National Park Service
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Natural Resource Stewardship and Science

Vegetation Inventory, Mapping and Characterization Report, Montezuma Castle National Monument

Castle and Well Units

Natural Resource Report NPS/SODN/NRR—2019/1889









ON THE COVER

Clockwise from top left: Arizona sycamore - Velvet ash Riparian Forest Association; (Arizona juniper) Broom snakeweed - Featherplume Shrubland Association; Velvet mesquite / Red brome - Mouse barley Woodland and Shrubland Association; Velvet mesquite (Catclaw acacia) / (Mixed Perennial Grass - Broom snakeweed) Shrubland Association. NPS photos.

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Acronyms and Abbreviations

AA:	accuracy assessment
ac:	acre(s)
CEGL:	Community Element Code–Global
CI:	confidence interval
cm:	centimeter (s)
ESA:	Ecological Society of America
ESRI:	Environmental Systems Research Institute
FGDC:	Federal Geographic Data Committee
ft:	foot/feet
gal:	gallon(s)
GIS:	geographic information system
GPS:	global positioning system
ha:	hectare (s)
I&M:	Inventory and Monitoring Division
ID:	identification
ITIS:	Integrated Taxonomic Information System
m:	meter (s)
mi:	mile (s)
MMU	minimum mapping unit
MOCA:	Montezuma Castle National Monument
MOCC:	Montezuma Castle National Monument, Castle Unit
MOWE:	Montezuma Castle National Monument, Well Unit
n:	number
NA:	not applicable
NAD83:	North American Datum of 1983
NM:	national monument
NMDS :	non-metric multi-dimensional scaling
NPS:	National Park Service
NVC:	National Vegetation Classification
NVCS:	National Vegetation Classification Standard (or System)
OALS:	Office of Arid Land Studies (University of Arizona)
(P):	proposed
(PS):	park special
PRIMER :	Plymouth Routines in Multivariate Ecological Research
RRQRR:	Reversed Randomized Quadrant-Recursive Raster
SEINet:	Southwest Environmental Information Network
SIMPER :	similarity percentages
SIMPROF :	similarity profile
SODN:	Sonoran Desert Network (National Park Service)
sp./spp.:	species (singular/plural)
TNC:	The Nature Conservancy
UNESCO:	United Nations Education, Science, and Cultural Organization
USDA:	U.S. Department of Agriculture
USGS:	U.S. Geological Survey
USNVC:	United States National Vegetation Classification
UTM:	Universal Transverse Mercator

Executive Summary

From 2009 to 2014, the Sonoran Desert Network conducted a vegetation mapping and characterization effort at Montezuma Castle National Monument (NM), in collaboration with researchers from the University of Arizona's Office of Arid Lands Studies. 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 three major field phases: (1) concurrent, field-based data collection and mapping from aerial imagery (map unit delineation), (2) development of vegetation community types at the National Vegetation Classification (NVC) association level, and (3) map accuracy assessment. Phase 1 was completed in late 2008 and early 2009. Community-type descriptions were drafted to meet the NVC standard and applied to each mapped area. This classification was developed concurrently from plot data and field-censused polygon data (map units). Network staff conducted a thematic accuracy check in spring 2014. This check provided useful information that improved both the detail of the association descriptions and the accuracy of the mapped polygons. Staff conducted a thematic validation check in Spiring 2014. 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.

Montezuma Castle NM covers only 1,000 acres, but its landscape, topography, and geology are relatively complex. A total of 12 distinct communities (10 at the Castle unit and 9 at the Well unit) were described and mapped at the park. These ranged from lush riparian woodlands of Arizona sycamore (*Platanus wrightii*) and velvet ash (*Fraxinus velutina*) along Beaver Creek to velvet mesquite (*Prosopis velutina*) bosques and drier upland sites of crucifixion thorn (*Canotia holocantha*). These communities boast a diverse mixture of shrubs, succulents, and perennial grasses, with influences of the both the Colorado Plateau and the Basin and Range provinces. A total of 226 different plant species were recorded during the project.

Overall accuracy for all map classes was 89.7% (90% CI: 86.2, 93.3) with a Kappa (a measure of overall accuracy minus chance agreement) of 88.4% (90% CI: 84.3, 92.4). Individual accuracies ranged from 46.9% to 100%. Only two of the 12 vegetation types were "accepted" types within the NVC. The others, described here as specific to the park, are currently proposed for formal status within the NVC. The map was designed to facilitate ecologically based natural-resource 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 also 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 the vegetation.

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The authors would like to extend thanks to the staff of Montezuma Castle National Monument for their support of this project throughout its many phases. Additional thanks to Arizona State Parks & Trails, which provided camping sites for field crews at Dead Horse State Park, greatly facilitating our work. Many 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 efforts. These people included Greg Goodrum, Shannon Henke, Beth Fallon, Jeppe Albrektsen, Steve Buckley, Stephanie Roussel, Betsy Vance, Megan Kimball, and Dave Fenlon. Finally, we would like to thank Miguel Villarreal (U.S. Geological Survey) and Megan Swan (Southern Colorado Plateau Network) for their review and helpful comments.

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 (2009–2014) to classify, describe, and map vegetation at the two units of Montezuma Castle National Monument (the Castle and Well units), located in Yavapai County, in central Arizona.

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 Montezuma Castle National Monument (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 Montezuma Castle NM and other network parks, SODN needed baseline vegetation data upon which to develop and implement specific monitoring programs. Park managers needed baseline data and information on park vegetation resources for management purposes.

The current effort to create a new vegetation map for Montezuma Castle NM is part of the NPS Vegetation Mapping Inventory, in cooperation with SODN and the University of Arizona's Office of Arid Lands Studies (OALS). The map is required to meet the standards of the NPS Vegetation Mapping Inventory, including a minimum mapping unit 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 Montezuma Castle National Monument, a study area of about 408 hectares (1,008 acres).

Products developed for the park 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;
- Federal Geographic Data Committee-compliant metadata for all spatial database files and field data;
- 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 (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:

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 grosseseratus* Herbaceous Vegetation (Central Wet-mesic Tallgrass Prairie)

- 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 Montezuma Castle NM include the following:

- *(Larrea tridentata)* / *Parthenium incanum* Shrubland
- *(Juniperus arizonica)* / *Gutierrezia sarothrae - Dalea formosa* Shrubland

1.7 Project area description

1.7.1 Location and setting

Montezuma Castle National Monument comprises two sites, the Castle unit and the Well unit. The Castle unit preserves a 20-room, five-story Sinaguan cliff dwelling that is the largest, most accessible, and best-preserved Sinaguan cliff dwelling in the Southwest, as well as one of the best-preserved cliff dwellings in North America. The Well unit preserves an unusual example of a large, spring-fed limestone sink; prehistoric Hohokam and Sinagua-period ruins and sites; and historic Apache sites.

The two units are located about 18 kilometers (11 mi) apart, near the town of Camp Verde in central Arizona's Yavapai County. They are situated along Wet Beaver Creek, at an altitude of approximately 975 meters (3,200 ft) (Figure 1-1). The total area of the two units is approximately 408 hectares (1,008 acres), which includes the Castle unit's 297 hectares (734 ac) and the Well unit's 111 hectares (274 ac). The surrounding area includes private lands and the Coconino National Forest. Portions of the Yavapai-Apache Nation Indian Reservation are nearby and between the two park units. The Arizona State Land Board manages state trust land near the units (NPS 2010; USGS 2009).

Montezuma Castle NM is within the Central Highlands physiographic province of Arizona, which is a transition zone between the Plateau Uplands (Colorado Plateau) province to the north and the Basin and Range province to the south (USGS 1969, cited in Konieczki and Leake 1997). Rugged mountains composed of igneous, metamorphic, and sedimentary rocks characterize the

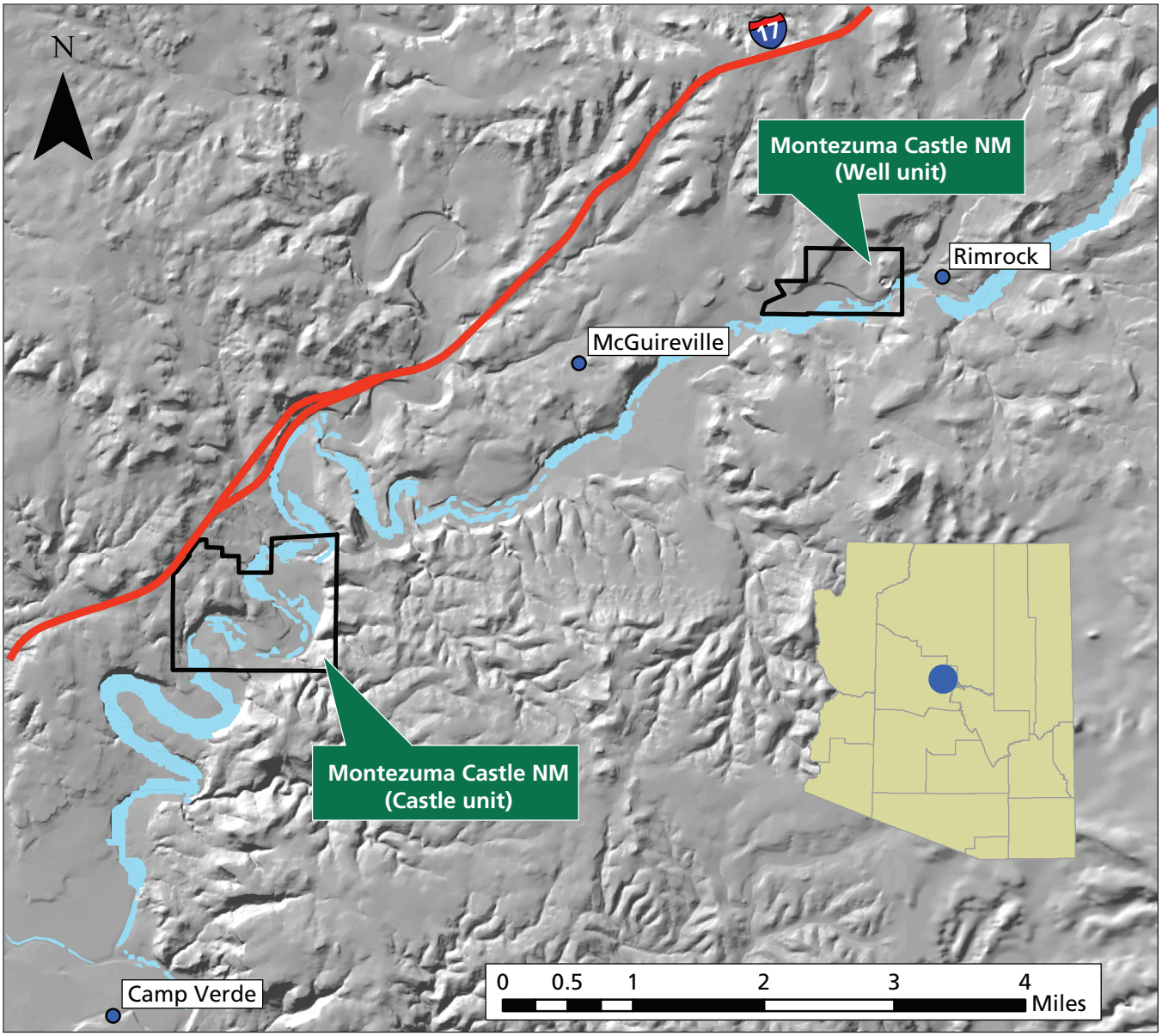


Figure 1-1. Map showing the relative locations of the Castle and Well units of Montezuma Castle National Monument. The prominent perennial water feature running between the two is Wet Beaver Creek, a tributary of Beaver Creek.

Central Highlands transition zone (ADWR 2009). Valleys, mesas, canyons, plateaus, and peaks contribute to the area's topographical diversity. People have intermittently farmed portions of a large area of fertile flat land along the creeks, beginning with the Sinagua around AD 600–800. Farming ceased after the Sinagua left the area, but European settlers resumed cultivation in the 1800s (MOCA 1994).

The Southwest is one of the fastest-growing regions in the United States. Population in the Verde River watershed (on the upper Verde River and part of the middle watershed upstream of Camp Verde) increased from approximately 82,000 in 1990 to an average population of over 148,000 from 2005 to 2009 (ESRI 2011). The number of housing units and households also increased, with more than 63,000 households and 75,000 housing units estimated in 2005–2009.

1.7.2 Park establishment and purpose

Between AD 600 and 1450, Hohokam and Sinagua peoples settled in the Verde Valley of central Arizona, where the natural environment in the rich riparian areas and adjacent uplands provided resources for daily life. Making extensive use of local water resources, they developed irrigation systems to support farming on the adjacent floodplains of Beaver Creek. They built cliff dwellings and pueblos for shelter. Then, around AD 1450, the Sinagua left their homes in the Verde Valley. To preserve these prehistoric ruins, two sites were set aside as a national monument.

On December 8, 1906, Presidential Proclamation No. 696 (34 Stat. 3265) established Montezuma Castle National Monument because ". . . the prehistoric structure known as Montezuma's Castle . . . is of the greatest ethnological value and scientific interest." The proclamation also reserved "as much land as may be necessary for the proper protection thereof." Although the cliff dwellings were never associated with the Aztec emperor Montezuma, early settlers to the area often assumed they were (in fact, the castle was abandoned almost a century before Montezuma was born).

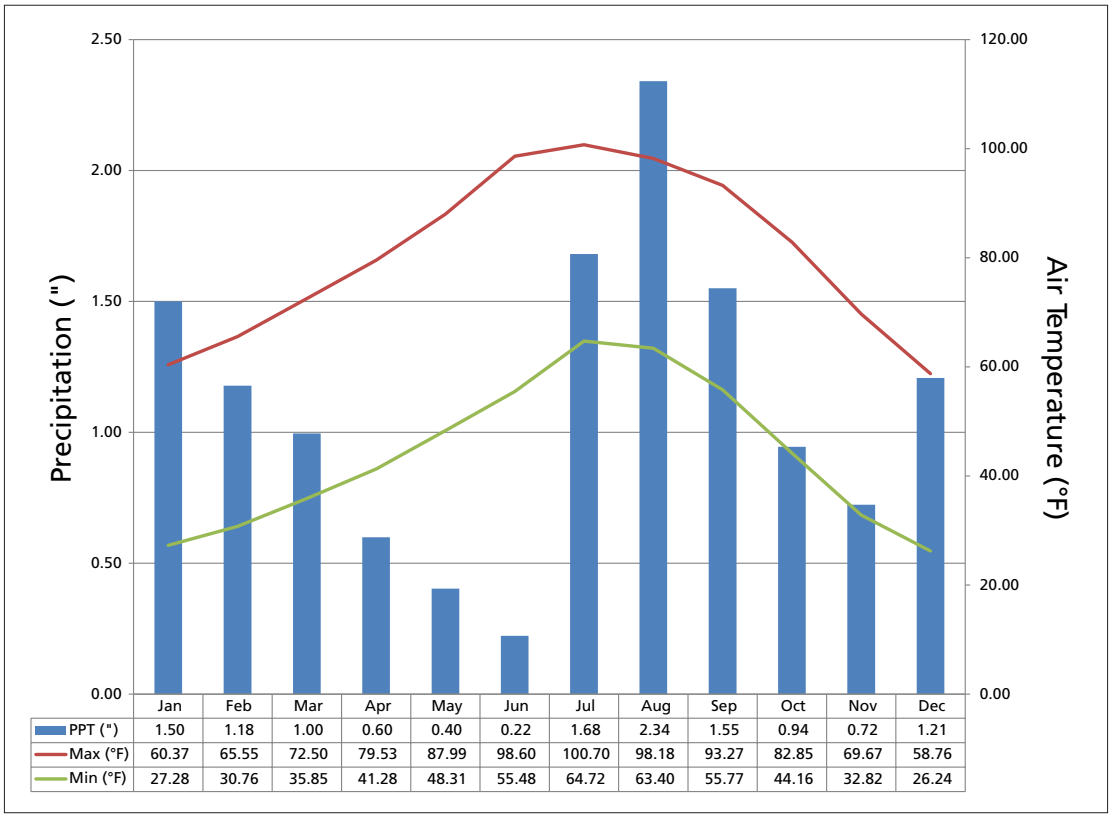
Later, more lands were added to the park. In 1937, 450 acres "required for the proper care, management, and protection of said prehistoric ruins and ancient cliff dwellings" were added by Presidential Proclamation No. 2226 (50 Stat. 1817). "In order to facilitate the administration and protection" of the park, Congress added 42 acres of land near Beaver Creek in 1959 (73 Stat. 108). In 1978, Public Law 95-625 (92 Stat. 3473) added approximately 13 acres to incorporate fossilized mammal tracks and excluded approximately five acres for use as right-of-way for Interstate 17. In December 2003, the boundary was again adjusted to include an additional 157 acres protecting the Beaver Creek riparian areas (Public Law 108-190).

On October 19, 1943, Congress (57 Stat. 572) authorized the acquisition of approximately 180 acres containing Montezuma Well, and another 80 acres of government-owned land to become a detached unit of Montezuma Castle NM. In 1959, Congress (73 Stat. 108) authorized the addition of another 17 acres "to facilitate the administration and protection" of the park. This land has not yet been acquired and remains in private ownership.

Montezuma Well illustrates the importance of water and riparian habitat to the Sinaguan people for farming and wild foods. Because the geological forms and biotic components of the park are integral features of its cultural resources, park managers are dedicated to maintaining the landscapes that attracted these early residents. Protecting and preserving the ecological processes that created the cultural setting is essential to interpreting the relationship between the Sinaguas and their natural environment.

1.7.3 Climate, geology, and hydrology

Montezuma Castle NM experiences the Southwestern or Arizona climate pattern, which is a distinct bimodal regime characterized by violent summer thunderstorms from the North American monsoon and frequent, low-intensity Pacific frontal precipitation in the winter months (Figure 1-2) (NPS 2005). At Montezuma Castle NM, recent (1987–2017) average annual precipitation is



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PPT (")	1.50	1.18	1.00	0.60	0.40	0.22	1.68	2.34	1.55	0.94	0.72	1.21
Max (°F)	60.37	65.55	72.50	79.53	87.99	98.60	100.70	98.18	93.27	82.85	69.67	58.76
Min (°F)	27.28	30.76	35.85	41.28	48.31	55.48	64.72	63.40	55.77	44.16	32.82	26.24

Figure 1-2. Mean monthly precipitation (PPT) and maximum (Max)/minimum (Min) air temperature for Montezuma Castle NM, based on 1987–2017 climate normals (climateanalyzer.org, accessed 09/18, ID#25635).

12.7 inches. Average maximum temperature is 81°F, and average minimum temperature is 44°F (NCDC 2012).

Both park units are located in the Verde Valley, a down-faulted Cenozoic sedimentary basin dominated by Verde Formation sediment (a young lacustrine sediment with classic, evaporitic, and limestone facies) (Figure 1-3) (Lindsay 2000a; 2000b). Deposits of lacustrine and fluvial origin dominate the area surrounding the park. Fluvial deposits from the Verde River are further separated into terraced (moderately sorted and lightly cemented) and alluvial (unsorted and uncemented) deposits (Woodward-Clyde 1997, cited in NPS 2005).

There are two broad soil types at Montezuma Castle NM: (1) riverine bottomland soils composed of alluvium, and (2) upland rocky calcareous soils. The Retriever soil series, which consists of limestone outcrops and soils derived from limestone, and is found on upland mesas, ridges, and side-slopes, is dominant at the Castle unit. Riverwash soils along Beaver Creek consist of stratified sand, silt, and clay, with scattered deposits of gravel, cobbles, stones, and boulders. The remainder of the Castle unit is characterized by several series of finer calcareous soils consisting of fine sandy loams, gravelly sandy loams, and clays (Rowlands 1999).

The dominant soil at Montezuma Well is the Guest series, a clayey bottomland soil derived from flood-borne fine-sediment deposits. Riverwash and Retriever soils are also found at the Well unit (Rowlands 1999). In general, the soils correlate to a broad vegetational dichotomy, with the riverine soils supporting the riparian gallery forests and the upland rocky calcareous soils bearing the scrubby and short-statured desert scrub vegetation.

Beaver Creek, a Verde River tributary, runs through the park's Castle unit. Its tributary, Wet Beaver Creek, runs through the Well unit. Both creeks are characterized by intermittent water flow (Schmidt et al. 2006), with perennial stretches through portions of both units. Montezuma Well, a limestone sink, was created when an underground cavern collapsed around a travertine spring.

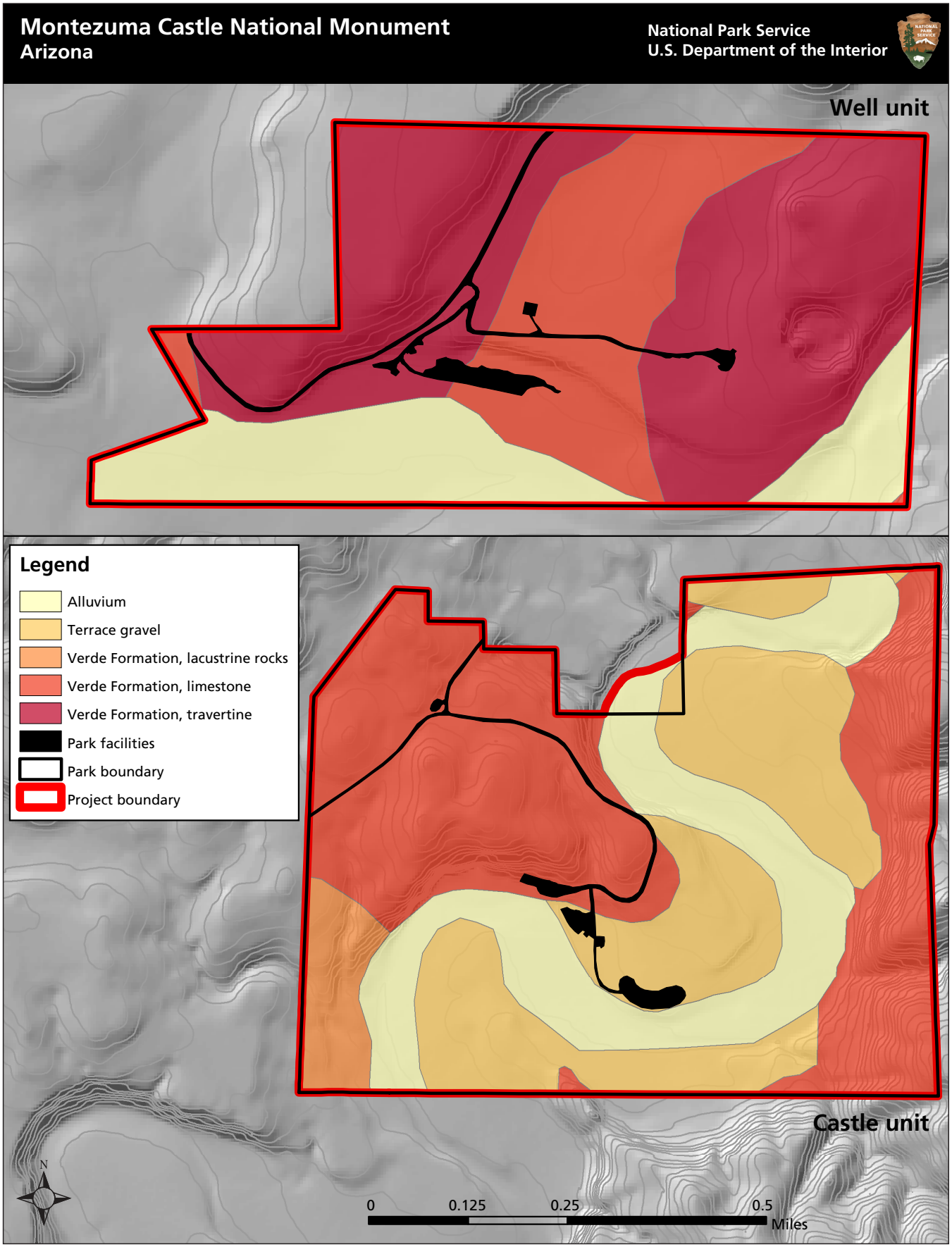


Figure 1-3. Geologic map of Montezuma Castle National Monument.

The well is fed from groundwater occurring within the Supai and Verde formations, in alluvium found in stream channels and along the Beaver Creek floodplain, and in porous volcanic rock along the margins of the Verde River. The well is 112 meters (368 ft) in diameter and 17 meters (55 ft) deep. It produces a constant flow of water, at 4,164 liters (1,100 gal) per minute (Sprouse et al. 2002).

Aquatic and riparian ecosystems supported prehistoric and historic settlement and land uses. These highly productive environments, created and sustained by surface and groundwater resources, have become increasingly important in the arid Southwest, as many have been significantly altered and/or destroyed. Excessive groundwater withdrawal, overgrazing, streambed channelization, alteration of surface water flow, impoundments, mining, and development have all contributed to reductions in the areal extent and complexity of these systems. These uses often conflict with protection and preservation of natural and cultural resources (MOCA 1994).

Groundwater is extremely important in the local area. Today, groundwater discharge into the Verde River and its tributaries accounts for approximately half the river's flow as it leaves the valley, most occurring as nonpoint discharge into streams.

1.7.4 Vegetation

At and near Montezuma Castle NM, a combination of upland and lowland habitats dissected by floodplains produces unique and diverse biological communities, making this area one of Arizona's most significant bioregions (MOCA 1994). The Castle unit is characterized by mesquite, acacia, and creosote bush at lower elevations, and scattered juniper amid subshrub-dominated landscapes at higher elevations. A rich sycamore, ash, and cottonwood riparian association grows along Beaver Creek. Montezuma Castle NM has high floristic diversity for its size, with around 600 species, subspecies, and varieties documented across both units. Overall, the Castle unit is more floristically diverse than the Well unit, with around 550 and 420 taxa, respectively.

1.7.5 Previous vegetation studies

For Rowlands's (1999) vegetation mapping report, 167 plots (128 at the Castle unit and 39 at the Well unit) were sampled using a modified Braun-Blanquet method. Ten associations were described and mapped at each unit. Rowlands identified, described, and numbered the associations following Brown (1982). The report notes the difficulty of utilizing the Brown system at the park due to the complexities of intergrading floristic provinces in this region.

Rowlands analyzed plots by using multivariate methods to identify species importance and constancy values from which the associations were derived. He then cross-walked these associations to the closest existing association within the Brown system. This work was of great utility during this current project and was referenced throughout for geographic and thematic information. Rowlands's original plot data were not used. New plot data were collected to capture any vegetation change in the intermediary 12 years. Some change was anticipated, as the park has actively engaged in restoration efforts for the past several years, including invasive plant control and native shrub and grass plantings. Additional data were also required within the boundary expansion lands acquired in the northeast corner in 2008, adding ~157 acres to the project boundary.

