae	*Aristida purpurea*	purple threeawn	–	–	✓	✓	–	✓
Poaceae	*Aristida schiedeana*	single threeawn	–	–	✓	✓	–	✓
Poaceae	*Aristida schiedeana* var. *orcuttiana*	Orcutt's threeawn	–	–	–	✓	–	–
Poaceae	*Aristida ternipes*	spidergrass	–	–	✓	✓	✓	✓
Poaceae	*Bothriochloa barbinodis*	cane bluestem	✓	–	✓	✓	✓	✓
Poaceae	*Bouteloua curtipendula*	sideoats grama	✓	✓	✓	✓	✓	✓
Poaceae	*Bouteloua eriopoda*	black grama	✓	–	✓	✓	–	✓
Poaceae	*Bouteloua gracilis*	blue grama	✓	✓	✓	✓	✓	✓
Poaceae	*Bouteloua hirsuta*	hairy grama	✓	–	✓	✓	✓	✓
Poaceae	*Bromus carinatus*	California brome	✓	–	✓	✓	✓	✓
Poaceae	*Bromus frondosus*	weeping brome	✓	–	✓	✓	–	✓

Table F-1. All plant species observed during intermediate plot data collection and polygon-scale data collection, Gila Cliff Dwellings NM, 2012–2013, cont.

			Intermediate plots			Pol✓gons		
Family	Scientific name	Common name	Main unit	TJ unit	FS	Main unit	TJ unit	FS
Poaceae	*Bromus inermis*	smooth brome	–	–	–	✓	–	✓
Poaceae	*Bromus japonicus*	field brome	–	–	✓	–	–	✓
Poaceae	*Bromus rubens*	red brome	–	–	–	–	✓	✓
Poaceae	*Bromus tectorum*	cheatgrass	✓	–	✓	✓	–	✓
Poaceae	*Echinochloa crus-galli*	barnyardgrass	✓	–	✓	✓	✓	✓
Poaceae	*Elymus arizonicus*	Arizona wheatgrass	✓	–	✓	✓	–	–
Poaceae	*Elymus canadensis*	Canada wildrye	–	–	–	–	–	✓
Poaceae	*Elymus canadensis* var. *canadensis*	Canada wildrye	✓	–	✓	✓	✓	✓
Poaceae	*Elymus elymoides*	squirreltail	✓	✓	✓	✓	✓	✓
Poaceae	*Eragrostis curvula*	weeping lovegrass	–	–	✓	✓	✓	✓
Poaceae	*Glyceria striata*	fowl mannagrass	✓	–	–	–	–	✓
Poaceae	*Koeleria macrantha*	prairie Junegrass	✓	–	–	✓	–	✓
Poaceae	*Leersia oryzoides*	rice cutgrass	✓	–	–	✓	✓	✓
Poaceae	*Leptochloa dubia*	green sprangletop	–	–	✓	✓	–	–
Poaceae	*Lolium perenne*	perennial ryegrass	–	–	✓	–	–	–
Poaceae	*Muhlenbergia*	muhly	–	–	✓	✓	–	✓
Poaceae	*Muhlenbergia alopecuroides*	bristly wolfstail	✓	✓	✓	✓	✓	✓
Poaceae	*Muhlenbergia dubia*	pine muhly	–	–	✓	✓	–	✓
Poaceae	*Muhlenbergia elongata*	sycamore muhly	–	–	✓	–	–	–
Poaceae	*Muhlenbergia emersleyi*	bullgrass	✓	–	✓	✓	–	✓
Poaceae	*Muhlenbergia longiligula*	longtongue muhly	–	–	✓	–	–	–
Poaceae	*Muhlenbergia mexicana*	Mexican muhly	✓	–	–	✓	–	✓
Poaceae	*Muhlenbergia montana*	mountain muhly	–	–	✓	✓	–	✓
Poaceae	*Muhlenbergia polycaulis*	cliff muhly	✓	–	✓	✓	✓	✓
Poaceae	*Muhlenbergia racemosa*	marsh muhly	✓	–	✓	–	–	–
Poaceae	*Muhlenbergia repens*	creeping muhly	–	–	✓	–	–	–
Poaceae	*Muhlenbergia rigens*	deergrass	✓	–	✓	✓	–	✓
Poaceae	*Muhlenbergia rigida*	purple muhly	–	–	–	–	–	✓
Poaceae	*Muhlenbergia wrightii*	spike muhly	–	–	✓	–	–	–
Poaceae	*Munroa squarrosa*	false buffalograss	–	–	✓	–	–	–
Poaceae	*Pascopyrum smithii*	western wheatgrass	✓	✓	✓	–	✓	✓
Poaceae	*Piptochaetium fimbriatum*	pinyon ricegrass	✓	✓	✓	✓	–	✓
Poaceae	*Piptochaetium pringlei*	Pringle's speargrass	–	–	✓		–	–
Poaceae	*Poa fendleriana*	muttongrass	✓	–	✓	✓	✓	✓
Poaceae	*Poa pratensis*	Kentucky bluegrass	✓	–	✓	✓	–	✓
Poaceae	*Polypogon monspeliensis*	annual rabbitsfoot grass	–	–	–	✓	–	✓
Poaceae	*Schizachyrium*	little bluestem	–	–	–		–	✓
Poaceae	*Schizachyrium cirratum*	Texas bluestem	✓	–	✓	✓	–	✓
Poaceae	*Sphenopholis obtusata*	prairie wedgescale	✓	–	–		–	–
Poaceae	*Sporobolus contractus*	spike dropseed	–	–	✓		–	–