In 1991, Jenkins and others (1991) prepared "Vegetation Inventory, Classification, and Monitoring for Montezuma Well, Montezuma Castle National Monument." The report produced a detailed inventory and classification of vegetation growing within the Montezuma Well feature and established monitoring plots. Jenkins and others (1991) supplemented our assessment of vegetation within the Well unit.

During 2010 and 2011, the Sonoran Desert Network established 12 long-term monitoring plots for vegetation and soils at the Castle unit. Data from these plots and other vegetation-mapping efforts were referenced as the current vegetation classification was developed. These plots are marked and will be resampled every five years to monitor change in species cover and composition over time.

A status report based on SODN monitoring data is available.

1.7.6 Exotic (non-native) plants

Long-term anthropogenic disturbance in the Verde Valley has contributed to the introduction and spread of non-native flora and fauna, creating a significant challenge to natural-resource managers at Montezuma Castle NM (Rowlands 1999). Non-native grasses, such as red brome (*Bromus rubens*), ripgut brome (*Bromus diandrus*), and Lehmann lovegrass (*Eragrostis lehmanniana*) are well-established. Saltcedar (*Tamarix* spp.) is prevalent along the banks of Beaver and Wet Beaver creeks. A complete inventory of exotic-plant distribution and abundance for 50 targeted species was completed over the summers of 2003 and 2004. Mau-Crimmins (2009) summarized the results of these surveys. Overall, 33 targeted exotic-plant species were observed across both units (Appendix A). Many occurrences were mapped, and within each mapped area, percent cover was estimated for each exotic species.

During the classification phase of this current vegetation mapping project, crews documented 29 exotic species (see Appendix A).

1.7.7 Disturbance history

Both park units have been subjected to significant disturbance, both recent and historical. Beginning in the mid-19th century, large portions of what are now park lands were used for agriculture and grazing (Rowlands 1999). At both units, the majority of low-gradient lands outside the riparian corridor were probably used for one of these purposes at least until park establishment. Agriculture occurred primarily in areas now occupied by mesquite bosque, where the parent material is predominately alluvium and gravel terraces with sandy or silty soils. Livestock grazing occurred throughout both units, but was likely focused on the higher, rockier slopes less suited for crop production. These sites are currently occupied by sparse velvet mesquite (*Prosopis velutina*) shrublands. Grazing along western portions of the riparian area at Montezuma Well continued into the 1990s, with mules and horses from Saguaro National Park using these areas for winter pasture (K. Davis, personal communication).

Park staff is currently managing and restoring some of the most disturbed areas of the park, with particular focus on the recovering pastures south and west of the picnic area on Wet Beaver Creek in the Well unit. Much of this work is focused on removing exotic plant species, such as Johnsongrass (*Sorghum halpense*), horehound (*Marrubium vulgare*), and Russian thistle (*Salsola* spp.), and planting native species, such as fourwing saltbush (*Atriplex canescens*), desert willow (*Chilopsis linearis*), and big sacaton (*Sporobolus wrightii*).

In recent history, fire has had a limited effect on vegetation at the park. Since 1980, the 2005 Visitor Fire is the only wildfire to have occurred within the park. This fire, located in the riparian corridor of the Castle unit, was quickly extinguished and affected less than one acre. A few controlled burns have been completed.

In the mid- to late 1970s, major construction on Interstate 17 necessitated the creation of a new park entrance road. This left behind a highly disturbed strip of land where the original road was located. Rehabilitation efforts were employed, but the scar is still evident on the ground and in satellite imagery.

2 Classification and Mapping of Plant Communities

2.1 Methods

2.1.1 Planning and scoping

A general planning and scoping meeting was held on January 27, 2011, at the park headquarters building in Camp Verde, Arizona. The meeting addressed the work plan for both the Castle and Well units. Present at the meeting were park staff, network staff, and representatives from neighboring Arizona state parks. The goal of the meeting was to discuss the logistics of the effort and identify any site-specific needs or modifications to the standard mapping process. Arizona state park staff were invited to gauge interest in expanding the mapping boundary and working collaboratively. While no such expansion was agreed upon, the meeting provided all present with details of the national program standards and the possibility of cross-walking vegetation maps should similar projects be undertaken in the future. No special requests or modifications to proposed methods were made during the scoping. No issues of access were identified. Housing/camping locations for field crews were secured.

This project was successfully completed by SODN and OALS. Park personnel provided invaluable logistical support for all field-based components of the project. OALS prepared and printed imagery for field-mapping. SODN staff conducted or oversaw all other project aspects, including collecting data for classification, performing vegetation ground-mapping, drafting the local vegetation association descriptions, conducting validation and accuracy-assessment phases, and preparing the final spatial database with relevant attributes for mapped polygons and vegetation plots.

2.1.2 Data collection overview

The methods used to classify and map vegetation generally followed the guidelines outlined in the NPS technical guidance and support documents. However, our approach was more integrated than traditional practice, in which ecologists collect plot data to develop a classification, and photo interpreters delineate polygons solely using imagery. Instead, we used an integrated team of observers who concurrently collected plot- and polygon-scale data for classification while creating map polygons in the field. Map polygons were drawn based on imagery, topographic relief, and field observations. As Montezuma Castle NM is relatively small, this method worked well and was achieved by way of a census.

2.1.3 Digital imagery acquisition and processing

Imagery for both park units was obtained free of charge from a Tucson-based company, Western Mapping Inc., which had recently been hired by the park to conduct detailed planimetric mapping of both units. These high-resolution, three-band aerial photographs (Figure 2-1) had a pixel size of 0.5 m (50 cm), providing detailed images. No post-processing of the images was needed. Imagery was used in various ways throughout the mapping project, including as a guide when conducting on-the-ground mapping (see Section 2.1.4.2, polygon delineation).

2.1.4 Field-data collection

2.1.4.1 Classification plots

Jennings and others (2009) identified the need for vegetation units to be sampled and described through the use of plot data. They recommended that plots be distributed in



Figure 2-1. Example section of aerial image from Montezuma Well.

homogenous areas so as to minimize sampling in areas with high physiognomic, floristic, and environmental variation, which would complicate interpretation of plot data. 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 add a smaller number of plots subjectively to account for any under- or un-sampled areas.

Prior to the start of fieldwork, plot locations were preselected 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, 27 points were distributed at the Castle unit and 24 at the Well unit (Figure 2-2). Plots associated with two of these points (one at each unit) were not sampled due to inaccessibility and proximity to the park boundary, leaving a total of 49 sampled plots. The number of plots sampled was determined by the authors, using their best judgment and knowledge of the park's vegetation diversity and estimate of potential vegetation types.*

All data were collected by an NPS crew of 5–7 people, working either in pairs or altogether. Crew leads had experience in vegetation mapping at other SODN parks (e.g., Chiricahua NM, Tonto NM) for several months prior to this field effort, and were proficient in all mapping and classification methodologies. Field-based mapping and data collection for classification were conducted at the Well unit over the course of five days in mid-May 2011, and at the Castle unit over the course of five days the following week. Working in teams of two or more to facilitate a multiple-observer, consensus-based approach, the field crew visited each of the distributed points.

In the field, these generated points served as one corner of a 1,000-m^2 classification plot. Ideally, the plot location represented the surrounding vegetation community. When it did not, the classification protocol allowed crews to evaluate the surrounding vegetation and move the point up to 50 meters into more representative vegetation. Crews laid out the plots so as to best capture the sampled community, both in terms of orientation and shape. 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 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 diagnostic 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 (see Table 2-1 and 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.

2.1.4.2 Polygon delineation and community-level data collection

Concurrent with plot-based data collection, crews, assisted by hardcopy prints of

*In retrospect, more plots would have been advisable, as the final classification was assisted by other data sources, including the validation effort (see Section 2.3.1).

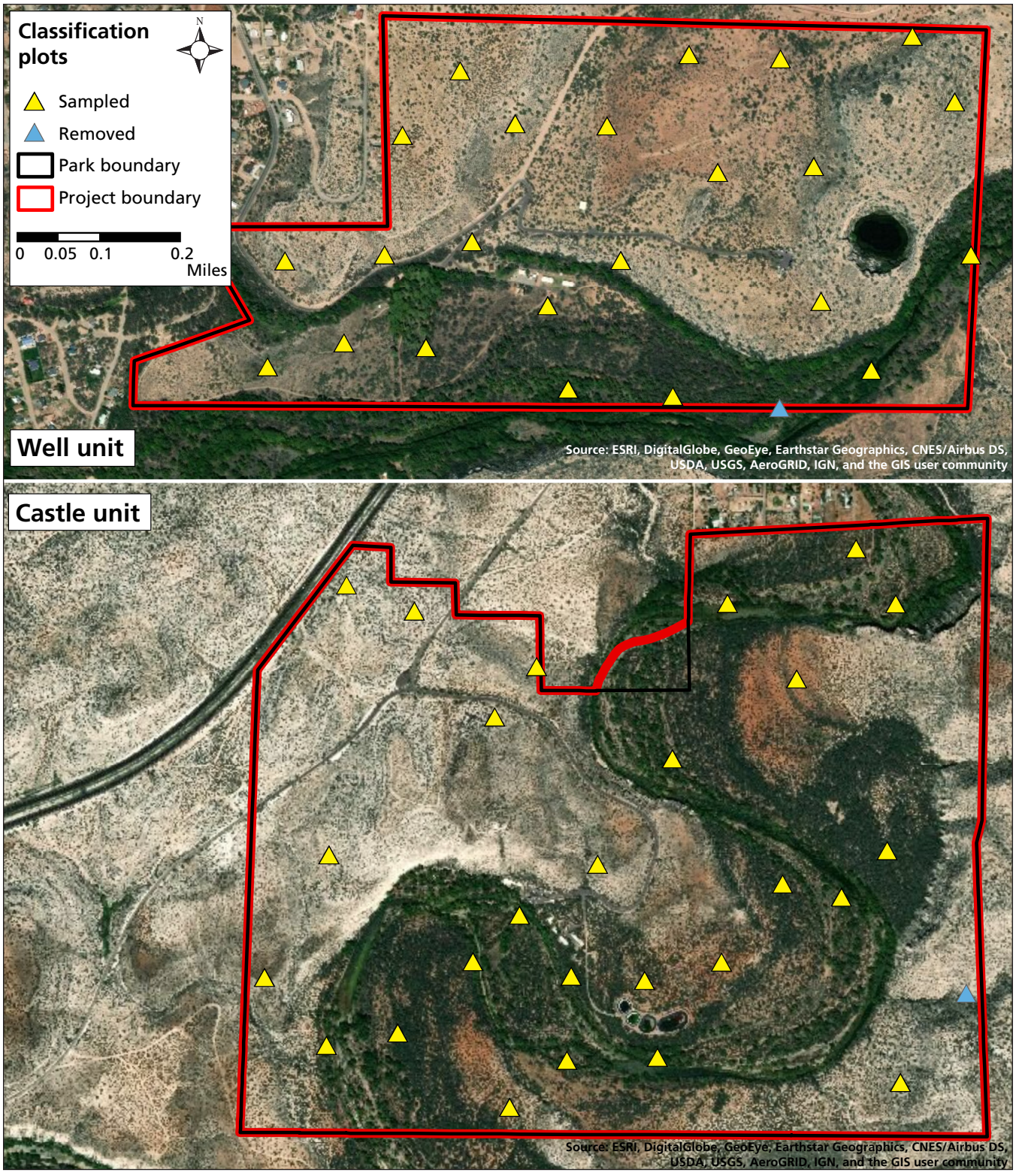


Figure 2-2. Map of classification plot locations at both units.

Table 2-1. Types of information and items noted on classification plots and polygons.

Data type	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 characteristics	Homogeneity, stand maturity, similarity to other types, mortality, disturbance

imagery and GPS-linked handheld mapping units, created polygons to define the extent of each vegetation association. Crews walked the boundary and interior of each proposed polygon while hand-drawing its extent onto the printed imagery. Within each of these polygons, 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 (see Appendix B). A sequence of four representative photographs in the four cardinal directions was taken 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 nomenclature was enforced for polygons, such that unique names were assigned to each polygon. These names reflected the verified physiognomic formation type by a prefix of representative letters (e.g., W = Woodland, SS = Shrub Savanna), followed by a number.

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 (later to be transferred into the PLOTS database when creating final products and deliverables). The digital data were subsequently quality-checked for accuracy against the original datasheets, and any transcription errors were rectified prior to analysis. Data were also validated by an alternate mapping-team member for logical errors or unusual species entries. These processes followed the quality standards outlined in the global operating standards 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 attributed to reflect changed polygon identification numbers and tentative alliance names. Hardcopy maps were 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 Plot-data analysis

Using the program Plymouth Routines in Multivariate Ecological Research (PRIMER), version 7 (Clarke and Gorley 2006), we employed a multivariate approach to delineate vegetation communities using our sampled classification plots (n = 49). For all analyses, we used the midpoint of the selected cover class. For example, the value used from the cover class that spans 11–25% was changed to a value of 18. These 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 midpoint cover values as the 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, the 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 (Figure 2-3). In addition, a SIMPROF (similarity profile) test was performed in conjunction with the cluster analysis. SIMPROF is a permutation test of the null hypothesis such 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).

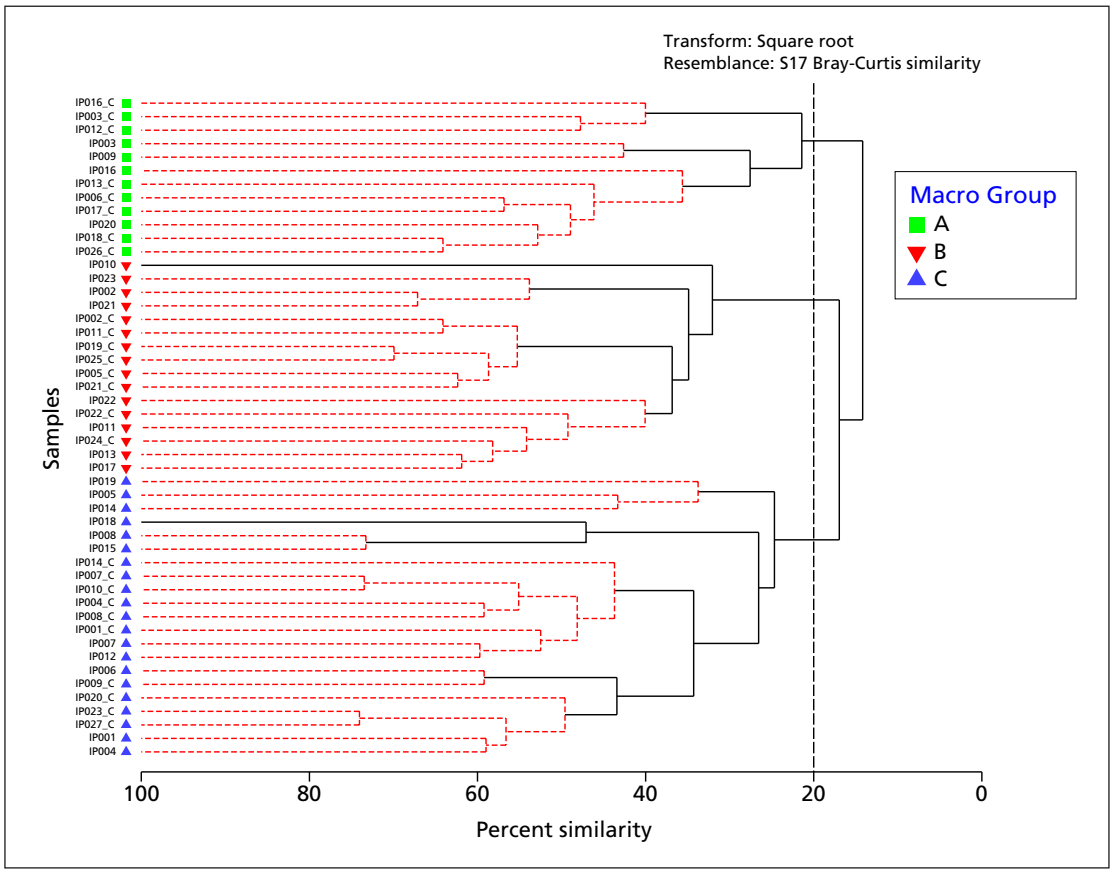


Figure 2-3. Cluster analysis results for 49 plots across both units. Symbols identify the three macro groups. The red dashed lines indicate the SIMPROF results, with a transition from solid black lines to red dashed lines showing the point after which plots are not significantly differentiated based on floristic composition and cover.

The dendrogram and associated SIMPROF test split the data into 11 groups with a minimum membership of two plots, and an additional two groups represented by solitary plots. Initially, we evaluated the results at a subjective similarity of 20%, where plots were lumped into three macro groups: A, B, and C (see Figure 2-3). These groups were further analyzed using similarity percentages (SIMPER). This is a tabular output from PRIMER that shows the average similarity of members within each group, as well as the contribution of each species to that similarity. Based on this information, we determined that these three groups were each defined by the presence or absence of 3–5 diagnostic species.

- **Macro Group A:** Twelve plots defined by the dominance of Arizona sycamore (*Platanus wrightii*), velvet ash (*Fraxinus velutina*), ripgut brome (*Bromus diandrus*), and/or desert willow (*Chilopsis linearis*), with an average similarity of 25%. This group contains all riparian woodlands and shrublands documented during the classification phase.
- **Macro Group B:** Sixteen plots, split into four SIMPROF groups, defined by the presence/absence of a suite of upland shrub species, including crucifixion thorn (*Canotia holocantha*), mariola (*Parthenium incanum*), featherplume (*Dalea formosa*), and littleleaf ratany (*Krameria erecta*), with an average similarity of 30%. This group contains all upland communities that lack dominant velvet mesquite (*Prosopis velutina*).
- **Macro Group C:** Twenty-one plots, split into six SIMPROF groups, defined by the dominance of velvet mesquite (*P. velutina*), often with catclaw acacia (*Senegalia greggii*) and an understory of non-native, annual grasses, with an average similarity of 28%.

With the data split into macro groups, we further analyzed them by employing NMDS (non-metric multi-dimensional scaling). In the resulting diagram, similarity/dissimilarity can be assessed based on the distance between points (samples). In addition, we used the bubble-plot feature to visualize the distribution and cover of important species within each macro group. Using the NMDS, SIMPROF groups, and SIMPER profiles, we further explored the finer grouping within each macro group.

2.2.1.1 Macro group associations

Macro Group A (2 associations)—. Macro group A split into three SIMPROF groups, all with more than one member. Using the bubble-plot feature within the NMDS plot, we visualized the distribution and cover of the three species that defined this group (Figure 2-4). Based on these observations, we maintained groups Aa and Ac, while considering Ab to be a variation of Ac.

> **Group Aa** (*n* = 3) was designated a *Chilopsis linearis* Shrubland Association.
>
> **Group Ac** (*n* = 7) was designated a *Platanus wrightii - Fraxinus velutina* Riparian Forest. All members of group Ab (*n* = 2) were placed in this group and considered a variation of the broader association.

Macro Group B (3 associations)—. Macro group B split into four SIMPROF groups, including one with only a single member. The bubble-plot feature within the NMDS plot proved useful for this group, as well (Figure 2-5). While there is species overlap between groups, the presence or absence of one of these species appears to drive the differences between groups (excluding the solitary plot, Bd). Based on these observations, we maintained three of the SIMPROF groups and combined the solitary plot with the most similar group.

> **Group Be** (*n* = 3) was designated a (*Juniperus arizonica*) / *Gutierrezia sarothrae - Dalea formosa* Shrubland Association.
>
> **Group Bf** (*n* = 6) was designated a *Canotia holocantha* Shrubland Association.
>
> **Group Bg** (*n* = 6) was designated a (*Larrea tridentata*) / *Parthenium incanum* Shrubland Association. Due to the lack of both crucifixion thorn (*C. holocantha*) and featherplume (*D. formosa*) while exhibiting dominant mariola (*P. incanum*), the solitary plot was merged into this group.

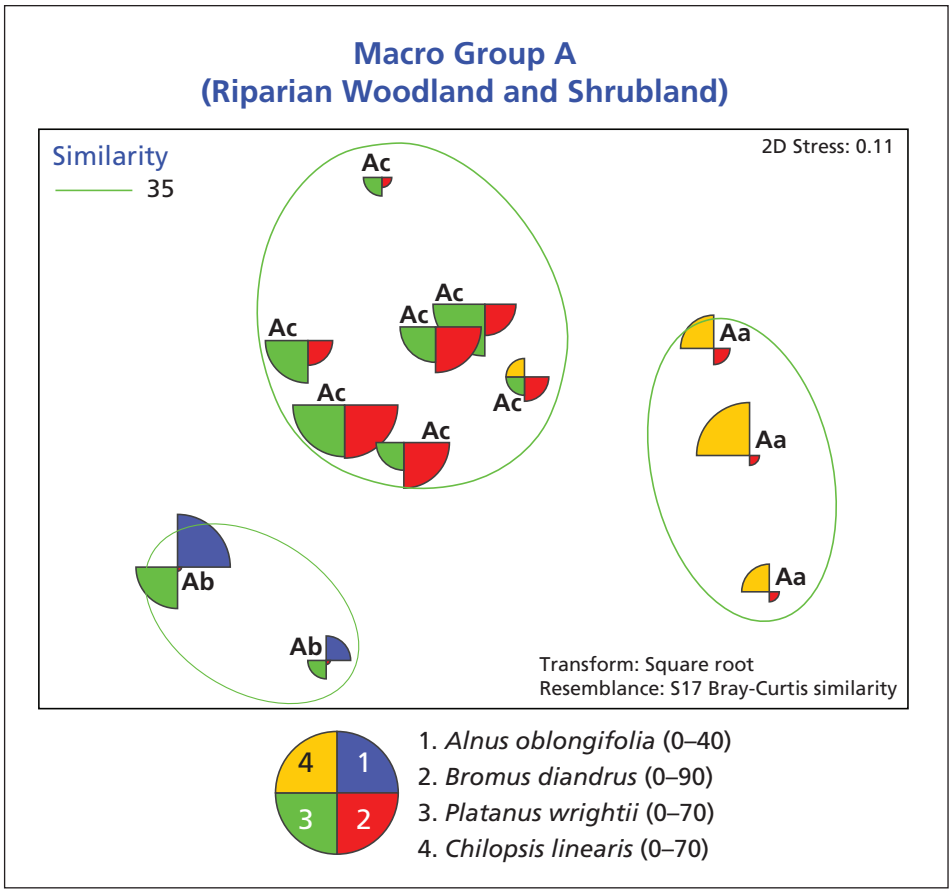


Figure 2-4. NMDS diagram of macro group A, showing 35% similarity between plots in each subgroup (green lines) and the relative abundance of the key dominant species (colored pie sections), *Alnus oblongifolia* (Arizona alder), *Bromus diandrus* (ripgut brome), *Platanus wrightii* (Arizona sycamore), and *Chilopsis linearis* (desert willow).

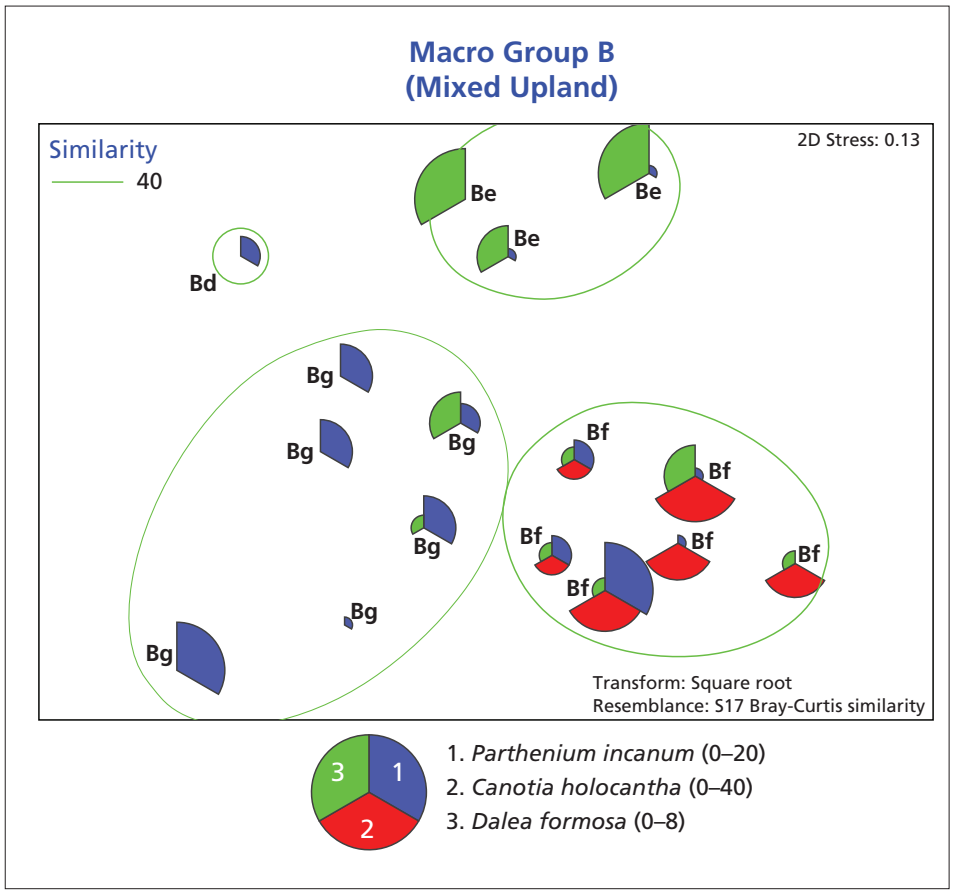


Figure 2-5. NMDS diagram of macro group B, showing 40% similarity between plots in each subgroup (green lines) and the relative abundance of the key dominant species (colored pie sections), *Parthenium incanum* (mariola), *Canotia holocantha* (crucifixion thorn), and *Dalea formosa* (featherplume).

***Macro Group C (3 associations)*—.** Macro group C split into six SIMPROF groups, including one with only a single member (Figure 2-6). While the 2D stress of the NMDS was low (0.13), the groupings were finer than our field observations indicated. Of the six groups, two were maintained (Ch and Ck). The remaining groups were lumped into a single group (Cm).

Group Ch (*n* = 3) was designated a (*Prosopis velutina*) / *Hordeum murinum* - *Bromus rubens* - *Bromus diandrus* Ruderal Shrub Savanna Association. This type describes a very disturbed area with ongoing restoration efforts, so it was eventually classified as a "park special," rather than a provisional association. It is the result of its own particular land-use history, and would not be expected to repeat in other areas.

Group Ck (*n* = 8) was designated a *Prosopis velutina* / *Bromus rubens* - *Hordeum murinum* Woodland and Shrubland Association.

Group Cm (*n* = 10) was designated a *Prosopis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association. This association is the combination of four SIMPROF groups (Ci, Cj, Cl, and Cm) that were lumped based on similar species composition and position outside the floodplain. The differences between the SIMPROF groups can be attributed to differing field components—mainly, perennial grass and broom snakeweed (*Gutierrezia sarothrae*).

All groups were reviewed in detail (datasheets, photos, and spatial data), plot by plot, to evaluate their assignment. Special attention was paid to groups with low similarity (<40%) and limited membership (<3 plots). Provisional types were developed based on the similarities of dominant species in similar strata, their relative similarity in species-cover values and lifeform dominance, and characteristic associated species.

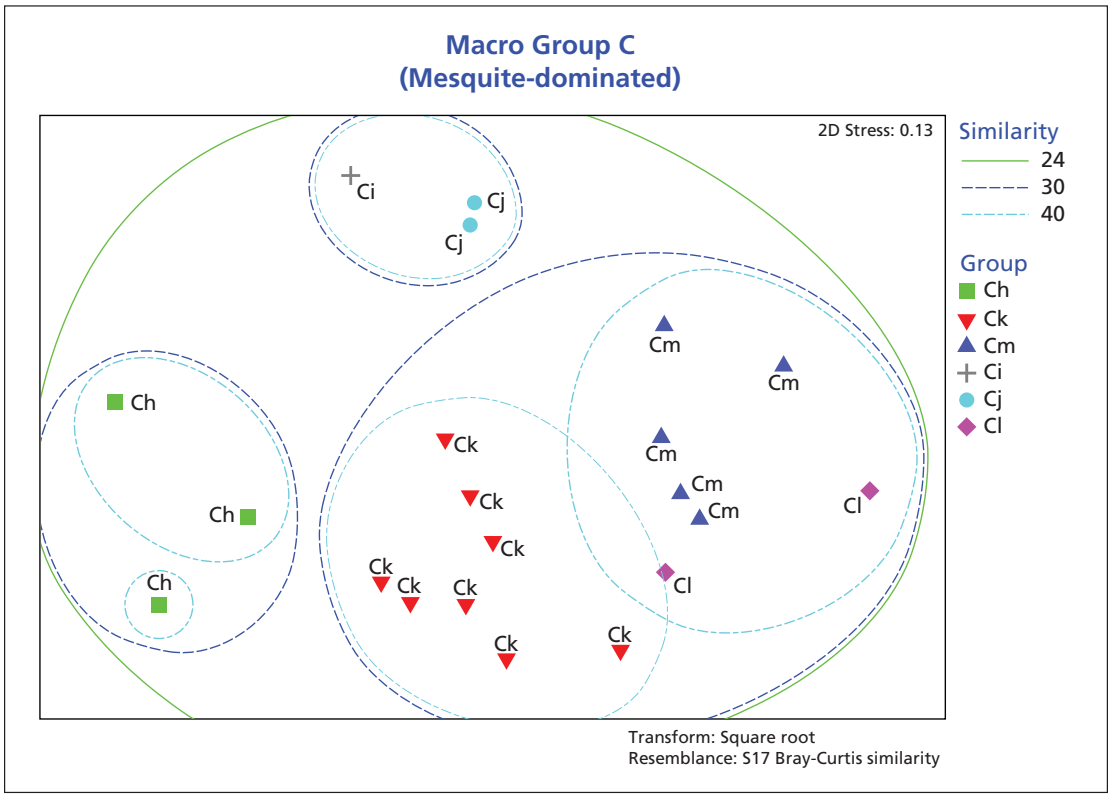


Figure 2-6. NMDS diagram of macro group C, showing multiple similarity levels between the six subgroups (dashed lines). At 24% similarity, all the plots fall into one group. Further separation to the three final subgroups was done subjectively, based on review of the field data and photos.

2.2.2 Polygon data evaluation

After the PRIMER analysis and the detailed review of identified vegetation communities, we began to assign/attribute mapped polygons to one of the provisional communities. Mapped polygons were placed within provisional types based on their species composition and dominance. For most polygons, there was a clear corollary with a provisional type. However, two sets of polygons did not have an obvious match. This discrepancy led to the creation of two additional communities: a creosote bush (*Larrea tridentata*) Shrubland Association and a Mixed Shrub / New Mexico feathergrass (*Hesperostipa neomexicana*) Shrub Savanna Association. To confirm the validity of these new communities, we consulted SODN's long-term monitoring dataset, which contains 14 plots across the Castle unit. While no plots landed within the New Mexico feathergrass (*H. neomexicana*) types, three monitoring plots were contained within the creosote bush (*L. tridentata*) type. These data were used to help develop a classification for this community.

2.2.3 Preliminary classification results

During this initial round of classification, we identified 10 vegetation groups at the association level, with eight occurring at the Castle unit and seven at the Well unit. These associations were attributed to 70 polygons (39 at the Castle unit and 31 at the Well unit). The preliminary associations were:

1. *Chilopsis linearis* Shrubland Association
2. *Platanus wrightii - Fraxinus velutina* Riparian Forest Association
3. (*Juniperus arizonica*) / *Gutierrezia sarothrae - Dalea formosa* Shrubland Association
4. *Canotia holocantha* Shrubland Association
5. (*Larrea tridentata*) / *Parthenium incanum* Shrubland Association
6. *Prosopis velutina* / (*Bromus rubens - Hordeum murinum*) Woodland and Shrubland Association
7. *Prosopis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association
8. *Larrea tridentata* Shrubland Association
9. Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna Association
10. (*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna Association

2.3 Validation

2.3.1 Process

Following the initial classification, we revisited both park units to validate the described communities and the mapping of the associated polygons. This field work was conducted over the course of five days in spring 2014. Prior to field-based efforts, the polygon map was altered to facilitate an unbiased validation assessment of map classes. Using the "explode multipart feature" tool in ArcToolbox, all multipart polygons were split into individual polygons ($n = 96$). Within each polygon, a point was distributed using the spatially balanced RRQRR algorithm. To avoid assessing the ecotone between associations, the boundaries of these polygons were buffered so that no point landed within 10 meters of a polygon boundary. Each point and polygon was stripped of identifying vegetation data and assigned a generic, unique identifier and attributed as either a priority for sampling ($n = 71$) or an oversample point ($n = 25$).

Considering the text descriptions of relevant vegetation types, crew members visited the assessment points within each priority polygon, evaluated the lifeforms and canopy cover of the dominant species in each stratum, and selected the best-fitting association for the polygon. A rating of how well the association description represented what was observed on the ground (poor, fair, good, or excellent) was also requested, along with any notes or observations that might aid interpretation of the assessment data. These could, and did, include notes on the polygon boundary, but the assessors were asked to choose a class name for the polygon as mapped, considering the area around the assessment point. As with initial mapping efforts, the assessors captured four photos, one in each of the cardinal directions, at the assessment point. The assessors visited all priority assessment

points (n = 71) and seven oversample points, and sampled five additional, subjectively placed assessment points.

2.3.2 Validation results

The validation phase revealed the need for two new provisional types to be described, as two distinct vegetation communities were observed that had not been captured during earlier field efforts. Adding these two brought the total to 12 communities:

11. *Celtis reticulata - Salix exigua* / (*Schoenoplectus tabernaemontani*) / *Bromus diandrus* Woodland Association
12. T*ypha domingensis* (*Schoenoplectus tabernaemontani*) Herbaceous Association

In addition, numerous improvements were made to both the community descriptions and the polygon boundaries. Edits to polygon boundaries were most prevalent at the Castle unit, and included the addition of six newly defined polygons:

- two desert willow (*Chilopsis linearis*) shrublands, split from large adjacent riparian woodlands,
- two creosote bush (*Larrea tridentat*a) shrublands, split from an adjacent velvet mesquite (*Prosopis velutina*) shrubland and a mariola (*Parthenium incanum*) shrubland,
- one broom snakeweed (*Gutierrezia sarothrae*) and featherplume (*Dalea formosa*) shrubland, split from an adjacent creosote bush (*Larrea tridentat*a) shrubland, and
- the creation of one southern cattail (*Typha domingensis*) herbaceous polygon from an area originally attributed as water.

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 in Lea and Curtis (2010). All attempts were made to follow these procedures, but some minor changes were necessary—mainly, to accommodate the small and often linear nature of many polygons.

Due to the small area covered by each unit (Castle unit = 297 ha, Well unit = 111 ha) and the good accessibility across both, the inference area of the accuracy assessment was the total area of the park (408 ha). The only areas with limited accessibility included numerous cliff bands at the Castle unit. While these areas were difficult and potentially unsafe to visit, they were easily assessed from a distance with the aid of binoculars.

Before assessment points were distributed within the inference area, polygons for each map class were merged and total hectares calculated for each (Table 3-1). Using these values, points were distributed based on the total area covered by each class. These points served as the centroid of a circular assessment plot. For classes covering >50 hectares, a total of 30 plots were distributed. For classes covering 8.33–50 hectares, a plot was distributed for every 1.67 hectares. For classes covering <8.33 hectares, we attempted to distribute a minimum of five plots. However, due to the limited area of two types, only one spatially independent plot was distributed within each.

The area covered by each plot varied based on the size and shape of the polygons within each map class. The recommended size, equivalent to the MMU (0.5 ha), was too large for all map classes at the park. Due to the linear nature of certain map classes and the limited area covered by others, 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

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

Class	Final vegetation association name	Castle unit (ha)	Well unit (ha)	Plots	Radius (m)
1	*Chilopsis linearis* Shrubland Association	16.52	0.00	10	18
2	*Platanus wrightii - Fraxinus velutina* Riparian Forest Association	36.53	19.65	30	28
3	(*Juniperus arizonica*) / *Gutierrezia sarothrae - Dalea formosa* Shrubland Association	1.37	8.50	6	18
4	*Canotia holocantha* Shrubland Association	64.66	0.23	30	28
5	(*Larrea tridentata*) / *Parthenium incanum* Shrubland Association	25.11	16.41	25	18
6	*Prosopis velutina* / *Bromus rubens - Hordeum murinum* Woodland and Shrubland Association	80.00	8.76	30	28
7	*Prosopsis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association	22.25	33.58	30	28
8	*Larrea tridentata* Shrubland Association	40.28	5.05	25	18
9	Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna Association	2.63	0.00	5	18
10	*Celtis reticulata - Salix exigua* / (*Schoenoplectus tabernaemontani*) / *Bromus diandrus* Riparian Woodland Association PS	0.00	0.37	1	10
11	*Typha domingensis* (*Schoenoplectus tabernaemontani*) Herbaceous Association	0.66	0.00	1	18
12	(*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna Association	0.00	6.91	5	28

at different plot sizes. Based on this assessment, we distributed plots of three different sizes: 0.03-hectare/10-meter radius (n = 1), 0.1-hectare/18-meter radius (n = 72), and 0.25-hectare/28-meter radius (n = 125).

Using ArcMap, polygon boundaries were buffered at a distance equal to the radius of the selected plot size, taking into account the positional accuracy of the map and positional error of the GPS to be used by the assessment crew. This buffered area was erased from the polygons within that class to create an area in which to distribute points. The resulting polygons were converted to raster format and points were distributed using the "distribute spatially balanced points" function in ArcToolbox (ESRI 2011). This function uses the RRQRR algorithm to distribute spatially balanced points throughout the raster. Next, each point was buffered using the radius of the assigned plot size (Figure 3-1). Plots and centroids for all map classes were merged and assigned a unique identifier. All information was removed that could give an assessor any indication as to which class it belonged.

3.2 Field effort

Over the course of seven days in April 2015, a crew of two assessors sampled all plots distributed across the park (n = 197). Prior to data collection, assessors were thoroughly briefed on the assessment protocol and the vegetation associations assigned to each map class. The crew lead was experienced with vegetation mapping throughout Arizona, and knowledgeable about the park's diverse vegetation. The assessors were provided with keys to the vegetation associations, detailed descriptions of each, and a field guide to aid in plant identification. Using a Trimble 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 (Appendix C) and description, they determined which association provided the best match to the community present within the plot. If no association was applicable, they labeled it unplaced and assigned it a new 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 an association and level of fit. This served as a check on plot-ID transcription errors and allowed for quicker review and analysis.

3.3 Results

Table 3-2 is a contingency table showing the raw-value results of the accuracy assessment. Values in shaded cells indicate agreement (A) between the assessor and producer. Values in unshaded cells 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.

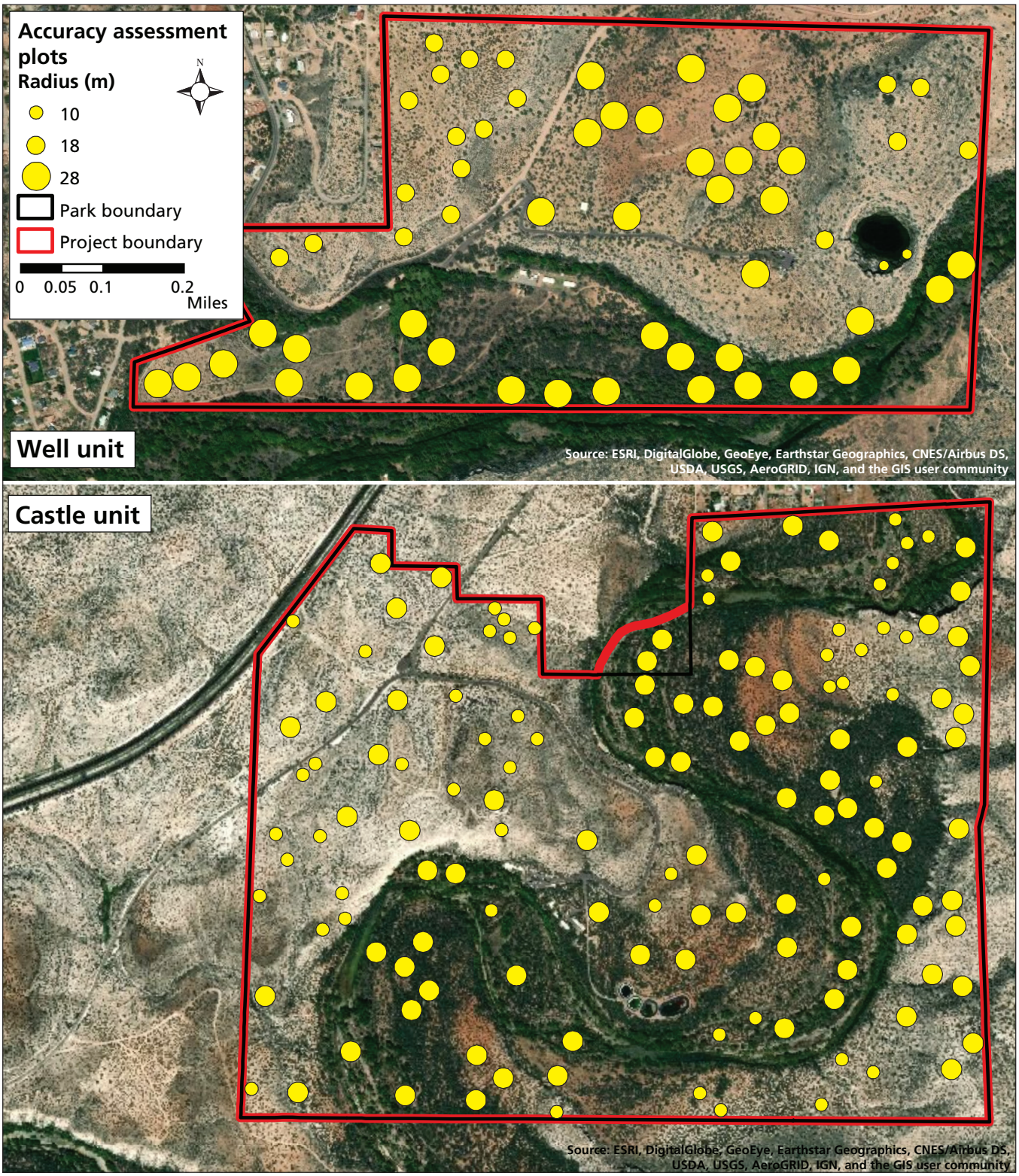


Figure 3-1. Accuracy-assessment plot distribution, symbolized by radius (m), across both units of the park.

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) (n = 197).†

Map class	Association name	1	2	3	4	5	6	7	8	9	10	11	12	13	Producers' total
1	*Chilopsis linearis* Shrubland Association	6 (A)	4 (D)	–	–	–	–	–	–	–	–	–	–	–	10
2	*Platanus wrightii - Fraxinus velutina* Riparian Forest Association	–	30 (A)	–	–	–	–	–	–	–	–	–	–	–	30
3	*(Juniperus arizonica) / Gutierrezia sarothrae - Dalea formosa* Shrubland Association	–	–	5 (A)	–	1 (D)	–	–	–	–	–	–	–	–	6
4	*Canotia holocantha* Shrubland Association	–	–	–	28 (A)	1 (D)	–	–	1 (D)	–	–	–	–	–	30
5	(*Larrea tridentata*) / *Parthenium incanum* Shrubland Association	–	–	–	–	21 (A)	–	–	4 (D)	–	–	–	–	–	25
6	*Prosopis velutina* / (*Bromus rubens - Hordeum murinum*) Woodland and Shrubland Association	–	–	–	–	–	27 (A)	–	1 (D)	–	–	–	2 (D)	1 (D)	31
7	*Prosopis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association	–	–	–	–	1 (D)	–	25 (A)	1 (D)	–	–	–	–	–	27
8	*Larrea tridentata* Shrubland Association	–	–	–	–	2 (D)	–	1 (D)	22 (A)	–	–	–	–	–	25
9	Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna Association	–	–	–	–	–	–	–	–	5 (A)	–	–	–	–	5
10	*Celtis reticulata - Salix exigua / (Schoenoplectus tabernaemontani) / Bromus diandrus* Riparian Woodland Association	–	–	–	–	–	–	–	–	–	1 (A)	–	–	–	1
11	*Typha domingensis* (*Schoenoplectus tabernaemontani*) Herbaceous Association	–	–	–	–	–	–	–	–	–	–	1 (A)	–	–	1
12	(*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna Association	–	–	–	–	–	–	–	–	–	–	–	6 (A)	–	6
13	Unplaced	–	–	–	–	–	–	–	–	–	–	–	–	0	0
	Assessors' total	6	34	5	28	26	27	26	29	5	1	1	8	1	197

† In table, A=agreement, D=disagreement. Cells showing agreement are also shaded ochre.

Table 3-3 is a population contingency table that includes user and producer accuracy per class. Overall accuracy for all classes was 89.7% (90% CI: 86.2%/93.3%). Kappa was 88.4% (90% CI: 84.3%/92.4%). Producer's accuracy indicates the likelihood that a class identified in the field matched the class attributed to the map (error of omission). User's accuracy is the reverse, indicating the likelihood that a class attributed to the map matched the class attributed in the field (error of commission). Kappa is a measure of overall accuracy minus chance agreement. As with the raw table, shaded cells indicate agreement, while the unshaded cells show disagreement.

Values in each cell were transformed to show the "proportion of the [inference] area in the corresponding true and mapped vegetation classes" (Lea and Curtis 2010). The estimated true-area values indicate the estimated total area occupied by each map class within the inference area. These values are adjusted from the mapped area based on the results of the accuracy assessment and are not necessarily equivalent to the total area of digitized map classes. For example, a class that was selected more often by the assessor than the producer will have a greater total area post-AA. In all, there were 19 discrepancies or mismatches between map classes and AA field classes, spread across nine map classes. The three classes without any discrepancies were those occupying the smallest areas and containing the fewest plots.

Of the 12 map classes, only one had a user accuracy of less than 80%: the *Chilopsis linearis* Shrubland Association. This association only achieved a 60.0% (90% CI: 29.5%/90.5%) user accuracy, indicating that it is difficult to identify in the field. Due to the small sample size and low accuracy, confidence intervals were wide, making it difficult to make inferences to the whole map class. The AA crew placed four of the ten plots assigned to this type within the adjacent riparian woodland class. The amount of overlapping vegetation composition of these classes, along with their frequent adjacency and small inclusions of one throughout the other, made this an unsurprising result. The small size (0.1 ha) of plots in this class was a further complication. The imagery indicates that these four plots were all distributed near large riparian trees. It is possible that if the crew had assessed plots covering a larger area, they might have placed them in the assigned type.

The community contingency table shows that three of the 12 map classes received a producers' accuracy of less than 80%:

- (*Larrea tridentata*) / *Parthenium incanum* Shrubland Association: 78.6% (90% CI: 77.1%/80.0%),
- *Larrea tridentata* Shrubland Association 72.4% (90% CI: 70.9%/73.8%), and
- (*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Shrub Savanna Association 46.9% (90% CI: 46.8%/47.0%).

P. incanum is the diagnostic species within the (*Larrea tridentata*) / *Parthenium incanum* Shrubland Association. Dominance of this species was the primary reason a number of plots from other map classes were placed in this association. This AA effort helped illustrate that this species is not solely restricted to this type. It can be found mixed throughout a number of similar associations, especially the *Larrea tridentata* and *Canotia holocantha* shrubland associations. The *Larrea tridentata* Shrubland Association was attributed to an additional seven plots of four classes (see Table 3-2). Four of these plots fell in the map polygons attributed as (*L. tridentata*) / *P. incanum* shrubland. However, the assessors placed the plots here primarily due to a lack of *P. incanum* dominance, and dominant *L. tridentata*, further illustrating how much these communities can intermix with each other. The remaining three plots were all placed in different classes. As these classes all had high producer and user accuracies, these plots likely hit small inclusions of *L. tridentata* dominance that were not representative of their respective class.

The (*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna Association was attributed to an additional two plots, distributed within the *Prosopis velutina* / (*Bromus rubens - Hordeum murinum*) Woodland and Shrubland Association. The shrub savanna class is a highly disturbed version of the woodland/shrubland class, usually in areas with evidence of past grazing.

Table 3-3. Calculated population contingency table showing percentages of producer's (columns) and user's (rows) accuracy (n = 197).†

Map class	Association name	1	2	3	4	5	6	7	8	9	10	11	12	13	User's accuracy	Lower confidence interval (90%)	Upper confidence interval (90%)	Percent of total inference area
1	*Chilopsis linearis* Shrubland Association	0.0252 (A)	0.0168 (D)	–	–	–	–	–	–	–	–	–	–	–	60.0%	29.5%	90.5%	0.0420
2	*Platanus wrightii - Fraxinus velutina* Riparian Forest Association	–	0.1449 (A)	–	–	–	–	–	–	–	–	–	–	–	100.0%	98.3%	100.0%	0.1449
3	*(Juniperus arizonica) / Gutierrezia sarothrae - Dalea formosa* Shrubland Association	–	–	0.0211 (A)	–	0.0042 (D)	–	–	–	–	–	–	–	–	83.3%	50.0%	100.0%	0.0253
4	*Canotia holocantha* Shrubland Association	–	–	–	0.1555 (A)	0.0056 (D)	–	–	0.0056 (D)	–	–	–	–	–	93.3%	84.2%	100.0%	0.1666
5	(*Larrea tridentata*) / *Parthenium incanum* Shrubland Association	–	–	–	–	0.0895 (A)	–	–	0.0170	–	–	–	–	–	84.0%	69.9%	98.1%	0.1066
6	*Prosopis velutina* / (*Bromus rubens - Hordeum murinum*) Woodland and Shrubland Association	–	–	–	–	–	0.1927 (A)	–	0.0071 (D)	–	–	–	0.0143 (D)	0.0071 (D)	87.1%	75.6%	98.6%	0.2212
7	*Prosopis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association	–	–	–	–	0.0061 (D)	–	0.1528 (A)	0.0061 (D)	–	–	–	–	–	92.6%	82.4%	100.0%	0.1650
8	*Larrea tridentata* Shrubland Association	–	–	–	–	0.0085 (D)	–	0.0043 (D)	0.0939 (A)	–	–	–	–	–	88.0%	75.3%	100.0%	0.1067
9	Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna Association	–	–	–	–	–	–	–	–	0.0068 (A)	–	–	–	–	100.0%	90.0%	100.0%	0.0068
10	*Celtis reticulata - Salix exigua / (Schoenoplectus tabernaemontani) / Bromus diandrus* Riparian Woodland Association	–	–	–	–	–	–	–	–	–	0.0007 (A)	–	–	–	100.0%	50.0%	100.0%	0.0007
11	*Typha domingensis* (*Schoenoplectus tabernaemontani*) Herbaceous Association	–	–	–	–	–	–	–	–	–	–	0.0017 (A)	–	–	100.0%	50.0%	100.0%	0.0017
12	(*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna Association	–	–	–	–	–	–	–	–	–	–	–	0.0126 (A)	–	100.0%	91.7%	100.0%	0.0126
13	Unplaced	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0%	0.0%	0.0%	0.0000
	Producers' accuracy	100.0%	89.6%	100.0%	100.0%	78.6%	100.0%	97.3%	72.4%	100.0%	100.0%	100.0%	46.9%	0.0%				
	Lower confidence liinterval (90%)	99.0%	89.4%	99.4%	98.9%	77.1%	98.2%	96.1%	70.9%	100.0%	100.0%	100.0%	46.8%	0.0%				
	Upper confidence interval (90%)	100.0%	89.8%	100.0%	100.0%	80.0%	100.0%	98.5%	73.8%	100.0%	100.0%	100.0%	47.0%	0.0%				
	Estimated true area (ha)	9.81	62.95	8.22	60.56	44.36	75.03	61.15	50.51	2.63	0.27	0.66	10.46	2.78				

† In table, A A=agreement, D=disagreement. Cells showing agreement are also shaded ochre. Individual cell values are the proportion of the project area the each plot represents, with all cells adding up to 1.0.

Of the 197 plots sampled, an excellent fit was selected for 147 plots (75%), a good fit for 20 plots (10%), a fair fit for 29 plots (15%), and a poor fit for 3 plots (1.5%). For all poor and fair fits, datasheets were assessed to determine which characteristics caused the lack of fit. Most resulted from the variable composition and cover of associate species. Many of the map classes are defined by a couple of dominant species, with a diverse and variable mix of associated species. Most of the fit issues reflected this inherent variation.

3.4 Resolution of accuracy assessment discrepancies

All discrepancies between assessors and producers were investigated to determine the reason for the mismatch. The same was done for all plots identified as having a fair or poor fit. The original datasheets from both polygon surveys and from classification plots were rereviewed, along with other field notes and photographs. In most cases, the data collected by the assessors were demonstrated to be correct, and no action was taken. In two instances, plant-identification issues were discovered. In these cases, the assigned type was changed if the misidentified species was the primary reason a plot was placed into the mismatched type. All changes made to AA field data that were included in accuracy calculations are detailed in Appendix D.

4 Final Map Products

In the final map, 12 vegetation associations were attributed to 73 total polygons: 10 associations to 44 polygons at the Castle unit (Figure 4-1) and 9 associations to 29 polygons (Figure 4-2) at the Well unit. For each, there was a one-to-one correlation between vegetation associations and map units (polygons). An additional three classes covered unvegetated areas, including roads, facilities, large expanses of bedrock, and water. Only two of the 12 vegetation types were "accepted" types within the NVC. The others, described here as specific to the park, are currently proposed for formal status within the NVC.

These field-mapped polygons represent the best approximation of distinct community boundaries as defined by the criteria provided in a series of standard operating procedures and a formation key (Appendix E) given to field crews. Under NVC definitions, these areas would be akin to "stands:" "contiguous areas of vegetation that are relatively homogeneous in species composition, structure and ecological setting" (Lea 2011).