Table F-1. All plant species observed during intermediate plot data collection and polygon-scale data collection, Gila Cliff Dwellings NM, 2012–2013, cont.

Family	Scientific name	Common name	Intermediate plots			Pol✓gons		
			Main unit	TJ unit	FS	Main unit	TJ unit	FS
Poaceae	*Sporobolus cryptandrus*	sand dropseed	✓	✓	✓	✓	✓	✓
Poaceae	*Zuloagaea bulbosa*	bulb panicgrass	✓	–	✓	✓	–	✓
Polemoniaceae	*Ipomopsis aggregata*	scarlet gilia	✓	–	✓		–	✓
Polemoniaceae	*Ipomopsis macombii*	Macomb's ipomopsis	–	–	✓		–	–
Polemoniaceae	*Ipomopsis thurberi*	El Paso skyrocket	✓	–	✓	✓	✓	✓
Polemoniaceae	*Leptosiphon nuttallii*	Nuttall's linanthus	✓	–	–	–	–	–
Polemoniaceae	*Phlox longifolia*	longleaf phlox	✓	–	–	–	–	–
Polygonaceae	*Eriogonum alatum*	winged buckwheat	✓	–	✓	✓	–	✓
Polygonaceae	*Eriogonum trichopes*	little deserttrumpet	–	–	✓	–	–	–
Polygonaceae	*Eriogonum wrightii*	bastardsage	–	–	✓	✓	✓	✓
Polygonaceae	*Fallopia convolvulus*	black bindweed	✓	–	✓	✓	–	✓
Polygonaceae	*Persicaria lapathifolia*	curlytop knotweed	–	–	✓	–	–	✓
Polygonaceae	*Persicaria maculosa*	spotted ladysthumb	✓	–	–	✓	✓	✓
Polygonaceae	*Polygonum aviculare*	prostrate knotweed	–	–	–	–	–	✓
Polygonaceae	*Rumex acetosella*	common sheep sorrel	–	–	–	✓	–	✓
Polygonaceae	*Rumex crispus*	curly dock	✓	–	✓	✓	–	✓
Portulacaceae	*Portulaca oleracea*	little hogweed	✓	–	✓	✓	✓	✓
Pteridaceae	*Argyrochosma fendleri*	Fendler's false cloak fern	–	–	✓	–	–	–
Pteridaceae	*Astrolepis cochisensis*	Cochise scaly cloakfern	–	–	✓	–	–	–
Pteridaceae	*Astrolepis sinuata*	wavy scaly cloakfern	–	–	✓	–	–	–
Pteridaceae	*Cheilanthes eatonii*	Eaton's lipfern	–	–	✓	–	–	–
Pteridaceae	*Cheilanthes feei*	slender lipfern	–	–	✓	–	–	–
Pteridaceae	*Cheilanthes fendleri*	Fendler's lipfern	–	–	✓	–	–	–
Pteridaceae	*Pellaea atropurpurea*	purple cliffbrake	–	–	✓	✓	–	✓
Ranunculaceae	*Aquilegia chrysantha*	golden columbine	✓	–	–	–	–	–
Ranunculaceae	*Clematis ligusticifolia*	western white clematis	✓	–	✓	✓	✓	✓
Ranunculaceae	*Thalictrum fendleri*	Fendler's meadow-rue	✓	–	✓	✓	✓	✓
Rhamnaceae	*Rhamnus betulifolia*	beechleaf frangula	✓	–	✓	✓	–	✓
Rhamnaceae	*Rhamnus californica*	California buckthorn	✓	–	–	–	–	–
Rosaceae	*Cercocarpus montanus*	alderleaf mountain mahogany	✓	–	✓	✓	–	✓
Rosaceae	*Fallugia paradoxa*	Apache plume	–	✓	✓	✓	✓	✓
Rosaceae	*Potentilla thurberi*	scarlet cinquefoil	✓	–	✓	✓	–	✓
Rosaceae	*Prunus serotina*	black cherry	✓	–	✓	✓	–	✓
Rosaceae	*Purshia mexicana* var. *stansburyana*	Stansbury cliffrose	–	–	✓	–	–	✓
Rosaceae	*Rosa woodsii*	Woods' rose	✓	–	–	✓	–	✓
Rubiaceae	*Galium fendleri*	Fendler's bedstraw	✓	–	–	–	–	–
Rubiaceae	*Galium mexicanum*	Mexican bedstraw	✓	–	–	–	–	–
Rubiaceae	*Galium microphyllum*	bracted bedstraw	✓	–	✓	✓	–	✓
Rubiaceae	*Galium wrightii*	Wright's bedstraw	✓	–	✓	–	–	–
Rubiaceae	*Houstonia wrightii*	pygmy bluet	✓	–	✓	✓	–	✓
Rutaceae	*Ptelea trifoliata*	common hoptree	✓	–	–	–	–	✓

Table F-1. All plant species observed during intermediate plot data collection and polygon-scale data collection, Gila Cliff Dwellings NM, 2012–2013, cont.