Polygons ranged in size from less than 0.5 hectares (1.23 ac, associated with numerous community polygons divided by roads and water), to 31 hectares (76.6 ac, for a stand of *Canotia holocantha* Shrubland Association that spans the entire eastern boundary of the Castle unit). This latter polygon accounts almost 8% of the vegetated area across the park. At the Castle unit, riparian communities covered roughly 20% (60 ha, 148 ac) of the vegetated area, including polygons attributed as water. Upland communities covered around 53% (156 ha, 385 ac), and floodplain communities covered 27% (80 ha, 197 ac). At the Well unit, riparian communities covered roughly 20% (21 ha, 52 ac) of the vegetated area, including polygons attributed as water. Upland communities covered around 63% (63 ha, 156 ac), and floodplain communities covered 16% (16 ha, 40 ac).

Table 4-1 shows each vegetation community type, the number of polygons attributed to that type, and the total area it covered at each unit.

Following the map are one-page summaries of the 12 associations identified and mapped at Montezuma Castle National Monument during this project. These summaries are abridged versions of the full association descriptions provided in Appendix F. Each summary briefly describes the floristic and structural characteristics of the vegetation and shows (1) a representative photo of the association (background), (2) its distribution across the Castle unit (top left), and Well unit (top right), and (3) an example of the satellite imagery for one polygon (bottom left; 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.

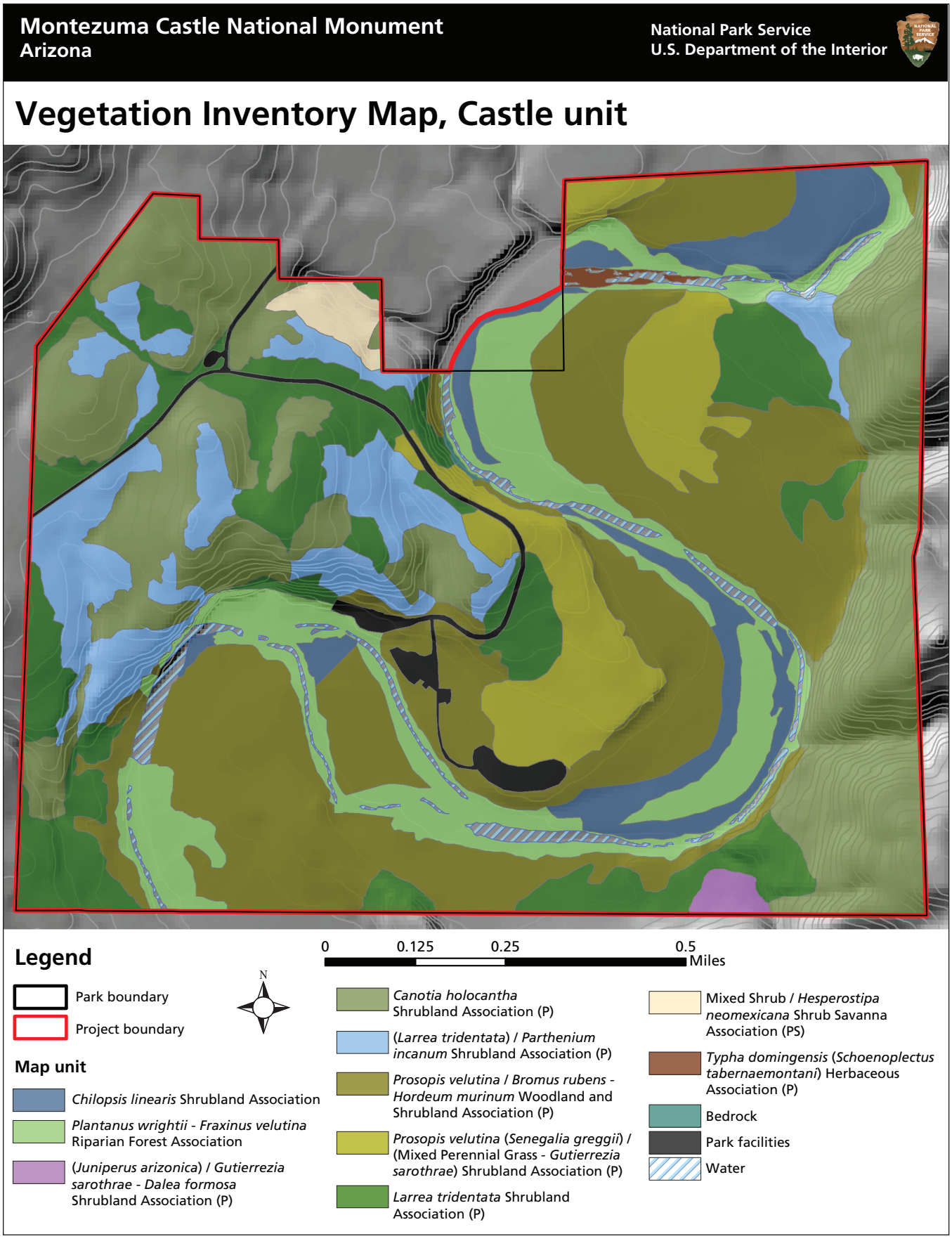


Figure 4-1. Vegetation Inventory map of the Castle unit, Montezuma Castle National Monument.

Montezuma Castle National Monument
Arizona

National Park Service
U.S. Department of the Interior

Vegetation Inventory Map, Well unit

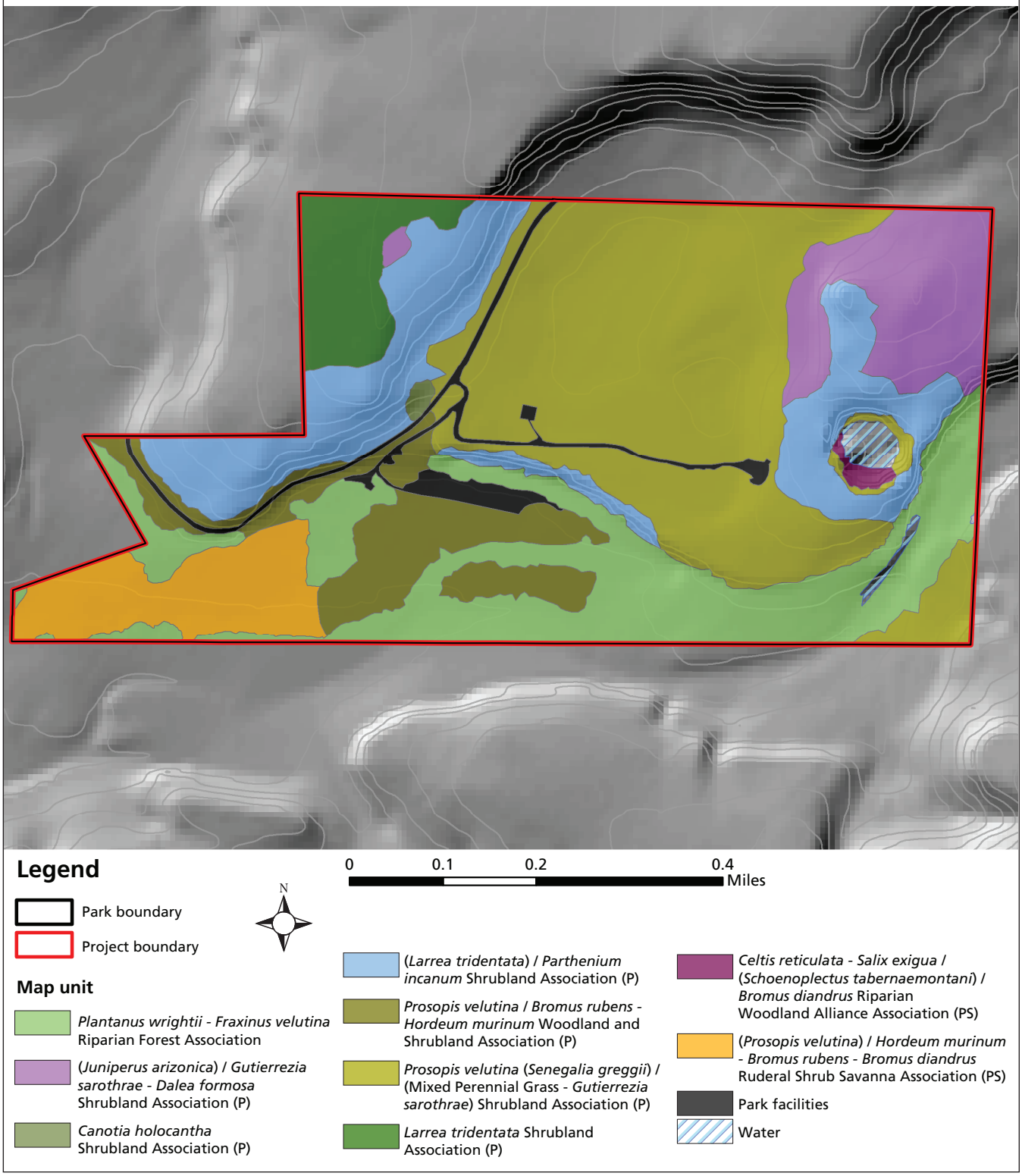


Figure 4-2. Vegetation inventory map of the Well unit, Montezuma Castle National Monument.

Table 4-1. Final vegetation community types, listed with their accepted NVC association codes or SODN placeholder codes, the number of polygons of each type mapped at each unit, and the number of acres covered.

Class	Map class name	NVC/SODN code	Castle unit		Well unit		Combined	
			Polygons	Acres	Polygons	Acres	Acres	% of total
1	*Chilopsis linearis* Shrubland Association	CEGL001164	5	40.81	–	–	40.81	4.24%
2	*Platanus wrightii - Fraxinus velutina* Riparian Forest Association	CEGL000644	5	90.27	4	48.56	138.83	14.43%
3	*(Juniperus arizonica) / Gutierrezia sarothrae - Dalea formosa* Shrubland Association (P)	NPSSODN031	1	3.39	4	20.99	24.38	2.53%
4	*Canotia holocantha* Shrubland Association (P)	NPSSODN030	6	159.77	1	0.56	160.32	16.66%
5	(*Larrea tridentata) / Parthenium incanum* Shrubland Association (P)	NPSSODN028	1	62.04	5	40.55	102.59	10.66%
6	*Prosopis velutina / Bromus rubens - Hordeum murinum* Woodland and Shrubland Association (P)	NPSSODN025	9	197.68	2	21.65	219.33	22.79%
7	*Prosopsis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association (P)	NPSSODN027	4	54.98	8	82.99	137.97	14.34%
8	*Larrea tridentata* Shrubland Association (P)	NPSSODN029	11	99.52	1	12.49	112.01	11.64%
9	Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna Association (PS)	NPSSODN033	1	6.50	–	–	6.50	0.68%
10	*Celtis reticulata - Salix exigua / (Schoenoplectus tabernaemontani) / Bromus diandrus* Riparian Woodland Association (PS)	NPSSODN026	–	–	1	0.91	0.91	0.09%
11	*Typha domingensis* (*Schoenoplectus tabernaemontani*) Herbaceous Association (P)	NPSSODN034	1	1.64	–	–	1.64	0.17%
12	(*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna Association (PS)	NPSSODN032	–	–	3	17.09	17.09	1.78%

#1 *Chilopsis linearis* Shrubland Association

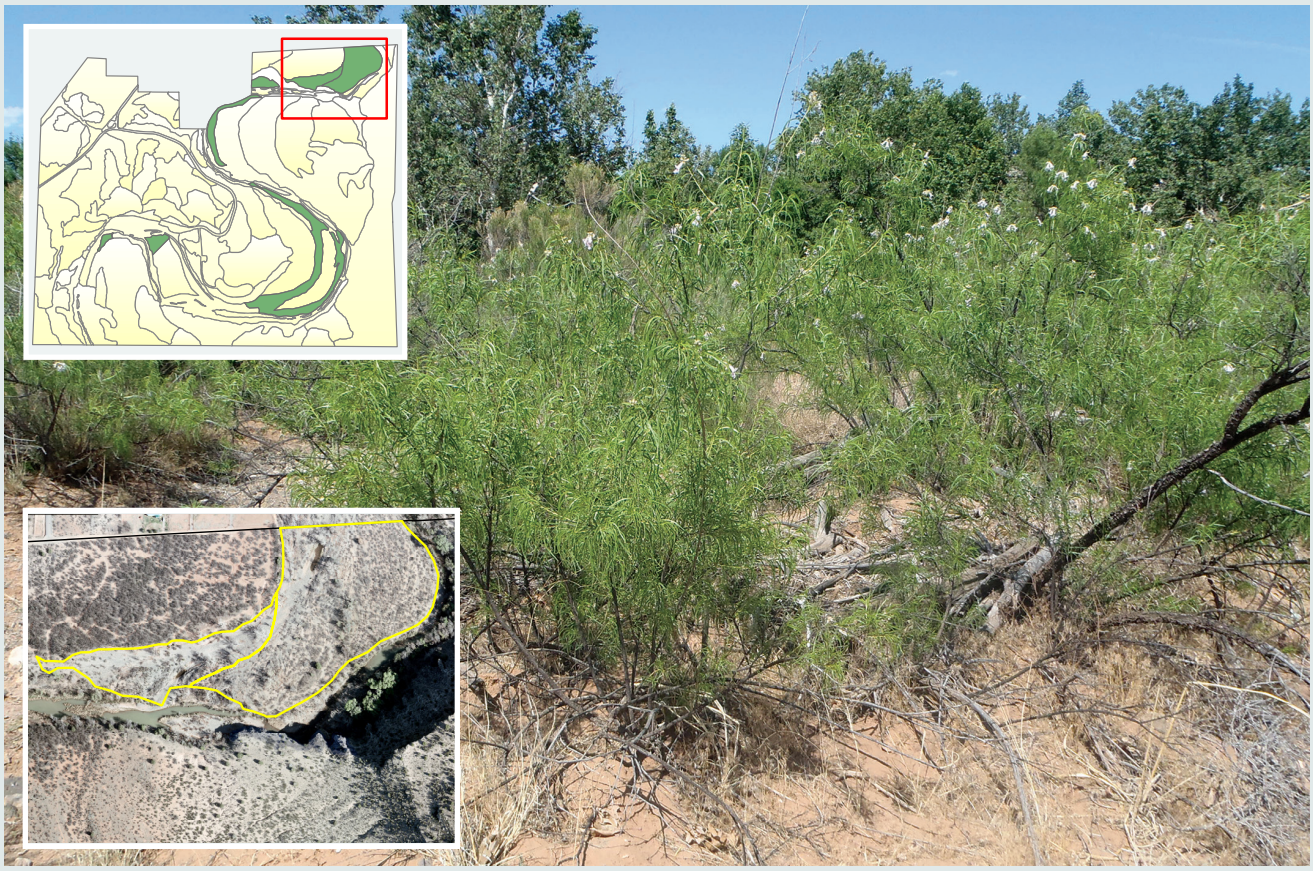
Desert willow Shrubland Association

Common species

- *Ambrosia monogyra*
- *Brickellia floribunda*
- *Bromus diandrus*
- *Bromus tectorum*
- *Chilopsis linearis*
- *Hordeum murinum*

This shrubland community is found within the greater floodplain areas and is characterized by a subcanopy (0.5–2 m) and canopy (2–5 m) dominated by desert willow (*Chilopsis linearis*). This species typically presents in a shrubby form, with heights ranging between 1 and 4 meters, but can occasionally appear as a small tree, especially in less-disturbed stands higher above the active floodplain. Average total cover of this species varies greatly across this type, from moderate cover of 18% to dense stands of up to 66%. Singlewhorl burrobrush (*Ambrosia monogyra*) is an inconsistent associate, with scattered patches mixed throughout the community. Cover is generally low, only averaging 2%, but can be locally abundant and rarely appear co-dominant with desert willow (*C. linearis*). Other noteworthy, low-cover shrub species include Chihuahuan brickellbush (*Brickellia floribunda*), desert broom (*Baccharis sarothroides*), Emory's baccharis (*Baccharis emoryi*), broom snakeweed (*Gutierrezia sarothrae*), and California brickellbush (*Brickellia californica*). Cover of herbaceous species is highly variable, ranging from 3 to 70%, mainly comprising a suite of non-native, annual grasses, including ripgut brome (*Bromus diandrus*), cheatgrass (*Bromus tectorum*), and mouse barley (*Hordeum murinum*).

This shrubland occurs mainly at the Castle unit, covering around 5% (16 ha/40 ac) of the total area, exclusively in the highly disturbed floodplain of Beaver Creek. While present at the Well unit, it provides little cover and is always intermixed with the widespread riparian woodland and mesquite bosque communities. In general, the ground cover is characterized by bare, sandy soils with large cobbles interspersed throughout. Large riparian trees are often present along the edge of these communities, including Arizona sycamore (*Platanus wrightii*), velvet ash (*Fraxinus velutina*), Arizona alder (*Alnus oblongifolia*), and Arizona walnut (*Juglans major*).



#2 *Platanus wrightii - Fraxinus velutina* Riparian Forest Association

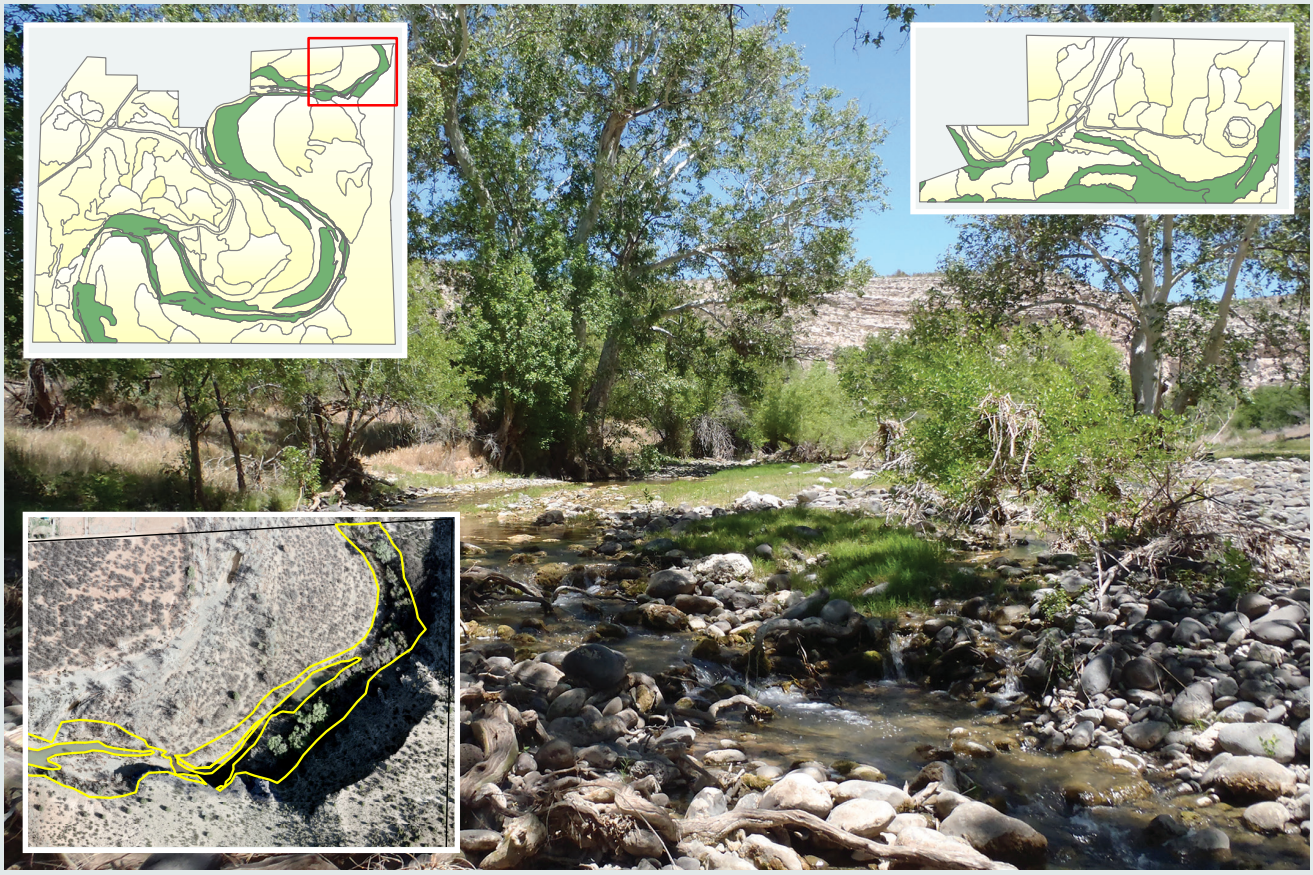
Arizona sycamore - Velvet ash Riparian Forest Association

Common species

- *Platanus wrightii*
- *Fraxinus velutina*
- *Alnus oblongifolia*
- *Populus fremontii*
- *Bromus diandrus*
- *Bromus tectorum*

This riparian woodland community is characterized by a tall tree canopy co-dominated by Arizona sycamore (*P. wrightii*) and Arizona ash (*F. velutina*). Average cover of canopy species is around 53%, with values ranging from 25% to 91%. Arizona sycamore, a large (15-m) riparian tree, provides variable cover, averaging to 18% and ranging up to 63% across both units. Cover of Arizona ash (*F. velutina*), a shorter-statured (6-m) and later successional tree, is closer to 12%, with values ranging up to 63%. On a large scale, both species provide consistent cover throughout the community. However, when examined locally they can be quite patchy, with either one becoming the sole dominant or being completely absent. A mix of widespread but inconsistent riparian trees intermingle throughout this community, including Arizona alder (*Alnus oblongifolia*), cottonwood (*Populus fremontii*), and Goodding's willow (*Salix gooddingii*). Emory's baccharis (*Baccharis emoryi*) and false indigo bush (*Amorpha fruticosa*) often form dense thickets along the edge of the watercourse, but provide little cover across the community as a whole. Cover of herbaceous species is highly variable, averaging 30% across the community and ranging from a few percent up to 90%. A mix of annual, non-native grasses, such as ripgut brome (*Bromus diandrus*), cheatgrass (*Bromus tectorum*), and red brome (*Bromus rubens*) usually dominate this stratum.

This riparian woodland is found on the low-gradient (1%) floodplains of Beaver Creek and the adjacent alluvial terraces at both units of the monument. This community covers 12% (36 ha/90 ac) of the Castle unit and 20% (19 ha/49 ac) of the Well unit. The surface cover is often composed of a sandy alluvial soil with various cobble sizes, ranging from larger boulders immediately adjacent to and in the creek, to moderately sized rocks and fine gravel on the upper alluvial terraces.



#3 (*Juniperus arizonica*) / *Gutierrezia sarothrae* - *Dalea formosa* Shrubland Association (P)

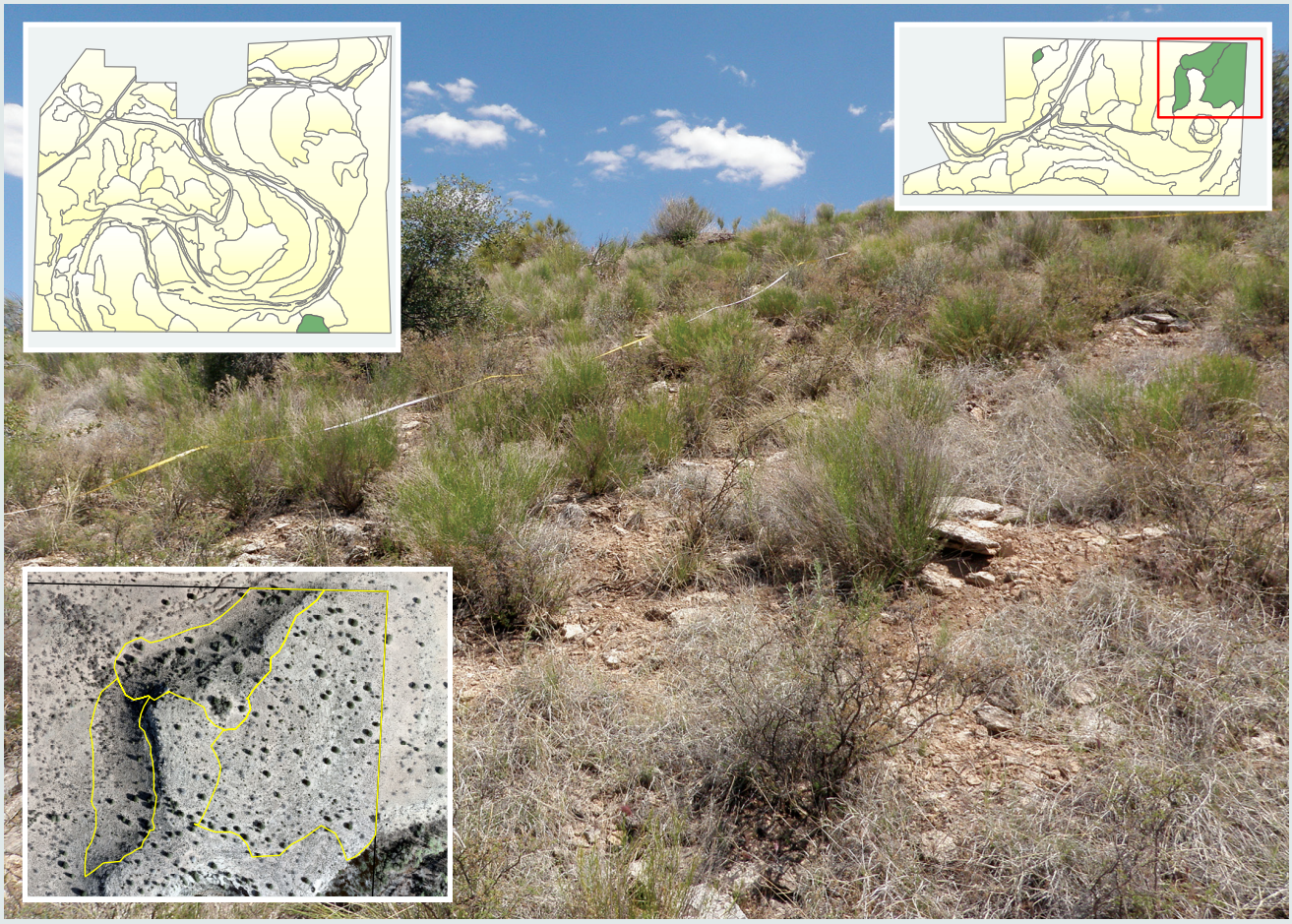
(Arizona juniper) / Broom snakeweed - Featherplume Shrubland Association (P)

Common species

- *Gutierrezia sarothrae*
- *Dalea formosa*
- *Juniperus arizonica*
- *Hesperostipa neomexicana*
- *Bouteloua eriopoda*

This shrubland community is characterized by a field stratum (<0.5 m) co-dominated by broom snakeweed (*Gutierrezia sarothrae)* and featherplume (*Dalea formosa*), with a common associate, Arizona juniper (*Juniperus arizonica*), in the canopy strata (>2 m) and a substantial perennial grass component with cover approaching 10%. Broom snakeweed (*G. sarothrae*) accounts for up to 18% cover in some areas of this shrubland, but averages around 7% throughout. The other co-dominant, featherplume (*D. formosa*), can be as high as 8% of total cover, but is often much more sparse, averaging to only 5%. This shrubland is very open and might best be described as a subshrubland, dominated by short-statured shrubs and forbs, with occasional, widely dispersed large shrubs and trees. Arizona juniper (*J. arizonica*) is present throughout this community, with variable cover ranging from less than 1% to 8%. The field stratum also contains a diverse range of perennial bunchgrasses. The two most consistent and widely distributed of these, New Mexico feathergrass (*Hesperostipa neomexicana*) and black grama (*Bouteloua eriopoda*), provide an average of 3% each. The remaining grasses—sideoats grama (*Bouteloua curtipendula*), purple threeawn (*Aristida purpurea*), and slim tridens (*Tridens mutica*)—are less consistent, with cover values closer to 1%.

This shrubland community is mainly found on low-angle to moderately steep (6–35%) shoulder slopes, backslopes, and some toeslopes of large mesas at the Well unit. This shrubland community covers 8% (8 ha/21 ac) of the Well unit and only 0.5% (1 ha/3 ac) at the boundary edge of the Castle unit. The surface soils are often exposed, either as scattered bedrock and small rocks, or commonly bare soil and gravel.



#4 *Canotia holocantha* Shrubland Association (P)

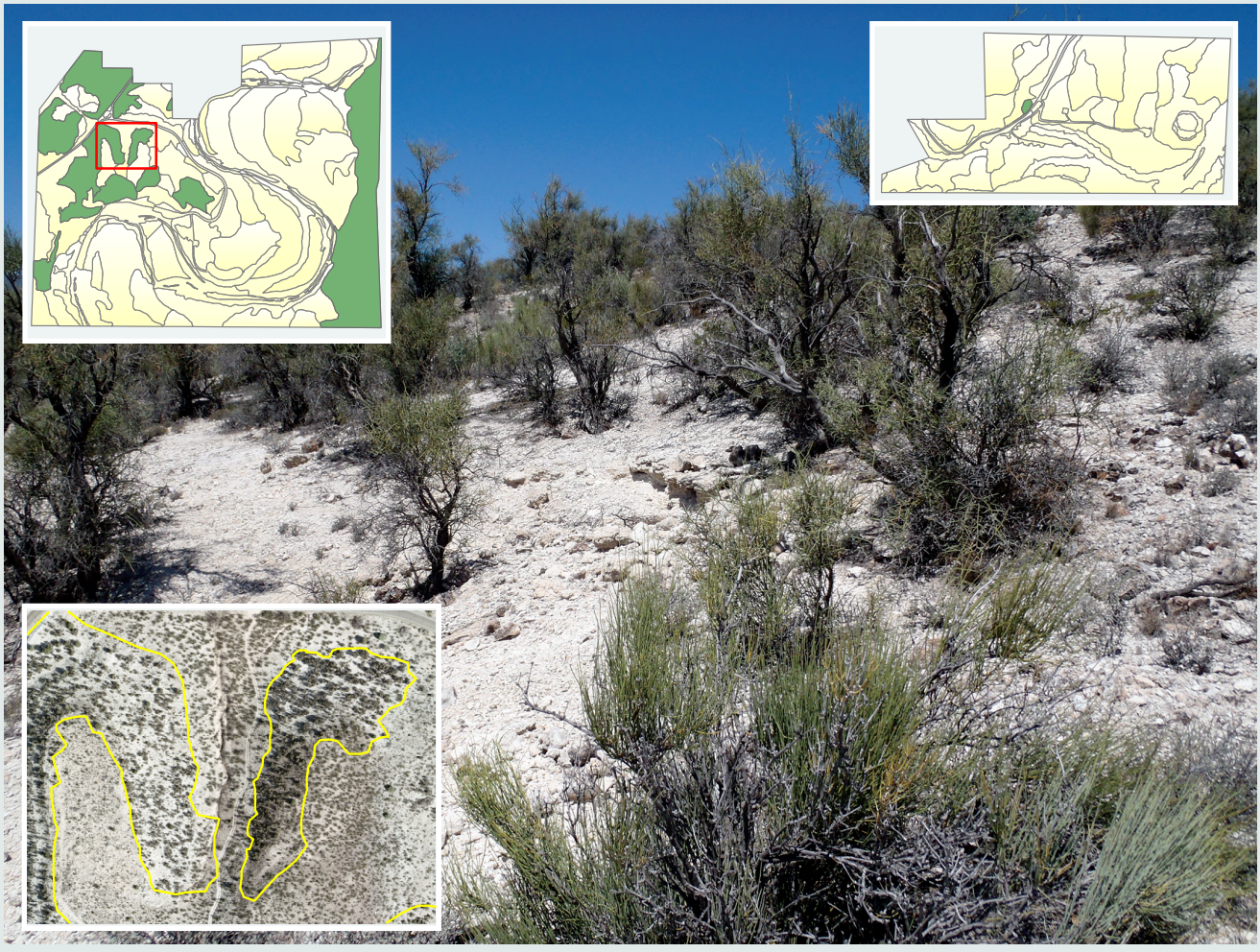
Crucifixion thorn Shrubland Association (P)

Common species

- *Canotia holocantha*
- *Juniperus arizonica*
- *Larrea tridentata*
- *Parthenium incanum*
- *Aristida purpurea*

This shrubland community is characterized by a canopy (2–5 m) and subcanopy (0.5–2 m) dominated by crucifixion thorn (*Canotia holocantha*) and a low-cover, diverse understory of shrubs, perennial forbs, and perennial grasses. Average total cover of all species combined is around 20%, but varies greatly across the community, with areas down to 8% and up to 45%. Crucifixion thorn has an average cover of 14%, ranging from 6% to 32%. Arizona juniper (*Juniperus arizonica*) and creosote bush (*Larrea tridentata*) are low-cover yet common associates, with average cover for both approaching 3%. Mariola (*Parthenium incanum*) is the most dominant low shrub (<0.5 m) in this community, but provides inconsistent cover throughout. Other species of note include red barberry (*Berberis haematocarpa*), Mormon tea (*Ephedra viridis*), lotebush (*Ziziphus obtusa*), catclaw acacia (*Senegalia greggii*), broom snakeweed (*Gutierrezia sarothrae*), New Mexico feathergrass (*Hesperostipa neomexicana*), purple threeawn (*Aristida purpurea*), slim tridens (*Tridens muticus*), featherplume (*Dalea formosa*), and ratany (*Krameria erecta*).

This shrubland occurs mainly at the Castle unit, covering around 21% (64 ha, 160 ac) of the total area, primarily on hillslopes and summits above the floodplain of Beaver Creek. While occupying a similar habitat, the community is very restricted at the Well unit, covering only 0.2% (0.2 ha/0.5 ac). In general, this community is present in areas with high surface rock and bedrock cover, usually composed of limestone.



#5 *(Larrea tridentata) / Parthenium incanum* Shrubland Association (P)

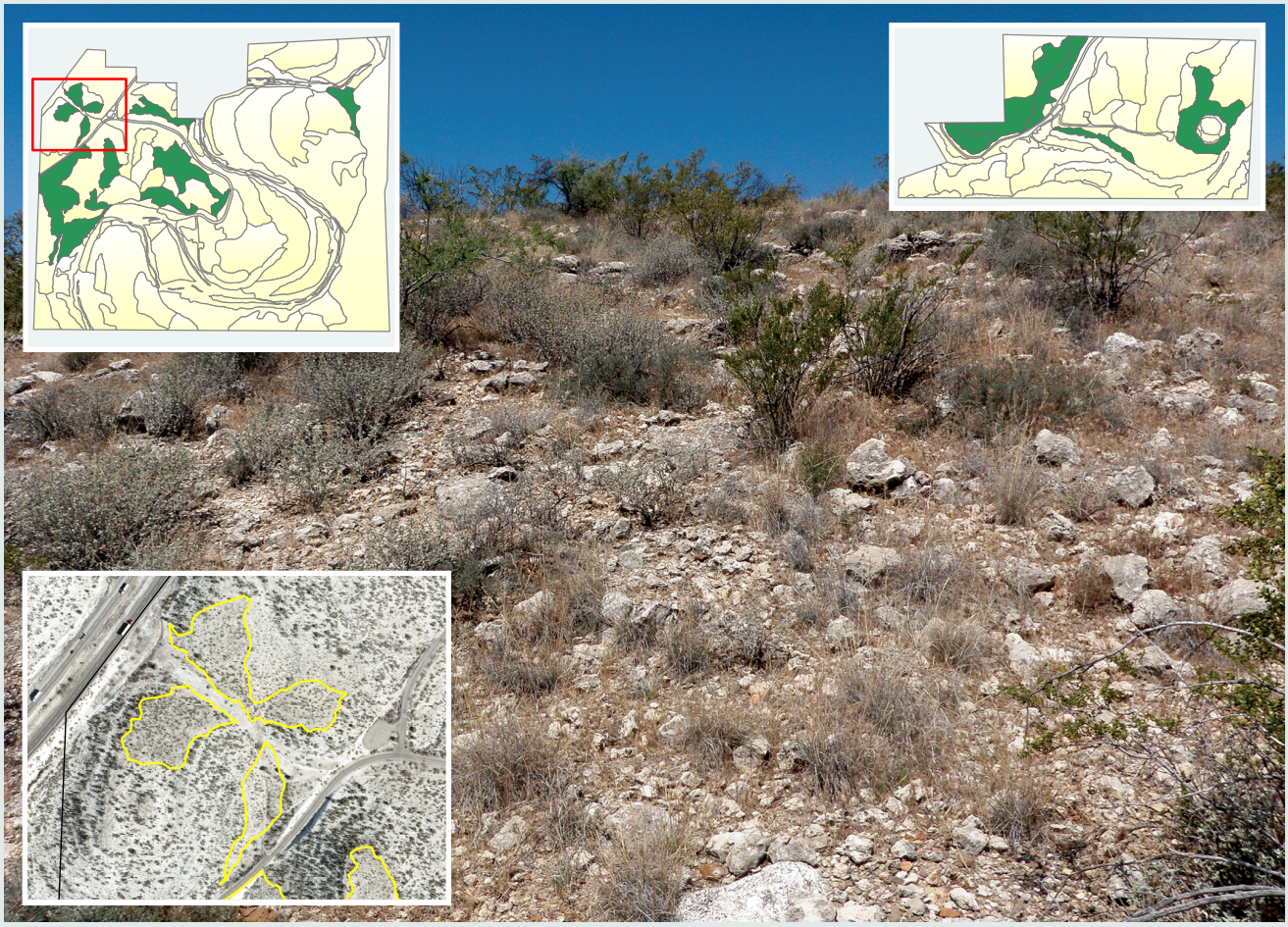
(Creosote bush) / Mariola Shrubland Association (P)

Common species

- *Parthenium incanum*
- *Larrea tridentata*
- *Krameria erecta*
- *Juniperus arizonica*
- *Senegalia greggii*

This shrubland association is characterized by a field stratum (<0.5 m) dominated by mariola (*Parthenium incanum*) and one common associate, creosote bush (*Larrea tridentata*), in the subcanopy stratum (0.5–2 m). Vegetation cover is sparse overall, averaging only 17% across all species, with mariola (*P. incanum*) contributing an average of 9%. Cover for this species is variable, ranging from 3 to 18%, but it is the most consistently dominant species within this association. Creosote bush (*L. tridentata*) is a patchy common associate in the subcanopy, with cover ranging from completely absent to dominant, with values up to 8%. The subcanopy is not very diverse and contains only a few other noteworthy, low-cover associates, including catclaw acacia (*Senegalia greggii*), Arizona juniper (*Juniperus arizonica*), red barberry (*Berberis haematocarpa*), and velvet mesquite (*Prosopsis velutina*). These species provide very patchy cover across the community, generally around 1%, but may be locally abundant in scattered locations. Other noteworthy species in the field stratum include ratany (*Krameria erecta*), featherplume (*Dalea formosa*), woody crinklemat (*Tiquilia canescens*), slim tridens (*Tridens muticus*), New Mexico feathergrass (*Hesperostipa neomexicana*), and purple threeawn (*Aristida purpurea*).

This shrubland occurs on generally south to southwest-facing summits, backslopes, and shoulders of mesas. This shrubland community covers 8% (25 ha/62 ac) of the Castle unit and 15% (16 ha/40 ac) of the Well unit. The soils are characterized as calcareous sedimentary, typically limestone. Ground cover is dominated by a mix of angular gravel and rock, with occasional patches of exposed bedrock.



#6 *Prosopis velutina / Bromus rubens - Hordeum murinum* Woodland and Shrubland Association (P)

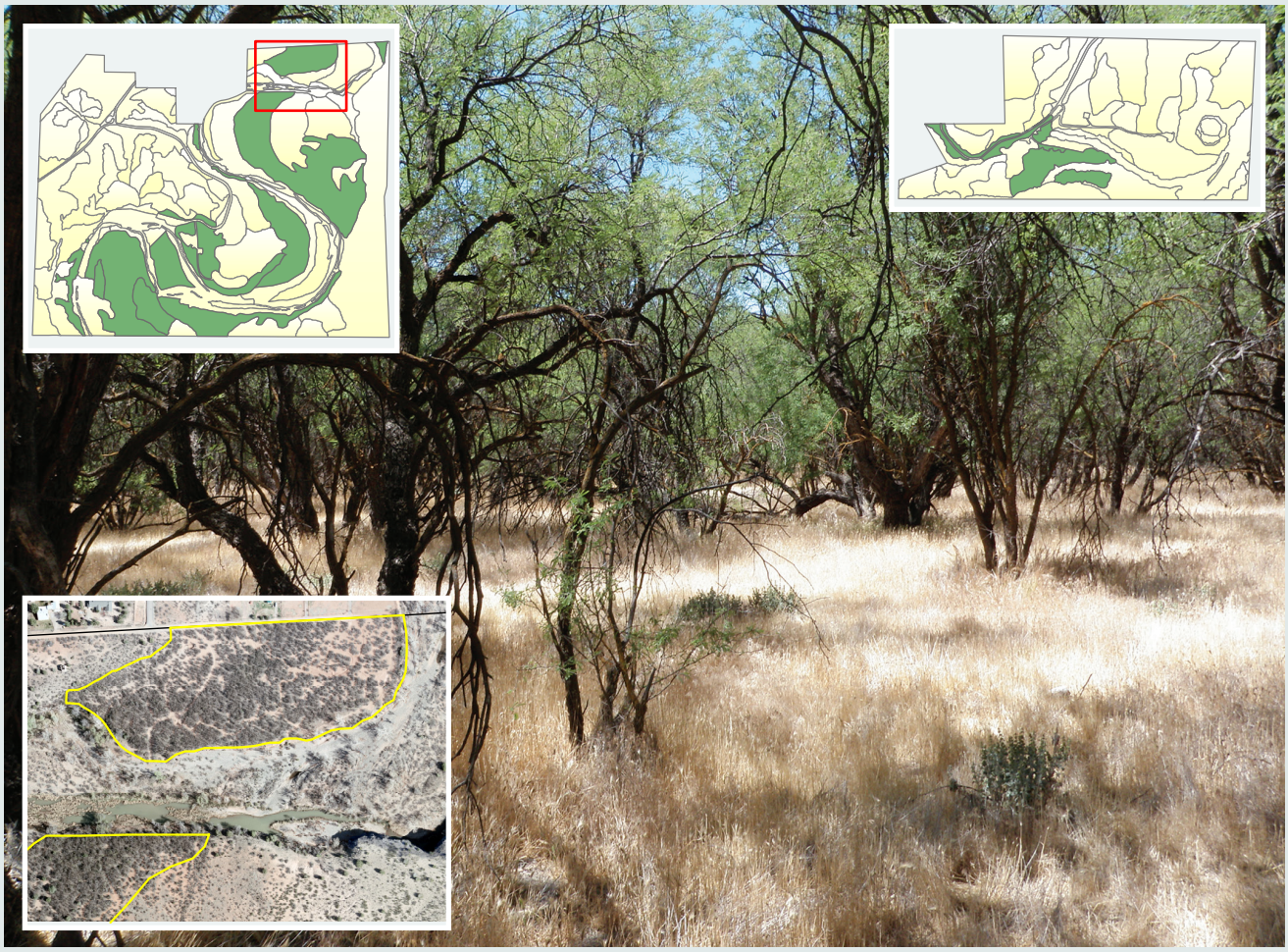
Velvet mesquite / Red brome - Mouse barley Woodland and Shrubland Association (P)

Common species

- *Prosopis velutina*
- *Senegalia greggii*
- *Bromus rubens*
- *Hordeum murinum*
- *Bromus diandrus*
- *Bromus tectorum*

This woodland community is characterized by a canopy (0.5–5-m) stratum dominated by velvet mesquite (*Prosopis velutina*), with a field stratum (<0.5 m) dominated by annual, non-native grasses. Velvet mesquite (*P. velutina*) accounts for an average of 30% cover, ranging up to 85%. In general, this species is present in a tree-like growth form, with heights ranging from 1 to 4.5 meters. However, the margins of this community tend to include more shrub-like individuals that generally coincide with a decline in overall cover. Catclaw acacia (*Senegalia greggii*) is a patchy associate, averaging 3% cover across the community, with inclusions of co-dominance. Other noteworthy shrub species include fourwing saltbush (*Atriplex canescens*), red barberry (*Berberis haematocarpa*), and pale desert thorn (*Lycium pallidum*). Cover of non-native grasses in the field stratum ranges from 12% to 92%, with an average of 48% across the community. These grasses are predominately composed of red brome (*Bromus rubens*), ripgut brome (*Bromus diandrus*), cheatgrass (*Bromus tectorum*), and mouse barley (*Hordeum murinum*).

This woodland is found along the low-gradient alluvial terraces and floodplain adjacent to Beaver Creek at both units of the monument. This community covers 25% (75 ha/186 ac) of the Castle unit and 10% (11 ha/27 ac) of the Well unit. The soils are characterized by a fine-grained alluvium, with bare soil or litter dominating the surface cover, depending on overstory vegetation.



#7 *Prosopis velutina (Senegalia greggii)* / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association (P)

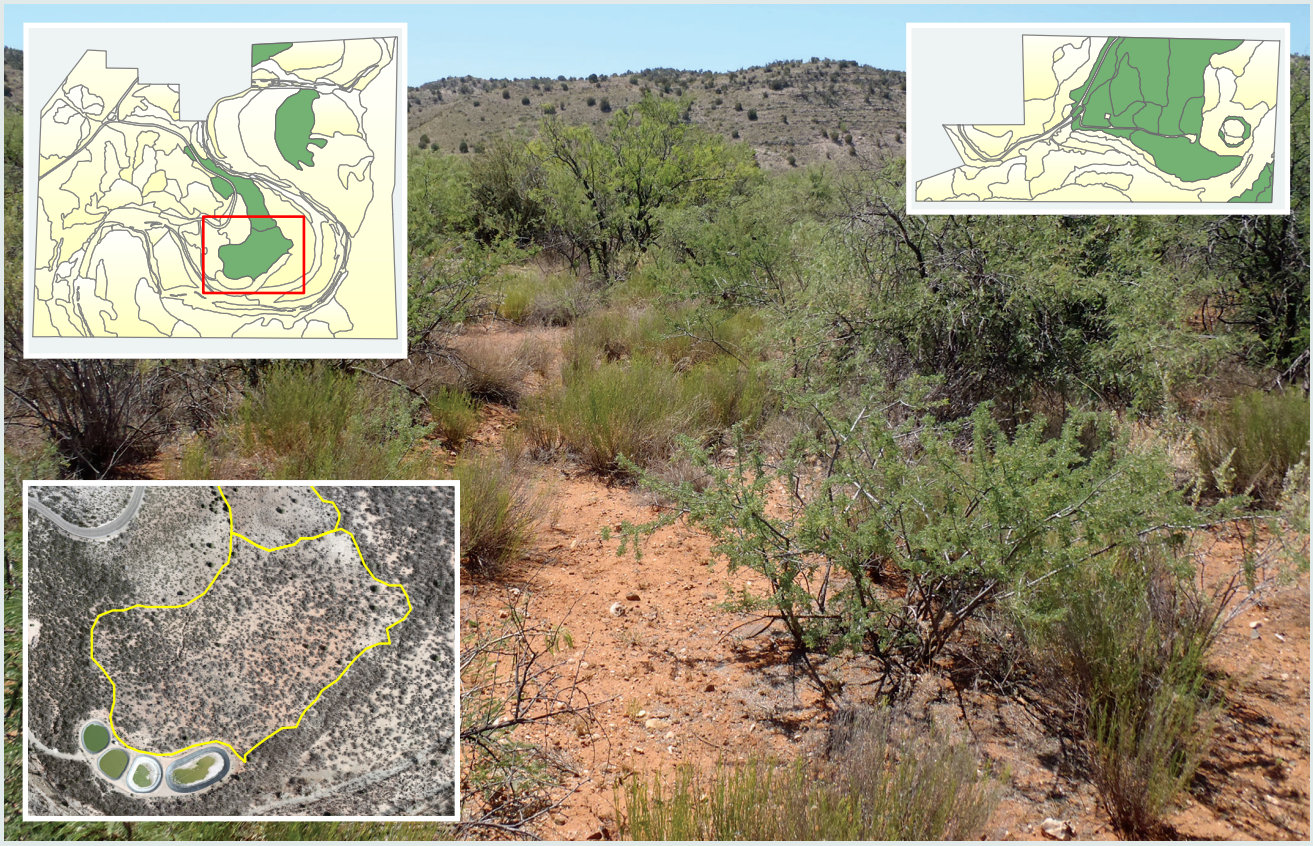
Velvet mesquite (Catclaw acacia) / (Mixed Perennial Grass - Broom snakeweed) Shrubland Association (P)

Common species

- *Prosopis velutina*
- *Senegalia greggii*
- *Larrea tridentata*
- *Gutierrezia sarothrae*
- *Hesperostipa neomexicana*
- *Muhlenbergia porteri*

This shrubland community is characterized by a subcanopy stratum (0.5–2 m) dominated by velvet mesquite (*Prosopis velutina*), with one common associate, catclaw acacia (*Senegalia greggii*), and a field stratum (< 0.5 m) composed of a variable mix of short-statured shrubs and perennial grasses. Velvet mesquite (*P. velutina*) is well-distributed in a generally low-statured (1–2 m), shrub-like growth form. It accounts for an average of 10% cover across the association, with areas ranging up to 30%. Catclaw acacia (*S. greggii*) is a consistent, common associate, with cover averaging 3% and ranging up to 8%. Creosote bush (*Larrea tridentata*) is a patchy associate that is most common at the Castle unit. The field stratum (<0.5 m) is characterized by a diverse mix of small shrubs and perennial grasses. Broom snakeweed (*G. sarothrae*) is the most dominant small shrub across this community, providing cover that averages to 6%. However, individual cover values are highly variable, ranging from less than 1% up to 18%, with the highest cover occurring at the Well unit. Bush muhly (*Muhlenbergia porteri*), New Mexico feathergrass (*Hesperostipa neomexicana*), and tobosagrass (*Hilaria mutica*) are the most widespread perennial grasses, with highly variable cover ranging from 0 to 8%.

This shrubland type is found on broad, low-angle alluvial terraces and toeslopes at both units of the monument. The community covers 10% (31 ha/76 ac) of the Castle unit and 32% (33 ha/82 ac) of the Well unit. Surface cover is characterized by sandy alluvium dominated by bare soil, with considerable biological and physical soil crusts throughout. Surface rock and gravel are rare surface cover components, with variable litter cover depending on overstory.



#8 *Larrea tridentata* Shrubland Association (P)

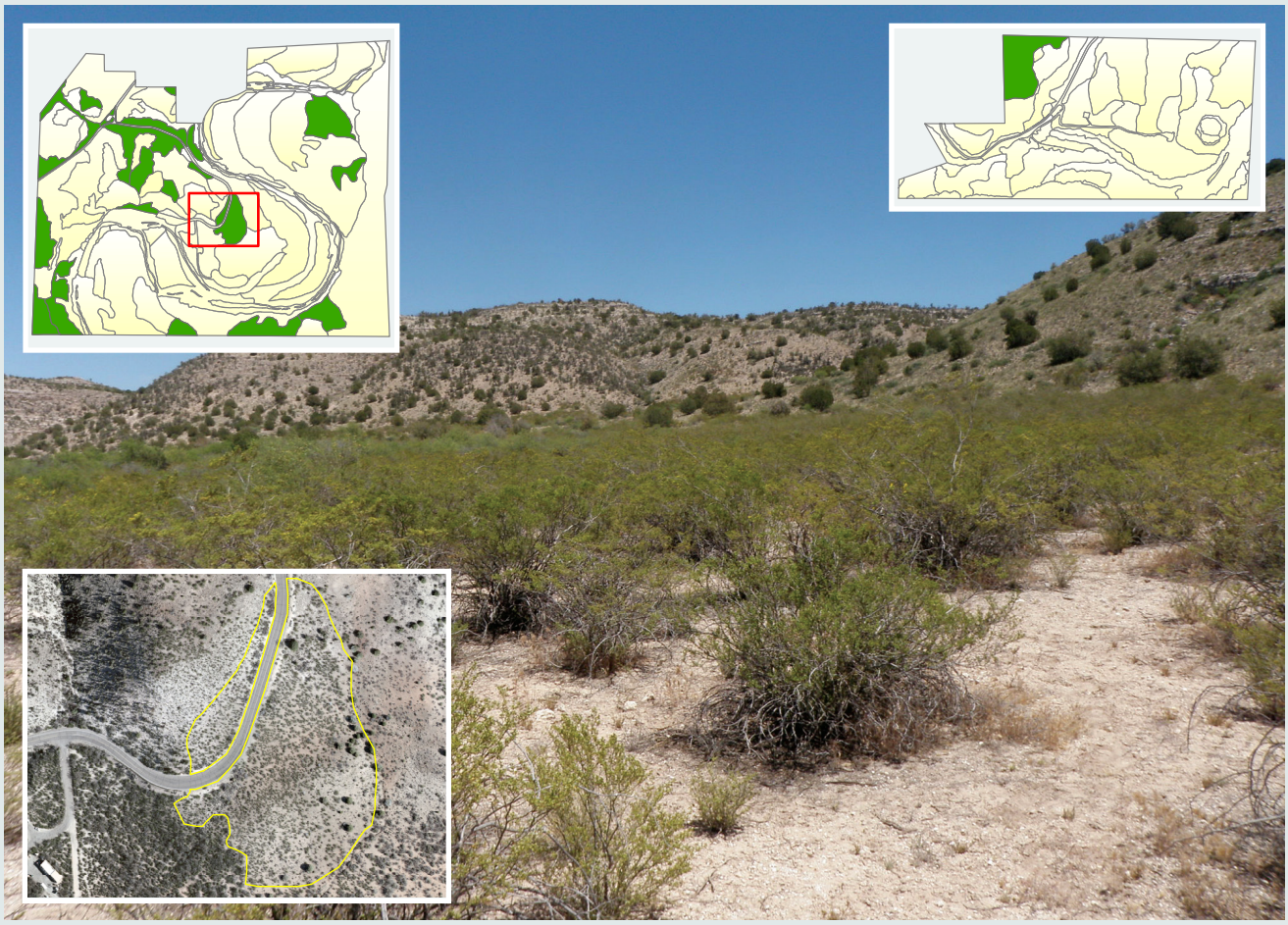
Creosote bush Shrubland Association (P*)*

Common species

- *Larrea tridentata*
- *Senegalia greggii*
- *Prosopis velutina*
- *Gutierrezia sarothrae*
- *Krameria erecta*
- *Bromus rubens*

This shrubland community is characterized by an open subcanopy stratum (0.5–2 m), dominated by widely spaced creosote bush (*Larrea tridentata*) and a diverse but inconsistent mix of additional shrubs and perennial grasses. Average total cover of creosote bush (*L. tridentata*) is around 10%, ranging up to 20%. Catclaw acacia (*Senegalia greggii*) provides inconsistent, low cover across the community, averaging about 2%, with rare areas of increased cover where it competes for dominance with creosote bush (*L. tridentata*). Velvet mesquite (*Prosopis velutina*) is another occasional species, most common at the margins of the community. Broom snakeweed (*Gutierrezia sarothrae*) is the most-common perennial component in the field stratum (<0.5 m), including scattered areas of dominance with cover approaching 10%, but averaging only 2% across the monument. Littleleaf ratany (*Krameria erecta*) and winterfat (*Krascheninnikovia lanata*) are sparse shrubs with occasional areas of noteworthy cover. Numerous perennial grasses, including purple threeawn (*Aristida purpurea*), bush muhly (*Muhlenbergia porteri*), sand dropseed (*Sporobolus cryptandrus*), tobosagrass (*Hilaria mutica*), and black grama (*Bouteloua eriopoda*), provide patchy cover throughout.