Family	Scientific name	Common name	Intermediate plots			Pol✓gons		
			Main unit	TJ unit	FS	Main unit	TJ unit	FS
Rutaceae	*Ptelea trifoliata* var. *baldwinii*	common hoptree	✓	–	✓	✓	–	✓
Salicaceae	*Populus angustifolia*	narrowleaf cottonwood	✓	–	✓	✓	✓	✓
Salicaceae	*Populus fremontii*	Fremont cottonwood	✓	–	–	✓	–	✓
Salicaceae	*Populus tremuloides*	quaking aspen	–	–	–	–	–	✓
Salicaceae	*Populus x acuminata*	lanceleaf cottonwood	–	–	–	–	–	✓
Salicaceae	*Salix exigua*	narrowleaf willow	✓	–	✓	✓	–	✓
Salicaceae	*Salix irrorata*	dewystem willow	✓	–	✓	✓	✓	✓
Salicaceae	*Salix lasiolepis*	arroyo willow	✓	–	–	–	✓	✓
Santalaceae	*Phoradendron juniperinum*	juniper mistletoe	–	–	✓	✓	–	✓
Sapindaceae	*Acer negundo*	boxelder	✓	–	✓	✓	✓	✓
Saururaceae	*Anemopsis californica*	yerba mansa	✓	–	–	–	–	–
Saxifragaceae	*Heuchera novamexicana*	New Mexico alumroot	✓	–	✓	–	–	–
Scrophulariaceae	*Scrophularia parviflora*	pineland figwort	✓	–	✓	✓	–	✓
Scrophulariaceae	*Verbascum thapsus*	common mullein	✓	✓	✓	✓	✓	✓
Solanaceae	*Datura wrightii*	sacred thorn-apple	✓	–	✓	✓	✓	✓
Solanaceae	*Lycium pallidum*	pale desert-thorn	–	✓	–	–	–	✓
Solanaceae	*Physalis hederifolia*	ivyleaf groundcherry	✓	–	✓	✓	–	✓
Solanaceae	*Solanum elaeagnifolium*	silverleaf nightshade	–	✓	✓	–	✓	✓
Solanaceae	*Solanum heterodoxum*	melonleaf nightshade	–	–	–	✓	–	✓
Solanaceae	*Solanum jamesii*	wild potato	✓	–	✓	–	✓	✓
Solanaceae	*Solanum stoloniferum*	Fendler's horsenettle	–	–	–	✓	–	✓
Tamaricaceae	*Tamarix chinensis*	five-stamen tamarisk	–	–	✓	–	✓	✓
Typhaceae	*Typha latifolia*	broadleaf cattail	✓	–	–	✓	–	✓
Urticaceae	*Urtica dioica*	stinging nettle	✓	–	✓	✓	–	✓
Verbenaceae	*Glandularia bipinnatifida*	Dakota mock vervain	✓	✓	✓	✓	✓	✓
Violaceae	*Viola canadensis*	Canadian white violet	✓	–	✓	✓	–	✓
Violaceae	*Viola sororia* var. *affinis*	sand violet	–	–	–	✓	–	–
Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	✓	–	✓	✓	✓	✓
Vitaceae	*Vitis arizonica*	canyon grape	✓	–	✓	✓	✓	✓
Woodsiaceae	*Woodsia oregana*	Oregon cliff fern	–	–	✓	–	–	–
Zygophyllaceae	*Kallstroemia parviflora*	warty caltrop	–	–	✓	–	–	–
Zygophyllaceae	*Tribulus terrestris*	puncturevine	–	–	–	✓	–	✓

Appendix G. Geodatabase Specifications, Description, and Schema

A file geodatabase (GDB) was used to house the final map and related data products. It was populated with point and polygon feature classes, relationship classes and tables as shown in Figure G-1. All data is NAD 83 zone 12N. The GDB also contains multiple look-up tables including cover classes, surficial geology and plant species names among others.

Feature-class and related-table descriptions:

- **Veg_Polys**: 203 polygon features, each attributed with an NVC ElCode, map class name, association name, association common name, and unique map class code. Polygons were symbolized and then converted to a representation using the "convert symbology to representation" tool. This embeds the symbology into the GDB such that when loaded into an ArcMap project, it automatically is symbolized using the same color scheme as in the report.

- **Plot_Locations**: 89 point locations. This was data collected in the field. This table is related to **tPlotEvents,** which lists basic information on plot location and shape, date sampled, and soil-cover characteristics and total cover by strata for vegetation.

- **tPlotEvents** is linked to **tPlotEventSpecies,** which details the stratum, species code and percent cover of each species recorded in that plot. TPlotevents also relates to **tPlots,** which contains landscape, landform, and geological attributes for each site. This table is derived from field collected data and is exported out of MS Access.

- **VegPoly_PhotoLocations**: these are locations where photos were taken. These were recorded in the field on handheld Trimble GPS units and subsequently merged and imported into the GDB.