This shrubland occurs predominately at the Castle unit, covering 12% (36 ha/90 ac) of the total area, mainly on the low-angle mesa shoulders and summits. At the Well unit, this community is restricted to a mesa top that accounts for 5% (5 ha/12 ac) of the total area. Surface cover is typically dominated by a mix of gravel and bare soil, with higher rock cover where slopes increase.



#9 Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna Association (PS)

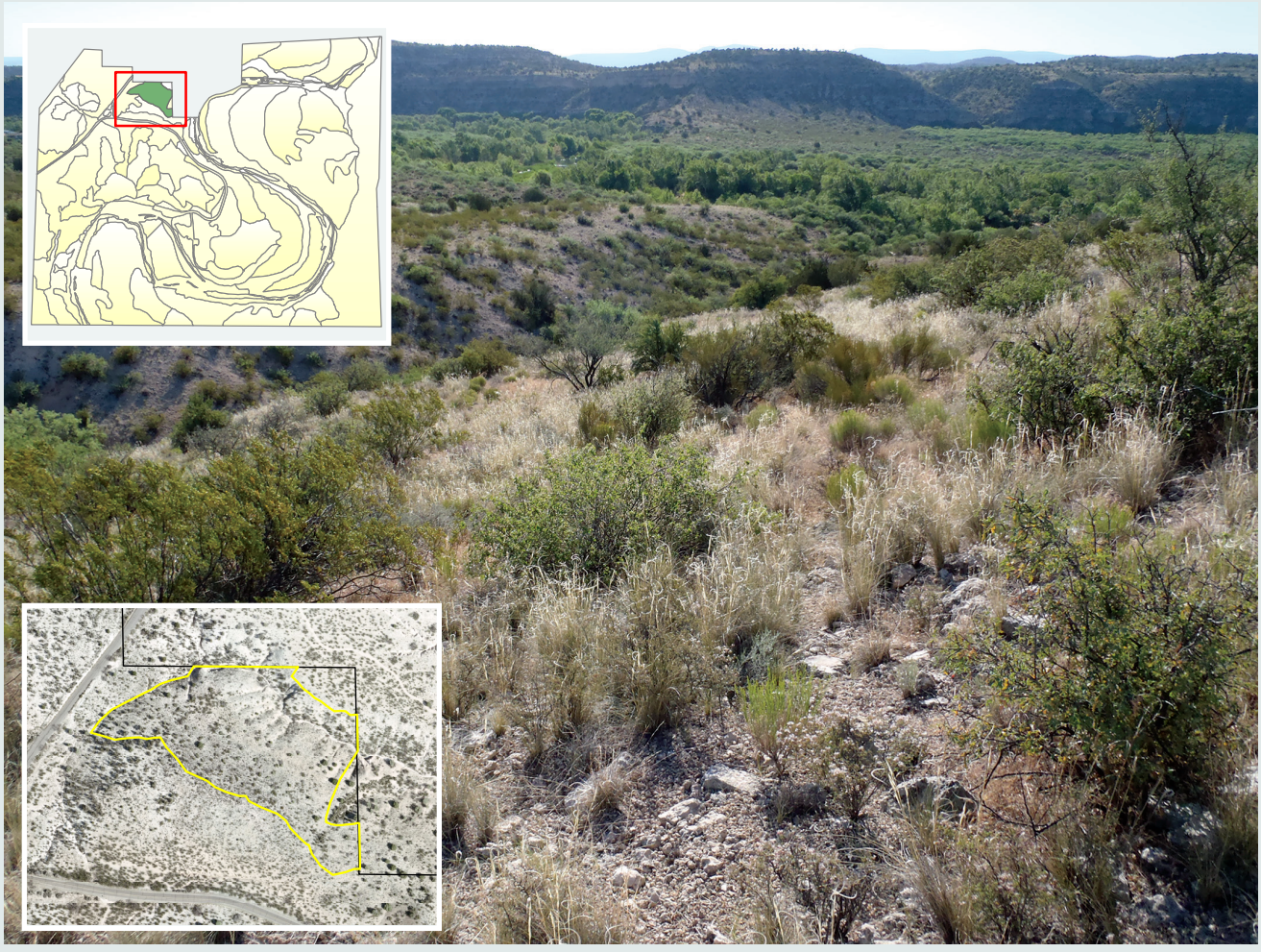
Mixed Shrub / New Mexico feathergrass Shrubland Association (PS)

Common species

- *Hesperostipa neomexicana*
- *Larrea tridentata*
- *Senegalia greggii*
- *Berberis haematocarpa*
- *Rhus aromatica*

This shrub savanna community is characterized by a subcanopy (0.5–2 m) dominated by a low-cover mix of shrubs and a field stratum (<0.5 m) dominated by New Mexico feathergrass (*Hesperostipa neomexicana*). Typically, cover of shrub species is around 5% and is split between creosote bush (*L. tridentata*), fragrant sumac (*Rhus aromatica*), red barberry (*Berberis haematocarpa*), and catclaw acacia (*Senegalia greggii*). Distribution of these species varies, with creosote bush (*L. tridentata*) occasionally present as the sole dominant. The other three species, when present, are large and well-spaced individuals, usually greater than 2 meters tall. The field stratum is characterized by a matrix of native perennial grasses, with cover approaching 30%. New Mexico feathergrass (*H. neomexicana*) is the clear dominant, providing cover around 20%. Sideoats grama (*Bouteloua curtipendula*), slim tridens (*Tridens muticus*), and purple threeawn (*Aristida purpurea*) are consistent, but low-cover, associates. A mix of subshrubs—littleleaf ratany (*Krameria erecta*) and featherplume (*Dalea formosa*)—provides consistent low cover throughout.

This shrub savanna community spans the northeast-facing backslope of a mesa at the Castle unit. The community covers 0.87% (3 ha/6 ac) of the Castle unit and is not present at the Well unit. The surface is characterized by loose soil, as well as calcareous gravel and rock fragments of various sizes, with the occasional small bedrock outcrop.



#10 *Celtis reticulata - Salix exigua / (Schoenoplectus tabernaemontani) / Bromus diandrus* Riparian Woodland Association (PS)

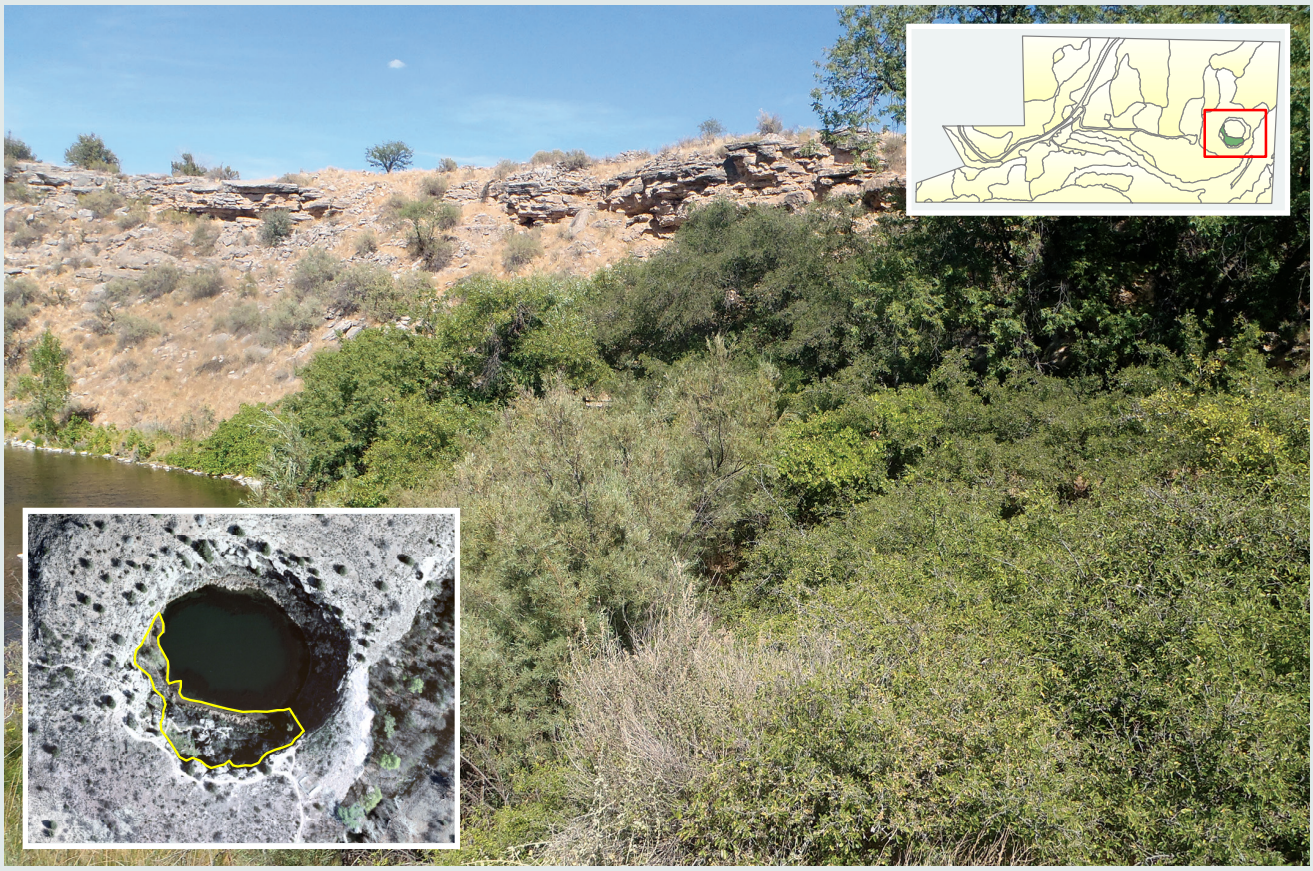
Netleaf hackberry - Narrowleaf willow / (Softstem bulrush) / Ripgut brome Riparian Woodland Association (PS)

Common species

- *Celtis reticulata*
- *Salix exigua*
- *Schoenoplectus tabernaemontani*
- *Bromus diandrus*
- *Juglans major*

This riparian woodland community is characterized by three distinct bands of vegetation, transitioning from an area of facultative and obligate wetland species at the water's edge to a more terrestrial community on the higher slopes surrounding the well. Overall, this community is defined by a canopy stratum (>2 m) dominated by netleaf hackberry (*Celtis reticulata*) and narrowleaf willow (*Salix exigua*), with dominant ripgut brome (*Bromus diandrus*) in the field stratum (<0.5 m) and one common associate, softstem bulrush (*Schoenoplectus tabernaemontani*), at the water's edge. Netleaf hackberry (*C. reticulata*) is generally present in a tree-like growth form, with cover approaching 45% and heights up to 7 meters. This species occupies the most terrestrial and largest band of vegetation within this community. Narrowleaf willow (*S. exigua*) provides around 20% cover in a dense, homogeneous band situated between the netleaf hackberry (*C. reticulata*) woodland and the herbaceous, obligate wetland species at the water's edge. In general, this species is present in a tree-like growth form, with an average height of 3.5 meters. Arizona walnut (*Juglans major*) is present as a single, large individual, situated near the outflow of the well.

This riparian woodland community spans the steep, north-facing slope and low-angle, water-saturated soils within the well feature. The community covers 0.25% (<1 ha/<1 ac) of the Well unit. Ground cover is characterized by the presence of limestone outcrops and boulders—especially toward the uphill end community, where a large cliff band dominates the landscape—with dense litter cover throughout.



#11 *Typha domingensis (Schoenoplectus tabernaemontani)* Herbaceous Association (P)

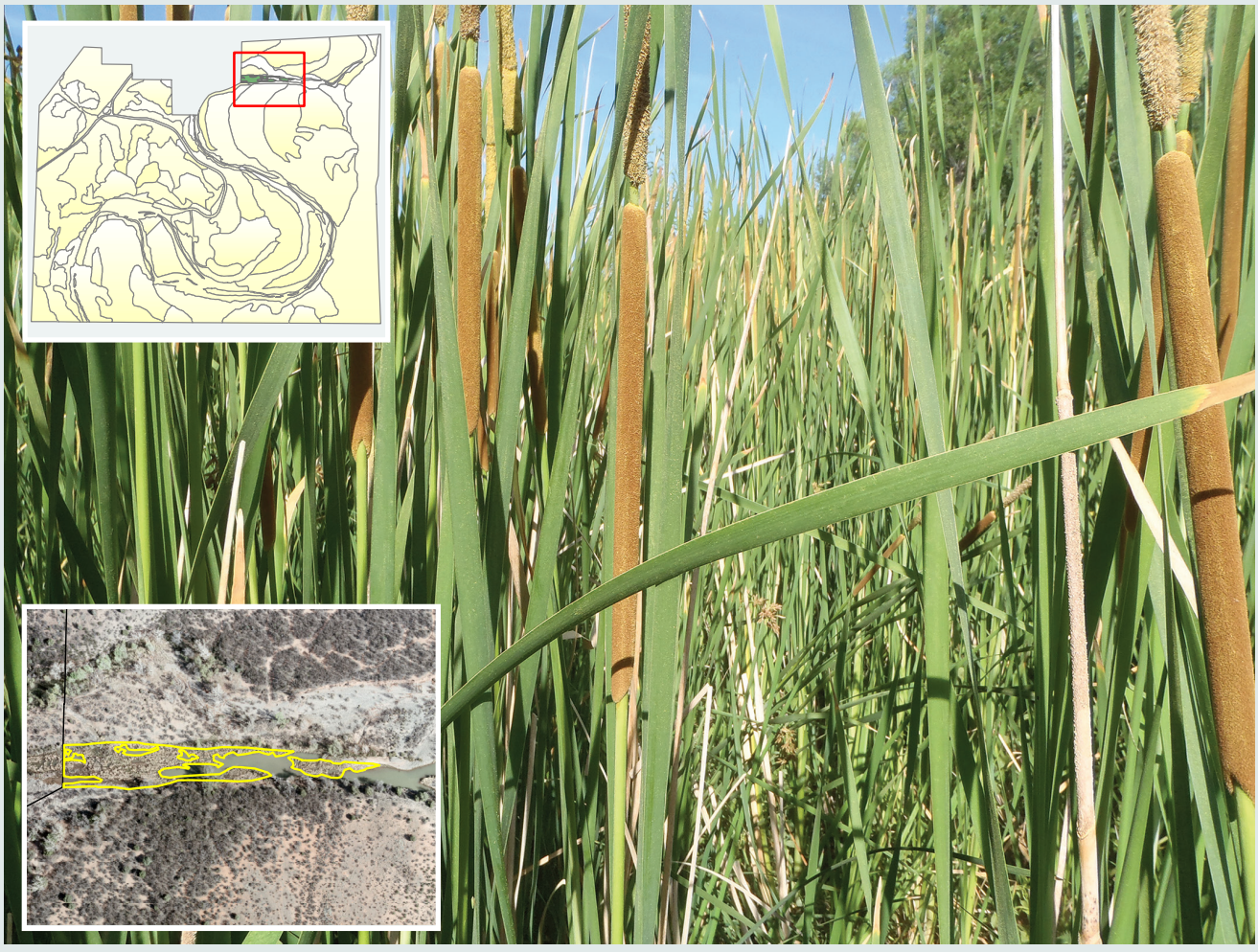
Southern cattail (Softstem bulrush) Herbaceous Association (P)

Common species

- *Typha domingensis*
- *Schoenoplectus tabernaemontani*

This herbaceous community is characterized by a subcanopy stratum (0.5–< 2 m) dominated by southern cattail (*Typha domingensis*) and one common associate, softstem bulrush (*Schoenoplectus tabernaemontani*). Southern cattail (*T. domingensis*) forms a dense matrix, up to 2.5 m tall, with cover often approaching 90%. Softstem bulrush (*S. tabernaemontani*) provides far less cover, but is a conspicuous associate species, especially at the margins of the community. This community is often in close proximity to the nearby riparian woodlands, and, as such, contains occasional large tree species, specifically, Goodding's willow (*Salix gooddingii*), Arizona sycamore (*Platanus wrightii*), and Arizona ash (*Fraxinus velutina*). The field stratum (<0.5 m) contains a diverse, low-cover mix of obligate and facultative wetland species, including: Parish's spikerush (*Eleocharis parishii*), fescue (*Schedonorus* sp.), smooth horsetail (*Equisetum laevigatum*), field horsetail (*Equisetum arvense*), wild mint (*Mentha arvensis*), swamp carex (*Carex senta*), and Rocky mountain rush (*Juncus saximontanus*). These species are very sparse and are usually only present at the margins of the community where southern cattail (*T. domingensis*) is less common.

This herbaceous community spans low-angle, usually still, stretches of Beaver Creek, covering around 0.22% (1 ha/2 ac) of the Castle unit. Ground cover ranges from water-saturated soils, often covered with dead cattail stems, at the margins of the creek to areas of standing water. At times, this community can cover the entire width of the watercourse, but is generally confined to its margins.



#12 *(Prosopis velutina) / Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna Association (PS)

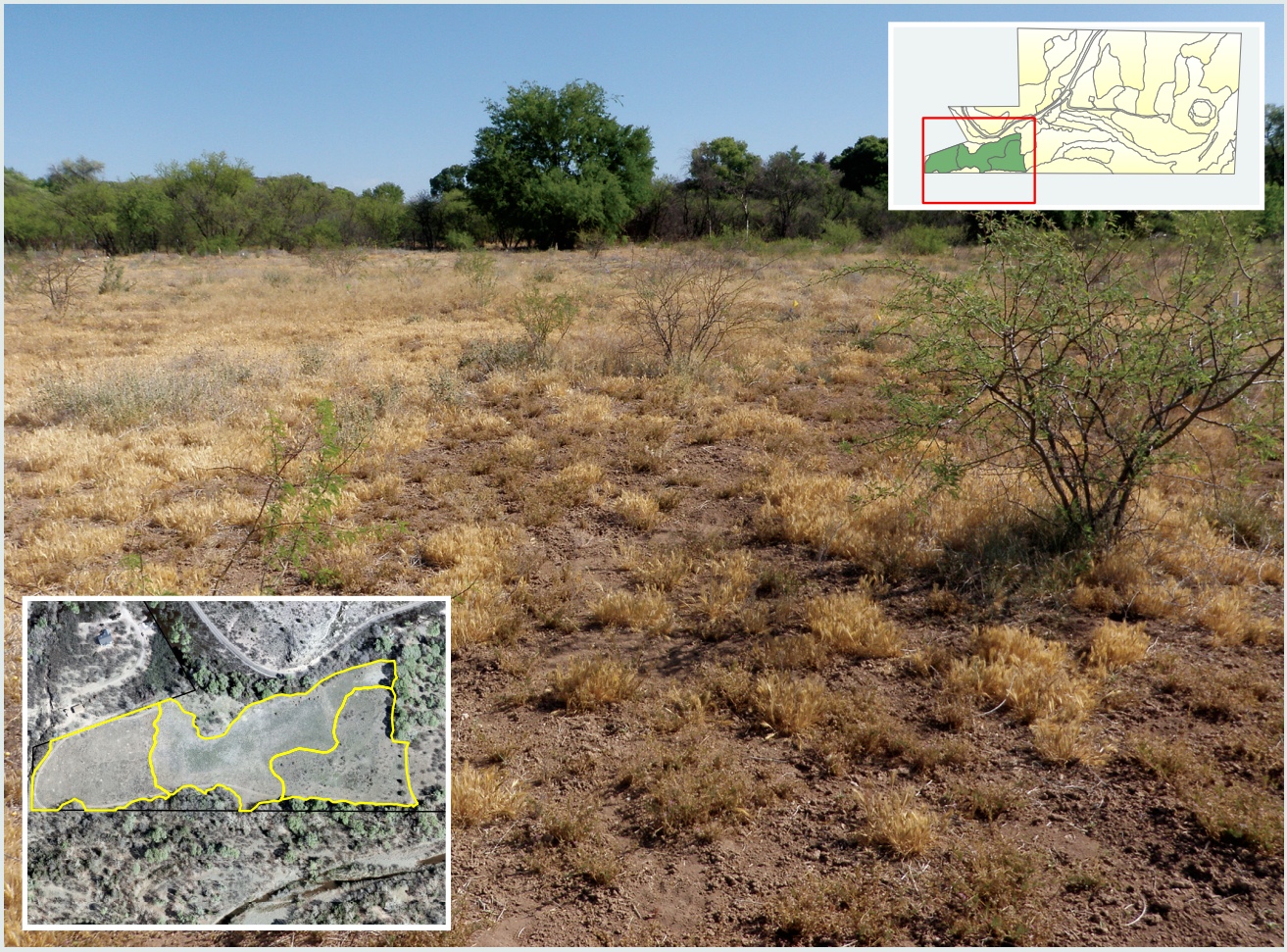
(Velvet mesquite) / Mouse barley - Red brome - Ripgut brome Ruderal Shrub Savanna Association (PS)

Common species

- *Hordeum murinum*
- *Bromus rubens*
- *Bromus diandrus*
- *Salsola* sp.
- *Prosopis velutina*

This shrub savanna community is characterized by patchy, low-cover velvet mesquite (*Prosopis velutina*) in the canopy (2–5 m) and field (<0.5 m) strata, dominated by a mix of exotic annual grasses. Velvet mesquite (*P. velutina*) is generally patchy, with variable cover averaging 11% across the community, small patches ranging up to 21%, and areas completely devoid of this species. In general, this species has a tree-like growth-form, with heights up to 4 meters. The field stratum is characterized by a diverse matrix of non-native grasses and forbs, dominated by mouse barley (*Hordeum murinum*), red brome (*Bromus rubens*), ripgut brome (*Bromus diandrus*), and Russian thistle (*Salsola* sp.). Cover of these species combined is variable throughout, ranging from 10% and up to 60%, with mouse barley (*Hordeum murinum*) providing the highest and most consistent cover. In the less-disturbed sections of this community, native grasses, including silver bluestem (*Bothriochloa saccharoides*), spidergrass (*Aristida ternipes*), green sprangletop (*Leptochloa dubia*), and sand dropseed (*Sporobolus cryptandrus*), provide low cover. Other noteworthy non-native species include horehound (*Marrubium vulgare*) and Johnsongrass (*Sorghum halepense*).

This shrub savanna community occurs on the low-angle, heavily disturbed floodplain immediately adjacent to Beaver Creek. The main occurrence spans a large, fallow pasture that was grazed by cattle until 1993 (Rowlands 1999).



5 Discussion

5.1 Vegetation characterization

Despite its small size (408 ha/1,008 ac) and limited elevational range (520 ft/158 m), Montezuma Castle National Monument hosts a wide array of vegetation associations and a diverse suite of species. There are several reasons for this: the park spans an ecotonal physiographic province, it includes a robust riparian corridor supported by a perennial creek, and has a legacy of prior disturbances occurring over varied spatial and temporal scales.

The park's vegetation can be classified into two broad types: (1) riparian woodlands and gallery forests, and (2) thornscrub communities in rocky uplands. Within the upland scrub communities, a secondary division into two groups is apparent, generally correlating to distance from and elevation above Beaver Creek. The lower-lying areas in the old alluvium and secondary-floodplain terraces represent a transitional area between the active floodplain and the uplands, where mesquite and acacia dominate. The calcareous, rocky soils on the steep slopes above the floodplain are characterized by co-mingling crucifixion thorn and creosote bush, with occasional perennial bunchgrasses and thorny shrubs. These species, along with ephedra (*Ephedra viridis*), littleleaf ratany (*Krameria erecta*), redberry mahonia (*Mahonia haematocarpa*), and graythorn (*Ziziphus obtusifolia*), define a scrubby landscape of widely spaced, low-growing plants, dotted with tall shrubs.

Park lands have a long history of human occupation and use, with Hohokam and Sinagua settlements dating back to at least 600 AD (NPS 1996). More recently, the broad floodplains and adjacent low-angle slopes were used as agricultural fields and pastures (Figures 5-1 and 5-2). Many of these areas were abandoned in the early 20th century, but one area of the Well unit was actively grazed until 1993. These areas were heavily impacted, with clear signs of disturbance still evident to this day.

In many cases, the boundaries of these areas aligned with those of our polygons. The most pronounced example of this occurred in the southwest corner of the Well unit. This area, which exactly aligns with the boundaries of the most recently grazed area, was described as (*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna Association, a "park special" community whose formation and species composition was a direct result of disturbance, in addition to active restoration efforts by park staff. This community is an extremely disturbed version of the *Prosopis velutina* / *Bromus rubens - Hordeum murinum* Woodland and Shrubland Association, in which non-native grasses are the dominant vegetation. In general, all other areas in or near areas of historic disturbance contained a dominant ground cover of non-native grasses, most commonly dominated by ripgut brome (*Bromus diandrus*), red brome (*Bromus diandrus*), and mouse barley (*Hordeum murinum*). The communities that dominated these disturbed areas were:

- (*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna Association
- *Prosopis velutina* / (*Bromus rubens - Hordeum murinum*) Woodland and Shrubland Association
- *Prosopsis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association

The remaining described communities occupied areas less suitable for agriculture and grazing, primarily due to steep slopes and extremely rocky soils. In these communities, non-natives are absent to patchy. When in close proximity to the floodplain, non-natives may become more prevalent, but should not be consistent across the broader community.

5.2 National Vegetation Classification placement

Two of the 12 community types had accepted association corollaries within the NVC at the time of report preparation. However, as the NVC is refined and the inclusion of more data

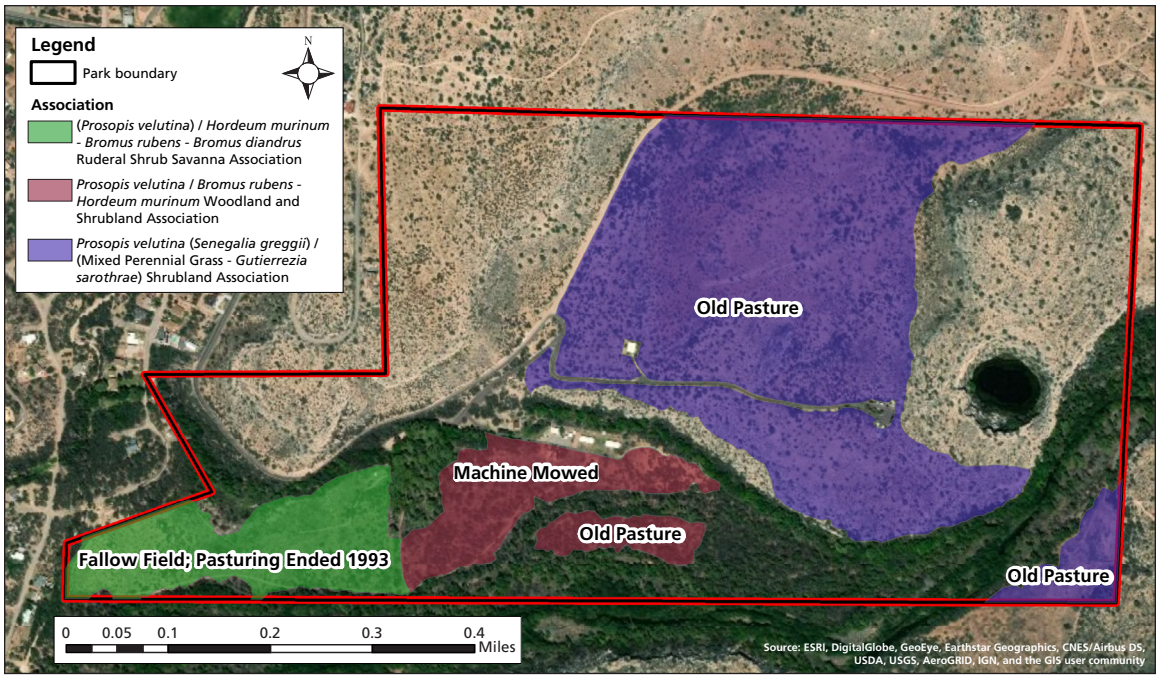


Figure 5-1. Map of disturbed communities at the Well unit. Overlaid text is taken from Rowlands's (1999) map of recent and historical disturbance. Identified associations/polygons match disturbed areas identified in Rowlands's report.

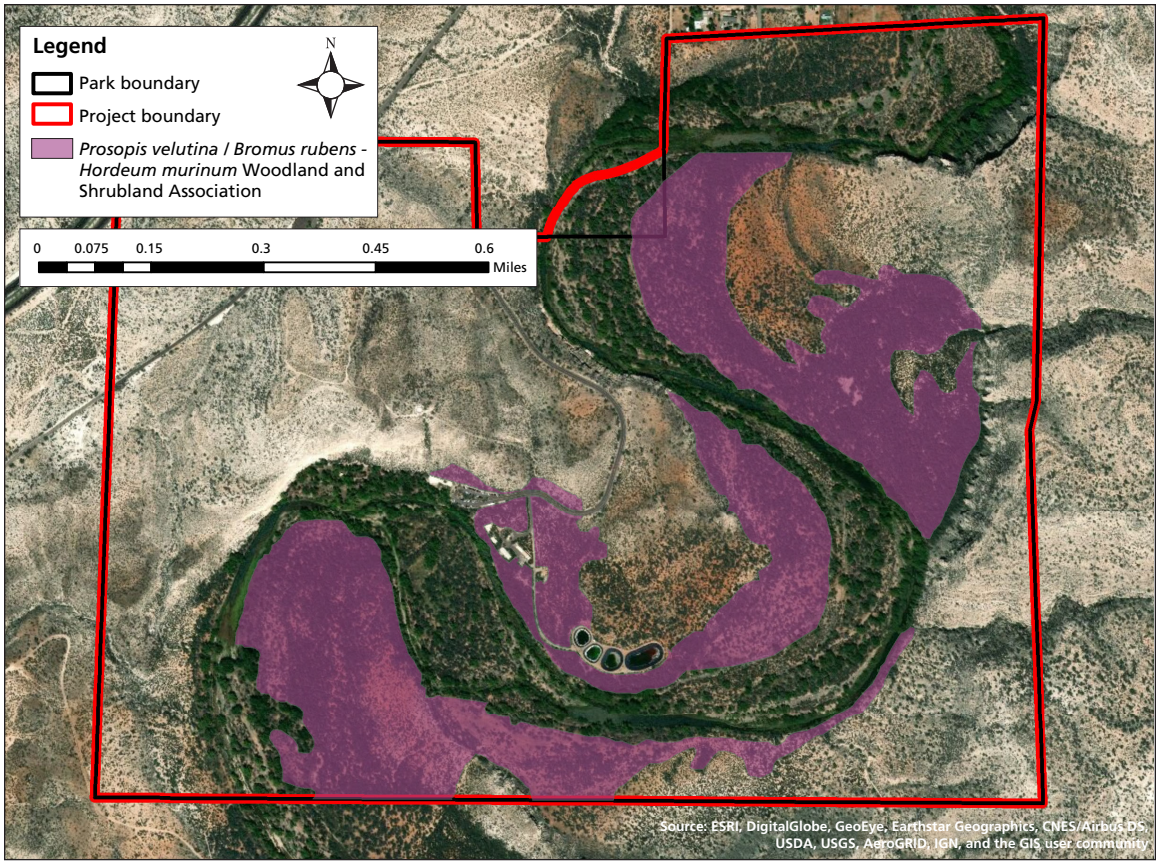


Figure 5-2. Map of disturbed communities at the Castle unit. All identified associations/polygons were listed as areas with potential agricultural or grazing disturbance in Rowlands's (1999) map of recent and historical disturbance.

leads to new type descriptions, additional global types are expected in future years. A number of our communities were similar to associations described in the NVC. However, we did not include them as a match if the NVC type did not include a detailed description and/or the associated species were clearly diagnostic of a different floristic region. Where no corollary was found to a mapped type within the NatureServe database, descriptions were limited to the study area locality. 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 F.

Alliances and associations (as well as all other levels of the hierarchy) are currently under review by the FGDC Vegetation Subcommittee, the Vegetation Panel of the Ecological Society of America, and Natureserve, with the purpose of updating the content into the revised NVC hierarchy (FGDC 2007). Current status and revisions to the hierarchy can be viewed at www.usnvc.org.

5.3 Park flora

5.3.1 Species observations

During this effort, a total of 176 species (119 at the Castle unit and 151 at the Well unit) were observed in classification plots. An additional six species were observed during polygon-scale data collection. During the accuracy assessment, an additional 43 species were documented (23 at the Castle unit and 27 at the Well unit), for a total of 226 species identified across all phases of the project. Overall, 37 species were documented only at the Castle unit and 67 species were documented only at the Well unit. One hundred twenty-two species were documented at both units.

Two species lists (one for each unit) are jointly maintained and updated by SODN and park staff. They are available for public viewing on the Southwest Environmental Information Network (SEINet) data portal, under the Agency Floras tab. The SEINet listings also provide links to herbarium specimens that were collected in the park and accessioned into any of the herbaria that participate in the SEINet. A full list of species recorded during this project is provided in Appendix G.

5.3.2 Global rarity

Based on the rarity ranking system originally developed by The Nature Conservancy (now managed by NatureServe), we evaluated all plants observed during this effort to see if any were considered rare or imperiled. The "global rank" describes each species's status globally and describes the risk of extinction, with G1 being critically imperiled and G5 being secure. State rank is also measured on a scale of 1–5, relative to distributions and abundances within state boundaries. Five species had a rank of G3 (Table 5-1), 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, Rusby's milkwort (*Polygala rusbyi*) also had a comparable state ranking of S3 ("Uncommon or restricted"). Eastwood's bluestar

Table 5-1. Species observed during project field work with either global or Arizona state rarity rankings.

Scientific name	Common name	Family	Global rank/ State rank†	Unit(s)
Amsonia tomentosa var. *stenophylla*	Eastwood's bluestar	Apocynaceae	NA/S3	Castle
Brickellia floribunda	Chihuahuan brickellbush	Asteraceae	G3/SNR	Castle and Well
Encelia virginensis	Virgin River brittlebush	Asteraceae	G3/SNR	Castle and Well
Alnus oblongifolia	oblong leaf alder	Betulaceae	G3/SNR	Castle and Well
Mirabilis pumila	dwarf four o'clock	Nyctaginaceae	G3/SNR	Well
Polygala rusbyi	Rusby's milkwort	Polygalaceae	G3/S3	Castle and Well

†G3 = Vulnerable. At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors; SNR = status not ranked (conservation status not yet assessed); S3 = Uncommon or restricted: 21–50 occurrences in the state; either rather rare throughout a fairly wide range, or fairly common in a rather restricted range within the state.

(*Amsonia tomentosa* var. *stenophylla*) had a state ranking of S3 but no global ranking. More details on these ranking systems are available from the NatureServe website.

5.4 Final products and geodatabase delivery

Spatial and tabular data collected during this project were put into a geodatabase designed to support relationships between the various 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 see all locations for a species, or see all species for a location. A description of the geodatabase structure and attachment formats is provided in Appendix H.

All final products, including this report and the geodatabase, are available for download and viewing from the NPS data store and the NPS Vegetation Mapping Inventory. Spatial map data products can also be viewed without downloading by searching by park or geographic area using the NPS Vegetation Mapping Inventory map viewer. Data can also be requested direct from SODN offices or accessed via the SODN website.

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Appendix A: Exotic Plant Species

Table A-1. Exotic plant species mapped in Montezuma Castle National Monument, 2003–2004 and 2009–2014.

			Exotic plant inventory (2003–2004)[a]		Vegetation mapping (2009–2014)[b]	
Family	**Scientific name**	**Common name**	**MOCC**	**MOWE**	**MOCC**	**MOWE**
Amaranthaceae	*Salsola* spp.	Russian thistle	X	X	X	X
Asteraceae	*Centaurea melitensis*	Maltese star-thistle	X	X	–	X
Asteraceae	*Centaurea solstitialis*	yellow star-thistle	–	X	–	–
Asteraceae	*Lactuca serriola*	prickly lettuce	X	X	–	–
Asteraceae	*Sonchus asper*	spiny sowthistle	–	X	–	X
Asteraceae	*Tragopogon dubius*	yellow salsify	–	–	–	X
Brassicaceae	*Brassica tournefortii*	Asian mustard	X	X	X	X
Brassicaceae	*Sisymbrium irio*	London rocket	X	X	–	–
Cyperaceae	*Cyperus esculentus*	yellow nutsage	X	X	–	–
Fabaceae	*Lotus corniculatus*	bird's-foot trefoil	–	–	–	X
Fabaceae	*Medicago minima* var. *brevispina*	little bur-clover	–	–	–	X
Fabaceae	*Melilotus albus*	sweetclover	X	X	–	–
Fabaceae	*Melilotus officinalis*	sweetclover	X	X	X	X
Geraniaceae	*Erodium cicutarium*	redstem stork's bill	X	X	X	X
Lamiaceae	*Marrubium vulgare*	horehound	X	X	X	X
Lamiaceae	*Mentha spicata*	spearmint	–	–	X	X
Plantaginaceae	*Linaria dalmatica*	Dalmatian toadflax	X	X	X	–
Plantaginaceae	*Plantago lanceolata*	narrowleaf plantain	–	–	X	X
Poaceae	*Aegilops cylindrica*	jointed goatgrass	–	–	–	X
Poaceae	*Avena fatua*	wild oat	X	X	–	X
Poaceae	*Bromus arvensis*	field brome	–	–	–	X
Poaceae	*Bromus catharticus*	rescuegrass	–	–	–	X
Poaceae	*Bromus diandrus*	ripgut brome	X	X	X	X
Poaceae	*Bromus inermis*	smooth brome	–	–	X	X
Poaceae	*Bromus japonicus*	Japanese brome	–	–	X	–
Poaceae	*Bromus rubens*	red brome	X	X	X	X
Poaceae	*Bromus tectorum*	cheatgrass	X	X	X	X
Poaceae	*Cynodon dactylon*	Bermudagrass	X	X	–	–
Poaceae	*Digitaria sanguinalis*	hairy crabgrass	X	X	–	–
Poaceae	*Echinochloa crus-galli*	barnyardgrass	X	X	–	–
Poaceae	*Eragrostis curvula*	weeping lovegrass	–	X	X	X
Poaceae	*Eragrostis lehmanniana*	Lehmann lovegrass	X	–	–	X
Poaceae	*Hordeum* sp.	barley	X	X	X	X
Poaceae	*Lolium perenne*	perennial ryegrass	X	–	–	–
Poaceae	*Polypogon monspeliensis*	annual rabbitsfoot grass	X	X	–	–
Poaceae	*Schedonorus arundinaceus*	tall fescue	–	–	X	–
Poaceae	*Schedonorus phoenix*	tall fescue	–	–	X	X

Table A-1. Exotic plant species mapped in Montezuma Castle National Monument, 2003–2004 and 2009–2014, cont.

			Exotic plant inventory (2003–2004)[a]		Vegetation mapping (2009–2014)[b]	
Family	**Scientific name**	**Common name**	**MOCC**	**MOWE**	**MOCC**	**MOWE**
Poaceae	*Schismus barbatus*	common Mediterranean grass	X	X	–	–
Poaceae	*Setaria viridis*	green bristlegrass	X	X	–	–
Poaceae	*Sorghum halepense*	Johnsongrass	X	X	X	X
Polygonaceae	*Polygonum aviculare*	prostrate knotweed	X	–	–	–
Polygonaceae	*Rumex crispus*	curly dock	–	X	X	–
Scrophulariaceae	*Verbascum thapsus*	common mullein	X	X	–	–
Simaroubaceae	*Ailanthus altissima*	tree of heaven	X	–	–	–
Tamaricaceae	*Tamarix* sp.	tamarisk	X	X	–	–
Zygophyllaceae	*Tribulus terrestris*	puncturevine	–	X	–	–

[a]Mau-Crimmins (2009). MOCC = Castle unit; MOWE = Well unit

[b]Current effort. MOCC = Castle unit; MOWE = Well unit

Appendix B: Example Datasheets

Sonoran Desert Network
Inventory and Monitoring Program

National Park Service
U.S. Department of the Interior

Page ____ of ____

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%)

Intermediate_Plot_Soil_Landscape_Datasheet_v005_3_20130319.ppt If you find this datasheet completed, please call (520) 343-8845

Sonoran Desert Network
Inventory and Monitoring Program

National Park Service
U.S. Department of the Interior

Page ____ of ____

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

Page ____ of ____

PARK:	**Date** (MM/DD/YYYY):	**Time** (00:00)**:**	**Crew:**	**PolyCode:**
Map:		Plot Id(s):		Formation:
Polygon visited?		Orig. PolyID(s):		Submap(s):

PolyCode suffix "D" for visited, "NV" for not visited or no photos	**Dominants and common associates:** (List strata below each taxon; the taxa will be assigned dominance in the first stratum listed and ranks will be assigned in order from left to right in each stratum)	
Recon/GPS:	**Alliance/Association Name:**	
Camera:	**Veg. Notes:**	
Photos:		
N:		
E:		
S:		
W:		
	Difference from surrounding veg:	
Proofread:	**Landscape notes:**	
Copied:		
GIS Edits:		
Entered:	**Bounding features:**	**Elev (ft):**
QA/QC:		**Aspect:**

If datasheet found completed, please call
(520) 343-8845

VegMap_ShortForm_Polygon_datasheet_v4_20110301.xlsx

Appendix C: Dichotomous Key to Mapped Vegetation Types

1a Vegetation primarily dominated by large riparian tree species, including *Platanus wrightii* and *Fraxinus velutina*. . . . . ***Platanus wrightii - Fraxinus velutina*** **Riparian Forest (page 4)**

1b Vegetation not as above. (2)

2a Vegetation primarily dominated by woody species (3)

2b Vegetation primarily dominated by herbaceous species (11)

3a Vegetation primarily dominated by large, tree to tree-like *Prosopis velutina* with an herbaceous layer of non-native, annual grasses. . . . . ***Prosopis velutina* / *Bromus rubens* - *Hordeum murinum*** **Woodland and Shrubland (page 5)**

3b Vegetation not as above. (4)

4a Vegetation primarily dominated by *Canotia holocantha* with a mix of associated shrub species including *Parthenium incanum*. . . . . ***Canotia holocantha*** **Shrubland (page 5)**

4b Vegetation not as above. (5)

5a Shrubland/Sub-shrubland primarily dominated by *Parthenium incanum* with patchy and rarely dominant *Larrea tridentata*. *Canotia holocantha* may be present, but should never be dominant. . . . . **(*Larrea tridentata*) / *Parthenium incanum*** **Shrubland (page 6)**

5b Vegetation not as above. (6)

6a Shrubland primarily dominated by *Larrea tridentata*, but with occasional areas of *Senegalia greggii* dominance. *Prosopis velutina* is occasional, but should not compete for dominance with *L. tridentata*. . . . . ***Larrea tridentata*** **Shrubland (page 6)**

6b Vegetation not as above. (7)

7a Shrubland primarily dominated by *Prosopis velutina* with numerous patchy, and occasionally dominant, associate species, including, *Gutierrezia sarothrae*, *Senegalia greggii*, *Muhlenbergia porteri*, and *Hilaria mutica*. *Larrea tridentata* may be present, but should not compete for dominance with *P. velutina*. . . . . ***Prosopis velutina*** **(*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland (page 6)**

7b Vegetation not as above. (8)

8a Shrubland primarily dominated by *Chilopsis linearis* with patchy, and occasionally dominant, *Ambrosia monogyra*. . . . . ***Chilopsis linearis*** **Shrubland (page 7)**

8b Vegetation not as above. (9)

9a Shrubland or Sub-shrubland dominated by *Gutierrezia sarothrae* and *Dalea formosa* with patchy *Juniperus arizonica* in the canopy. Perennial grasses are patchy, but occasionally provide noteworthy cover. . . . . **(*Juniperus arizonica*) / *Gutierrezia sarothrae* - *Dalea formosa*** **Shrubland (page 7)**

9b Vegetation not as above. (10)

10a Shrub Savanna dominated by a mix of shrubs and a matrix of *Hesperostipa neomexicana*. Noteworthy shrub species include, *Larrea tridentata*, *Senegalia greggii*, and *Berberis haematocarpa* ……**Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna (page 8)** (in part)

10b Riparian woodland primarily dominated by tree-like *Celtis reticulata,* potentially interspersed with dense bands of *Salix exigua* and *Schoenoplectus tabernaemontani*……..***Celtis reticulata - Salix exigua* / (*Schoenoplectus tabernaemontani*) / *Bromus diandrus* Riparian Woodland (page 8)**

11a Shrub Savanna dominated by a mix of shrubs and a matrix of Hesperostipa neomexicana. Noteworthy shrub species, include, *Larrea tridentata*, *Senegalia greggii*, and *Berberis haematocarpa* ……**Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna** (in part)

11b Vegetation not as above. (12)

12a Herbaceous community dominated by a matrix of Typha domingensis with patchy *Schoenoplectus tabernaemontani*……***Typha domingensis* (*Schoenoplectus tabernaemontani*) Herbaceous (page 8)**

12b Shrub savanna with sparse *Prosopis velutina* and a dense herbaceous layer of non-native grasses and forbs, including, *Hordeum murinum*, *Bromus rubens*, *Bromus diandrus*, and *Salsola* sp. Native, perennial grasses are occasional ……**(*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Shrub Savanna Disturbed. (page 9)**

Appendix D: Accuracy Assessment Documentation of Changes to Plot Attribution

This appendix provides a detailed listing of changes made to plot attributes post-accuracy assessment. Each case is treated individually and referenced using the plot ID.

AA128: This AA plot was distributed in the *Chilopsis linearis* Shrubland Association, but was placed in the *Prosopis velutina* / *Bromus rubens - Hordeum murinum* Woodland and Shrubland Association with a fair fit. Photos from the polygon mapping effort were compared to the AA photos and we determined that the defoliated *C. linearis* was misidentified as *P. velutina*. Therefore, we discounted the class selected during the AA and selected the only appropriate type, the *C. linearis* Shrubland Association.

AA013: This AA plot was distributed within the *Platanus wrightii - Fraxinus velutina* Riparian Forest Association, but was placed in the *Celtis reticulata - Salix exigua* / (*Schoenoplectus tabernaemontani*) / *Bromus diandrus* Riparian Woodland Association during AA. Photos from the polygon mapping effort were compared to the AA photos and we determined that *Baccharis emoryi* was misidentified as *Salix exigua*. Without *S. exigua*, the assigned association is not appropriate and makes far more sense as one of the listed variations within the *P. wrightii - F. velutina* association. Therefore, we discounted the class selected during the AA and selected the *P. wrightii - F. velutina* association.

AA038: This AA plot was distributed within the *Prosopis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association, but was placed in the *Prosopis velutina* / *Bromus rubens - Hordeum murinum* Woodland and Shrubland Association during AA. Based on photographs from the AA and mapping effort, as well as species composition and associated cover values, this plot was incorrectly placed. The low cover and short statured nature of the *P. velutina* and the considerable cover of native perennial grass, clearly fit better with the *Prosopis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association. Therefore, we discounted the class selected during the AA and selected the *Prosopis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association.

Appendix E: Key to Vegetation Formations

1. What is the dominant surface cover?

- Trees .....go to..... **2**
- Shrubs .....go to..... **3**
- Herbaceous .....go to..... **4**
- Sparse vegetation (1 – 10%) or Rock/Bare Soil .....go to..... **5**
- Agriculture.....go to..... **6**

2. Trees

1_1 Tree Cover > 60%?

2_1 Site is predominantly associated with an ephemeral watercourse. **Intermittently Flooded Forest (IFF)**

2_2 Site is predominantly associated with a perennial watercourse. **Riparian Forest (RF)**

2_3 Site is in an upland zone. **Forest (F)**

1_2 Tree Cover < 60%?

3_1 Site is predominantly associated with an ephemeral watercourse. **Intermittently Flooded Woodland (IFW)**

3_2 Site is predominantly associated with a perennial watercourse. **Riparian Woodland (RW)**

3_3 Site is in an upland zone. **Woodland (W)**

3. Shrubs

1_1 Tree Cover > 10%. **Wooded Shrubland (WS)**

1_2 Tree Cover < 10%. **Shrubland (S)**

4. Herbaceous

1_1 Tree cover < 10% AND Shrub cover < 10% **Herbaceous (H)**

1_2 Tree and/or Shrub cover >10%

2_1 Tree cover > Shrub cover **Tree Savanna (TS)**

2_2 Tree cover < Shrub cover **Shrub Savanna (SS)**

5. Sparse Vegetation/Rock/Bare Soil

1_1 Site is predominantly bedrock or surface rock with vegetative cover less than 10%.

2_1 Vegetation is primarily tree cover. **Wooded Rock Outcrop (WRO)**

2_2 Vegetation is primarily shrub cover. **Shrubby Rock Outcrop (SHRO)**

2_3 Vegetation is primarily herbaceous cover. **Herbaceous Rock Outcrop (HRO)**

2_4 There is no clear dominant. **Sparse Rock Outcrop (SRO)**

1_2 Site is predominantly covered with boulders, cobble, bare soil, or gravel with vegetative cover less than 10%.

3_1 There is no vegetation cover. **Barren (B)**

3_2 Vegetation is primarily tree cover. **Wooded Barren (WB)**

3_3 Vegetation is primarily shrub cover. **Shrubby Barren (SHB)**

3_4 Vegetation is primarily shrub cover**. Herbaceous Barren (HB)**

3_5 There is no clear dominant. **Sparse Barren (SB)**

6. Agriculture

1. Site is predominantly agricultural land. Agricultural (A)

Appendix F: Vegetation Type Descriptions

This appendix includes information on the 12 vegetation types that were identified and mapped at Montezuma National Monument between the years of 2010 and 2014. All information not identified as specific to Montezuma Castle NM was collected from NatureServe Explorer (http://www.natureserve.org/explorer/) or from the United States National Vegetation Classification (USNVC) website at http://usnvc.org/. This includes the NatureServe or USNVC codes, global descriptions, vegetation hierarchy, ecological systems placement and references. Distinctions between floristically similar types are made based on physiognomic differences identified through use of the key given in Appendix C.

Woodland

- *Platanus wrightii - Fraxinus velutina* Riparian Forest Association
- *Celtis reticulata - Salix exigua* / *(Schoenoplectus tabernaemontani*) / *Bromus diandrus* Riparian Woodland Association (PS)
- *Prosopis velutina* / *Bromus rubens - Hordeum murinum* Woodland and Shrubland Association (P)

Shrubland

- *Chilopsis linearis* Shrubland Association
- *(Juniperus arizonica)* / *Gutierrezia sarothrae - Dalea formosa* Shrubland Association (P)
- *Canotia holocantha* Shrubland Association (P)
- (*Larrea tridentata)* / *Parthenium incanum* Shrubland Association (P)
- *Prosopsis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association (P)
- *Larrea tridentata* Shrubland Association (P)

Savanna

- Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna Association (PS)
- (*Prosopis velutina*) / *Hordeum murinum - Bromus rubens - Bromus diandrus* Shrub Savanna Association (PS)

Herbaceous

- *Typha domingensis* (*Schoenoplectus tabernaemontani*) Herbaceous Association (P)

1. *Chilopsis linearis* Shrubland Association

Translated name: Desert willow Shrubland Association
NVC name: CEGL001164
Identifier: N/A

NVC CLASSIFICATION

Division:	North American Warm Desert Scrub & Grassland [3.A.2.Na]
Macrogroup:	North American Warm-Desert Xeric-Riparian Scrub [M092]
Group:	Warm Semi-Desert Shrub & Herb Dry Wash & Colluvial Slope [G541]
Association:	*Chilopsis linearis* Shrubland [CEGL001164]

DISTRIBUTION

Montezuma Castle National Monument

This shrubland occurs along the highly disturbed floodplain of Beaver Creek within the Castle unit of the monument. It is usually closely intertwined with the adjacent riparian forests.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This shrubland is found along the Beaver Creek floodplain at the Castle unit, at an elevation of 975 meters (3,200 ft). The surface cover is characterized by bare, sandy soils, with cover ranging from 15% to 60%, interspersed with gravel and larger cobbles. Although largely flat, this community has low-gradient slopes along the margins where it meets the watercourse or adjacent communities on the higher alluvial terraces. In addition, conspicuous areas of downed wood are present that appear associated with high water levels from flooding in the adjacent creek. This community is almost always associated with Arizona sycamore (*Platanus wrightii*) and velvet ash (*Fraxinus velutina*) riparian forests. It occurs in openings between forest stands or in auxiliary channels associated with Beaver Creek, where past scouring may have cleared other species. It is a disturbance-adapted riparian assemblage.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This shrubland community is characterized by desert willow (*Chilopsis linearis*) occurring as the dominant species in both the subcanopy (0.5–2 m) and canopy layers (2–5 m). This species typically presents as a shrub with heights ranging from 1 to 4 meters, but can occasionally appear as a small tree, especially in less-disturbed stands higher above the active floodplain. Cover values vary dramatically across examples of this type, from moderate cover of 18% to dense stands up to 66%. This species tends to do well on the interfluvial areas and cobble bars of abandoned side channels. Associated species in the upper canopies include uncommon and dispersed Arizona juniper (*Juniperus arizonica*) and infrequent hackberry (*Celtis reticulata*). In addition, a number of large, mature riparian tree species can be present, especially along the immediate banks of the watercourse and throughout the ecotone with the adjacent riparian woodlands. These include Arizona sycamore (*Platanus wrightii*), velvet ash (*Fraxinus velutina*), Arizona alder (*Alnus oblongifolia*), and Arizona walnut (*Juglans major*).