Feature-class attachments:

File attachments were created for the feature classes described above, the Veg_Polys, Plot_Locations and VegPoly_PhotoLocations. In ArcMap 10 this attachment function allows for photos or other files to be embedded into the GDB so they are always accessible through the ArcMap environment. Photos were attached to each plot point (one photo) and each polygon photopoint (four, one in each cardi,nal direction). PDF versions of the one-page vegetation type descriptions are attached to each polygon. All attachments are viewed by using the HTML pop-up tool in the standard toolbar. Once this tool is activated, the user just clicks on any polygon or photopoint and a window opens showing a small icon of the attachment and displays the attributes of the feature.

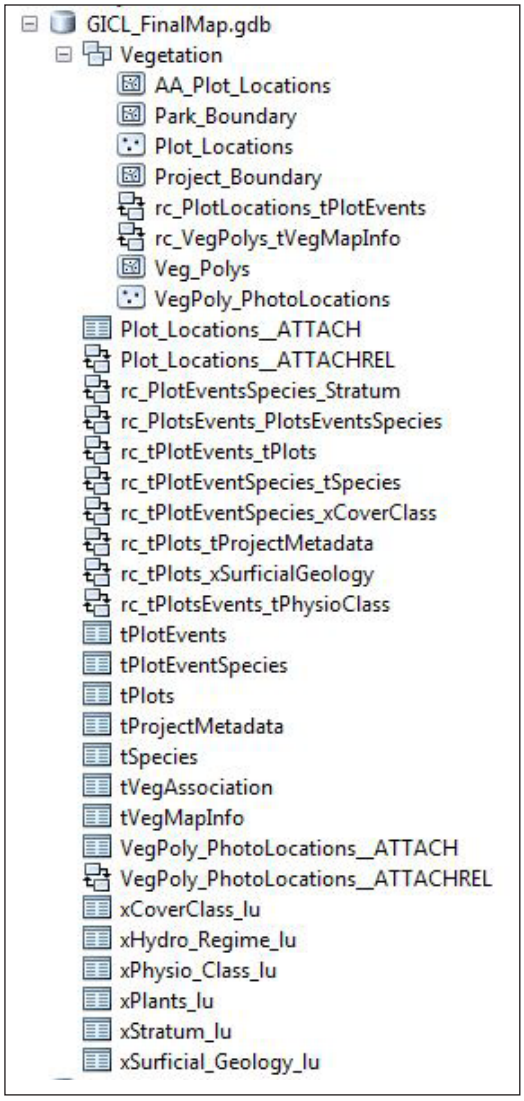


Figure G-1. Geodatabase schema.

Geodatabase:

- GICL_FinalMap.gdb

Feature Dataset:

- Vegetation: UTM Zone 12N. Contains all feature classes and some relationship classes

Feature Classes:

- AA_PlotLocations: Polygon feature representing accuracy assessment plot locations
- Park_Boundary: Unit boundary
- Plot_Locations: Plot corners (also used as plot photo points for feature attachments).
- Project_Boundary: Extent of mapped area
- VegPolys: Vegetation polygons with a unique identifier (Poly_ID or Poly_Code)
- VegPoly_PhotoLocations: Four photos are taken at each point; one for each cardinal direction.

Tables:

- tPlotEvents: Plot metadata and veg info
- tPlotEventSpecies: Recorded species within plot
- tPlots: Landscape attribute data
- tProjectMetadata: Metadata
- tSpecies: Species list
- tVegAssociation: Western veg associations list
- tVegMapInfo: Association data and codes
- xCoverClass_lu: Lookup table for cover classes
- xHydroRegime_lu: Lookup table for hydro regimes
- xPhysioClass_lu: Lookup table for physio classes
- xPlants_lu: Lookup table for plants with USDA symbol
- xStratum_lu: Lookup table for strata
- xSurficial_Geology_lu: Lookup table for surficial geology

Relationship Classes:

- Relates tables to other tables and feature class tables based on a keyed field

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NPS 349/154792, June 2019

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