In the subcanopy layer, singlewhorl burrobrush (*Ambrosia monogyra*), velvet mesquite (*Prosopsis velutina*), and catclaw acacia (*Senegalia greggii*) are inconsistent associates, with scattered patches mixed throughout the community. Cover is generally low, only averaging 2%, but can be locally abundant, with cover approaching 10%, and is rarely co-dominant with desert willow (*C. linearis*). Other noteworthy, low-cover shrub species include Chihuahuan brickellbush (*Brickellia floribunda*), desert broom (*Baccharis sarothroides*), Emory's baccharis (*Baccharis emoryi*), broom snakeweed (*Gutierrezia sarothrae*), and California brickellbush (*Brickellia californica*).

The field stratum (<0.5 m) is highly variable, with total covers ranging from a low of 3% all the way up to 70%, and an average around 16%. A complex of annual invasive grasses, including ripgut brome (*Bromus diandrus*), cheatgrass (*Bromus tectorum*), and Mediterranean barley (*Hordeum marinum*), accounts for the majority of the cover within this stratum. Cover of non-native annual grasses is generally highest along the boundaries shared with the

adjacent velvet mesquite (*Prosposis velutina*) bosque. Sideoats grama (*Bouteloua curtipendula*) is the only noteworthy native perennial grass within this shrubland community.

GLOBAL TYPE CONCEPT DESCRIPTION

This palustrine shrubland occurs along desert washes in the southwestern U.S. and northwestern Mexico. Sites are intermittently flooded drainages on alluvial fans and basins from 960 to 1,080 meters (3,135–3,550 feet) at Buenos Aires National Wildlife Refuge. Stands in the Verde Valley, at Tuzigoot National Monument, occur on floodplains at around 1,500 meters. Substrates are generally sandy. Vegetation is characterized by a tall-shrub layer dominated by desert willow (*Chilopsis linearis*). Catclaw acacia (*S. greggii*) may co-dominate in the tall-shrub layer, but velvet mesquite (*P. velutina*) generally has low cover (<10%). Desert broom (*B. sarothroides*) forms an open short-shrub layer in some stands. A sparse to moderately dense herbaceous layer is present and composed of a mixture of annual and perennial forbs and grasses. Common species include New Mexico copperleaf (*Acalypha neomexicana*), Palmer's amaranth (*Amaranthus palmeri*), scarlet spiderling (*Boerhavia coccinea*), needle grama (*Bouteloua aristidoides*), Arizona panicgrass (*Urochloa arizonica [= Brachiaria arizonica]*), sorrel buckwheat (*Eriogonum polycladon*), threadleaf snakeweed (*Gutierrezia microcephala*), and bristlegrass (*Setaria*) spp. The exotic, Lehmann lovegrass (*Eragrostis lehmanniana*), is present at relatively low cover in some stands.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Chilopsis linearis*
Subcanopy (0.5–2 m)	*Chilopsis linearis, Ambrosia monogyra, Brickellia floribunda*
Field (0–0.5 m)	*Bromus diandrus, Bromus tectorum, Hordeum murinum*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	*Platanus wrightii, Fraxinus velutina*
Canopy (2–5 m)	*Juniperus monosperma, Celtis reticulata, Juglans major*
Subcanopy (0.5–2 m)	*Prosopis velutina, Senegalia greggii, Brickellia californica, Baccharis sarothroides, Baccharis emoryi, Brickellia floribunda*
Field (0–0.5 m)	*Bouteloua curtipendula, Salsola* spp., *Matthiola longipetala, Gutierrezia sarothrae*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified from three classification plots, two mapped classification polygons, and two additional polygons created during the initial map validation phase. While similar to the described association CEGL0001164, the associated species are different; therefore, this description has been locally derived from data collected at Montezuma Castle NM. It is anticipated that future revisions of this association in the NVC will encompass the variants from this park unit. Rowlands (1999) described this association as a *Chilopsis linearis* - Mixed riparian scrub with *C. linearis* dominant, and *Gutierrezia sarothrae*, *Brickellia californica,* and *Hymenoclea monogyra* as common and consistent associates.

Global

Data not available.
Classification confidence: Low

NatureServe conservation status: Data not available

Global status: G3

Rounded global status: Data not available

Global range: Data not available

Reasons:

ELEMENT SOURCES

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Castle unit Plots: IP003 C, IP012 C, IP016 C

Montezuma Castle National Monument, Well unit Plots: None

Montezuma Castle National Monument, Castle unit Polygons: AA07, AAS01, S048_D, WS002_D

Montezuma Castle National Monument, Well unit Polygons: None

Local Description Authors: S. Buckley, J. Galvin, S. Studd

Citations: K.A. Shultz. 2007. Chilopsis linearis shrubland, 17Aug 2007. United States National Vegetation Classification. Federal Geographic Data Committee, Washington, D.C. Accessed 09/26/2018.

Rowlands, P. G. 1999. Vegetation survey of Montezuma Castle National Monument. National Park Service, Organ Pipe Cactus National Monument, Ajo, Arizona.

2. *Platanus wrightii - Fraxinus velutina* Riparian Forest Association

Translated name: Arizona sycamore - Velvet ash Riparian Forest Association
NVC name: CEGL000644
Identifier: N/A

NVC CLASSIFICATION

Division:	Western North American Interior Flooded Forest [1.B.3.Nd]
Macrogroup:	Interior Warm & Cool Desert Riparian Forest [M036]
Group:	Western Interior Riparian Forest & Woodland [G797]
Association:	*Platanus wrightii - Fraxinus velutina* Riparian Forest [CEGL000644]

DISTRIBUTION

Montezuma Castle National Monument

This riparian forest is found along Beaver Creek in both the Well and Castle units. It is confined to the floodplain of the creek, nearby abandoned channels, and adjacent alluvial terraces.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This riparian forest is found on the low-gradient (1%) floodplains of Beaver Creek and the adjacent alluvial terraces. The elevation ranges from 955 to 1,066 meters (3,100–3,500 ft). The surface cover is often composed of a sandy alluvial soil with various cobble sizes, ranging from larger boulders immediately adjacent to and in the creek, to moderately sized rocks and fine gravel on the upper alluvial terraces. The ground cover also has a large component of downed wood and is commonly covered with litter, which is often deep when immediately adjacent to the larger Arizona sycamore (*Platanus wrightii*) and velvet ash (*Fraxinus velutina*).

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This riparian forest community is characterized by a tree canopy co-dominated by Arizona sycamore (*P. wrightii*) and Arizona ash (*F. velutina*). Average cover of canopy species is around 53%, with values ranging from 25 to 91%. Arizona sycamore, a large (15-m) riparian tree, provides variable cover, averaging to 18% and ranging up to 63% across both units. Cover of Arizona ash (*F. velutina*), a shorter-statured (6-m) and later successional tree, is closer to 12%, with values ranging up to 63%. On a large scale, both of these species provide consistent cover throughout the community. However, when looked at locally, they can be quite patchy, with either one becoming the sole dominant or being completely absent. In general, Arizona sycamore (*P. wrightii*) is most consistent at the Castle unit, while Arizona ash (*F. velutina*) is most consistent at the Well unit. In addition, a mix of widespread, but inconsistent, riparian trees intermingle throughout this community, including Arizona alder (*Alnus oblongifolia*), cottonwood (*Populus fremontii*), and Goodding's willow (*Salix gooddingii*). At the Well unit, Arizona alder (*A. oblongifolia*) and Goodding's willow (*S. gooddingii*) form a dense, but narrow, band at the edge of the watercourse. At the Castle unit, these species are far less common, typically occurring in small patches where the watercourse runs up against a cliff band or steep embankment. Cottonwood (*P. fremontii*) is also most common at the Well unit, occurring in large, often uniform, patches set back from the watercourse, usually along abandoned channels. At times, this species can become co-dominant with Arizona sycamore (*P. wrightii*) and Arizona ash (*F. velutina*). Other patchy but noteworthy tree species include Arizona walnut (*Juglans major*) and wingleaf soapberry (*Sapindus saponaria*).

When this riparian forest is present on alluvial terraces and abandoned channels, a variation of this community can occur. This shift in vegetation composition is defined by decreased cover of canopy trees, while netleaf hackberry (*Celtis reticulata*) and velvet mesquite (*Prosopis velutina*) become dominant in the lower canopy, with patchy little Utah juniper (*Juniperus osteosperma*) in the upper canopy. These species create a dense understory that can also contain catclaw mimosa (*Mimosa aculeaticarpa*), especially at the Well unit, catclaw acacia (*Senegalia greggii*), and red barberry (*Berberis haematocarpa*).

The subcanopy stratum (0.5–<2 m) is generally sparse, with total cover averaging 10%, often consisting of smaller individuals of species common in the other canopy strata. Two major exceptions are Emory's baccharis (*Baccharis emoryi*) and false indigo bush (*Amorpha fruticosa*), both of which can form dense thickets along the edge of the watercourse but provide little cover across the community as a whole. Velvet mesquite (*Prosopsis velutina*) provides inconsistent cover throughout, but is most commonly found in distinct patches at the margins of the community, near the adjacent and more-arid velvet mesquite (*P. velutina*) bosque. Other subcanopy species of note include narrowleaf willow (*Salix exigua*), red barberry (*Berberis haematocarpa*), and Chihuahuan brickellbush (*Brickellia floribunda*). At the margins of this community and sometimes as inclusions, desert willow (*Chilopsis linearis*) and singlewhorl burrobrush (*Ambrosia monogyra*) can appear as patchy components of this stratum.

The field stratum (<0.5 m) contains highly variable cover, averaging 30% across the community and ranging from a few percent up to 90%. Usually, a mix of annual, non-native grasses, such as ripgut brome (*Bromus diandrus*), cheatgrass (*Bromus tectorum*), mouse barley (*Hordeum murinum*), and red brome (*Bromus rubens*), dominate this stratum. Other exotic species, including Johnsongrass (*Sorghum halepense*) and sweetclover (*Melilotus* spp.), are widespread, but typically confined to the banks of the creek. While uncommon, native perennial grasses, such as spider grass (*Aristida ternipes*), sideoats grama (*Bouteloua curtipendula*), and muttongrass (*Poa fendleriana*) are present and can rarely become locally dominant.

Throughout the watercourse of Beaver Creek and the adjacent, water-saturated soils, numerous obligate and facultative wetland species begin to dominate the field stratum. These species include, but are not limited to, Parish's spikerush (*Eleocharis parishii*), fescue (Schedonorus spp.), smooth horsetail (*Equisetum laevigatum*), field horsetail (*Equisetum arvense*), wild mint (*Mentha arvensis*), swamp carex (*Carex senta*), softstem bulrush (*Schoenoplectus tabernaemontani*), southern cattail (*Typha domingensis*), and Rocky mountain rush (*Juncus saximontanus*). Rarely, these areas appear away from the watercourse, where high surface water is present—specifically, around a small spring/seep in the Well unit.

GLOBAL TYPE CONCEPT DESCRIPTION

No description exists for the *Platanus wrightii - Fraxinus velutina* forest. However, a very similar community, dominated by *Platanus wrightii* (CEGL000937) but with other more varied associate tree species, is described from southern Arizona and southwest New Mexico. More work is needed to fully separate and distinguish these types from one another. The description for the *Platanus wrightii* woodland is copied below.

"This desert riparian woodland occurs in southern Arizona and southwestern New Mexico. The elevation ranges from 1000-1775 m (3280-5820 feet). Sites are on stream terraces in valley bottoms, foothills, and mountain canyons. Substrates are typically composed of gravelly to sandy alluvium and are often flooded during monsoon season. The vegetation is characterized by the dominance or codominance of *Platanus wrightii* in the tree canopy. *Prosopis velutina, Alnus oblongifolia, Fraxinus velutina, Juglans major*, or *Juniperus* spp. may codominate. If present, the shrub layer is sparse to moderately dense and composed of mixed shrubs, including *Baccharis sarothroides, Brickellia* spp., *Celtis laevigata var. reticulata (= Celtis reticulata), Dasylirion wheeleri, Erythrina flabelliformis, Gossypium thurberi, Lycium* spp., *Mimosa aculeaticarpa var. biuncifera (= Mimosa biuncifera)*, and *Rhus trilobata*. The herbaceous layer is sparse to moderately dense and typically dominated by perennial graminoids *Bouteloua curtipendula* and *Muhlenbergia rigens*, but numerous forbs and other grasses are often present."

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	*Platanus wrightii, Fraxinus velutina*
Canopy (2–5 m)	*Prosopis velutina*
Subcanopy (0.5–2 m)	*Prosopis velutina*
Field (0–0.5 m)	*Bromus diandrus, Bromus tectorum*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	*Populus fremontii, Alnus oblongifolia, Salix gooddingii, Juniperus osteosperma*
Canopy (2–5 m)	*Celtis laevigata, Juniperus monosperma, Juglans major, Sapindus saponaria*
Subcanopy (0.5–2 m)	*Baccharis emoryi, Amorpha fruticosa, Berberis haematocarpa, Mimosa aculeaticarpa* var. *biuncifera, Brickellia floribunda, Salix exigua*
Field (0–0.5 m)	*Bromus rubens, Aristida ternipes, Bouteloua curtipendula, Poa fendleriana, Schedonorus* spp., *Juncus saximontanus, Typha domingensis, Mentha arvensis, Eleocharis parishii, Equisetum arvense, Equisetum laevigatum, Schoenoplectus tabernaemontani, Carex senta, Hordeum murinum*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified from five classification plots and four mapped classification polygons at the Well unit, and five classification plots and five mapped classification polygons at the Castle unit.

Rowlands (1999) also described this type at the monument. He identified this community using the BLP *Platanus wrightii* association (BLP 223.222). It is described as having *Fraxinus velutina* as a prevalent associate which can approach 40% cover, and is seen to intergrade with the *Chilopsis linearis* - Mixed Scrub association. Most other common associates and the landscape characteristics remain similar between the two descriptions.

Classification confidence: Low

NatureServe conservation status: Data not available

Global status: GNR

Rounded global status: GNR–Not yet ranked

Global range: Mexico, United States

Reasons:

ELEMENT SOURCES

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Castle unit Plots: IP006 C, IP013 C, IP017 C, IP018 C, IP026 C

Montezuma Castle National Monument, Well unit Plots: IP003, IP005, IP009, IP016, IP020

Montezuma Castle National Monument, Castle unit Polygons: 5 polygons

Montezuma Castle National Monument, Well unit Polygons: 4 polygons

Local Description Authors: S. Buckley, J. Galvin, S. Studd

Citations: Western Ecology Group 1999. Platanus wrightii–Fraxinus velutina Riparian Forest, 30Dec1999. United States National Vegetation Classification. Federal Geographic Data Committee, Washington, D.C. Accessed 09/26/2018.

Rowlands, P. G. 1999. Vegetation survey of Montezuma Castle National Monument. National Park Service, Organ Pipe Cactus National Monument, Ajo, Arizona.

3. *(Juniperus arizonica) / Gutierrezia sarothrae - Dalea formosa* Shrubland Association (P)

Translated name: (Arizona juniper) / Broom snakeweed - Featherplume Shrubland Association
NVC name: Not available
Identifier: NPSSODN031

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: (*Juniperus* monosperma) / Gutierrezia *sarothrae - Dalea formosa* Shrubland

DISTRIBUTION

Montezuma Castle National Monument

This shrubland community occurs in limited locations at both units. At the Well unit, the main occurrence spans all aspects of a small hill just north of the well. At the Castle unit, the only occurrence covers a small area along the southern boundary, but is thought to be present in other areas just outside the park.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This shrubland community is found on low-angle to moderately steep (6–35%) shoulder slopes, backslopes, and some toeslopes of large mesas at 980–1,100 meters' (3,215–3,608 ft) elevation. The soils are composed of calcareous sedimentary rock. Erosion features are rare to non-existent. The surface soils are often exposed, either as scattered bedrock and small rocks or, commonly, bare soil and gravel. Even areas dominated by bare soil support considerable vegetation.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This shrubland community is characterized by a field stratum (<0.5 m) co-dominated by broom snakeweed (*Gutierrezia sarothrae)* and featherplume (*Dalea formosa*), with a common associate, Arizona juniper (*Juniperus arizonica*), in the canopy strata (>2 m) and a substantial perennial grass component with cover approaching 10%. Broom snakeweed (*G. sarothrae*) accounts for up to 18% cover in some areas of this shrubland, but averages around 7% throughout. The other co-dominant, featherplume (*D. formosa*), can be as high as 8% of total cover, but is often much more sparse, averaging to only 5%. Featherplume (*D. formosa*) was observed to prefer northern and eastern aspects, whereas the broom snakeweed was slightly more abundant on southern aspects. This shrubland is very open and might best be described as a sub-shrubland, dominated by short-statured shrubs and forbs, with occasional, widely dispersed large shrubs and trees. Arizona juniper (*J. arizonica*) is present throughout this community, with variable cover ranging from less than one percent to 8%.

In addition to the co-dominant subshrubs, the field stratum is also characterized by a diverse range of perennial bunchgrasses. The two most consistent and widely distributed of these, New Mexico feathergrass (*Hesperostipa neomexicana*) and black grama (*Bouteloua eriopoda*), each provide an average 3% cover across the community, but in some areas the cover of these two species approaches 8%. The remaining grasses—sideoats grama (*Bouteloua curtipendula*), purple threeawn (*Aristida purpurea*), and slim tridens (*Tridens mutica*)—are less consistent, with cover values closer to 1%. A diverse mix of perennial forbs is also spread throughout this community, including plains blackfoot (*Melampodium leucanthum*), brownfoot (*Acourtia wrightii*), common fleabane (*Erigeron divergens*), and rose heath (*Chaetopappa ericoides*).

Other noteworthy, but uncommon, shrubs and cacti include catclaw acacia (*Senegalia greggii*), red barberry (*Berberis haematocarpa*), Christmas cactus (*Cylindropuntia leptocaulis*), littleleaf ratany (*Krameria* erecta), Mormon tea (*Ephedra viridis*), fragrant sumac (*Rhus aromatica*), and velvet mesquite (*Prosopis velutina*).

Sonoran scrub oak (*Quercus turbinella*) is present as a small, but conspicuous, inclusion within this community, providing up to 6% cover in a dense patch of shrub to tree-like individuals on a north-facing slope. This species is typically associated with "interior chaparral" communities along the Mogollon Rim, wherein it is the most common and consistently occurring shrub. At both units of Montezuma Castle NM, it is rare.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Juniperus arizonica*
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	*Gutierrezia sarothrae, Dalea formosa, Bouteloua eriopoda, Hesperostipa neomexicana*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Pinus discolor, Juniperus deppeana*
Subcanopy (0.5–2 m)	*Quercus turbinella, Senegalia greggii, Yucca elata, Berberis haematocarpa, Ephedra viridis, Rhus aromatica, Cylindropuntia leptocaulis, Prosopis velutina*
Field (0–0.5 m)	*Bouteloua curtipendula, Aristida purpurea, Tridens mutica, Melampodium leucanthum, Acourtia wrightii, Erigeron divergens, Chaetopappa ericoides*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified from three classification plots and two mapped classification polygons, one at each unit.

Rowlands (1999) described the area mapped as *G. sarothrae - D. formosa* during this project as a *Hesperostipa neomexicana* - Mixed scrub association (BLP 143.155). Rowlands (1999) had *Hesperostipa neomexicana* dominant, *G. sarothrae* second-dominant, and *Dalea formosa* sixth in terms of cover and constancy. While the two descriptions bear similarities, the classification methods were dissimilar enough, coupled with (presumed) actual change in dominance over the years, that these were identified and described somewhat differently between projects. They are otherwise thought to be equivalent.

Global

There are several *G. sarothrae* types described in the NVCS, but none quite matches the community seen during this project. One described association has *G. sarothrae* dominant in the Apacherian-Chihuahuan grassland types, but none is described as having featherplume (*Dalea formosa*) as the secondary dominant.

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

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Well unit Plots: IP002, IP013, IP021, IP023

Montezuma Castle National Monument, Castle unit Plots: None

Montezuma Castle National Monument, Well unit Polygons: 4 polygons

Montezuma Castle National Monument, Castle unit Polygons: 1 polygon

Local Description Authors: S. Buckley, J. Galvin, S. Studd

Citations: Rowlands, P. G. 1999. Vegetation survey of Montezuma Castle National Monument. National Park Service, Organ Pipe Cactus National Monument, Ajo, Arizona.

4. *Canotia holocantha* Shrubland Association (P)

Translated name: Crucifixion thorn Shrubland Association
NVC name: Not available
Identifier: NPSSODN030

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Canotia holocantha* Shrubland Association

DISTRIBUTION

Montezuma Castle National Monument

This widespread shrubland community is found on the mesas surrounding the Beaver Creek floodplain, mainly in the Castle unit, where this community spans two large areas set back from the main drainage and high above the floodplain. One runs the entire length of the eastern boundary. The other occurs as a patchwork in the northwestern mesa, where it is interspersed with a creosote bush (*Larrea tridentata*) shrubland and a mariola (*Parthenium incanum*) shrubland. At the Well unit, this community is restricted to a small patch near the entrance gate.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This shrubland community occurs on generally steep (15–50%) backslopes, and low-gradient shoulders and summits of varying aspects. Elevation ranges from 975 to 1,066 meters (3,200–3,500 ft). Soils are characterized as calcareous sedimentary, typically limestone, with exposed bedrock found along the summits of the ridgetops and scattered occasionally throughout. A mixture of loose cobble and gravel with cover values between 35% and 60% dominates surface cover. Litter is present, but sparse, averaging less than 15%, with minimal crust and cyanobacteria noted in only a few specific locations.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This shrubland community is characterized by a canopy (2–5 m) and subcanopy (0.5–2 m) dominated by the tall shrub, crucifixion thorn (*Canotia holocantha*), and a low-cover, diverse understory of shrubs, perennial forbs, and perennial grasses. This community has an open structure of widely spaced shrubs and only occasional instances of individuals overlapping or growing in close proximity to one another. The average total cover for all species in the canopy and subcanopy strata combined is around 20%, and ranges from 8% to 45%. Crucifixion thorn (*C. holocantha*) accounts for around three-quarters of the total cover (14%) across both canopy and subcanopy strata, with a range from 6% to 32%. Arizona juniper (*Juniperus arizonica*) is a patchy associate species in the canopy that is most prevalent, and occasionally locally co-dominant, on lower-angle mesa tops and backslopes along the eastern boundary of the Castle unit, especially where drainages and other hydrologic features are present. The remaining cover in the canopy strata is split across a diverse mix of low-cover shrub species. Creosote bush (*Larrea tridentata*) is the most consistent associate in the subcanopy, accounting for an average of 3% cover across the community. Occasional subcanopy associates include red barberry (*Berberis haematocarpa)*, Mormon tea (*Ephedra viridis*), lotebush (*Ziziphus obtusa)*, and catclaw acacia (*Senegalia greggii*).

The field stratum is characterized by a diverse mix of species, with total covers ranging from 3% to 30% and averaging to 8%. Mariola (*Parthenium incanum*) is the most abundant of these species, albeit with inconsistent cover, ranging from 0% to 18% and averaging to 7%. Broom snakeweed (*Gutierrezia sarothrae)*, New Mexico feathergrass (*Hesperostipa neomexicana),* purple threeawn (*Aristida purpurea*), slim tridens (*Tridens muticus*), featherplume (*Dalea formosa*), and ratany (*Krameria erecta)* are occasional associates throughout this shrubland.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Canotia holacantha, Juniperus monosperma*
Subcanopy (0.5–2 m)	*Canotia holacantha, Larrea tridentata*
Field (0–0.5 m)	*Parthenium incanum*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Ziziphus obtusa, Acacia greggii, Berberis haematocarpa, Ephedra viridis*
Field (0–0.5 m)	*Gutierrezia sarothrae, Krameria erecta, Bromus rubens, Dalea formosa, Tiquilia canescens, Hesperostipa neomexicana, Tridens muticus, Thymophylla acerosa, Melapodium leucanthum, Aristida purpurea*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified and described at the local level from six classification plots and seven mapped classification polygons. This type was identified and described in Rowlands (1999), where it was described as a sub-association under the BLP *Larrea divaricata - Canotia holocantha* association (BLP–154.124). Dominance and common associated species are similar between this and the current description.

Global

Broader, more regional classification descriptions are not currently available but are anticipated to be completed in the future. At this time, the most closely related description in the USNVC is from the Grand Canyon National Park vegetation inventory (Kearsley et al. 2015). The description for *Canotia holacantha* Grand Canyon Shrubland is copied below.

"This crucifixion-thorn shrubland association is currently described from Grand Canyon National Park in Arizona. More survey and classification work are needed to fully characterize this type. It occurs on sideslopes of canyons typically from 575 to 975 m (1875-3625 feet) elevation, but it has been found as high as 1275 m (4150 feet). It usually occurs on north-facing, moderately-sloping gradients (15 to 25 degrees), but occasionally occurs on very steep slopes (40-50 degrees) as well. Soils are rapidly-drained sandy loams; the underlying geology is usually limestone. This community often occurs in protected areas with a relatively high cover of moss. This community is characterized by a tall-shrub layer dominated by *Canotia holacantha*, which is invariably accompanied by the short shrub *Ephedra fasciculata* and occasionally by *Acacia greggii*. A variety of dwarf-shrubs also occur, including *Gutierrezia microcephala, Echinocereus* sp., *Agave utahensis*, and *Encelia farinosa*. A sparse graminoid layer is usually present, in which *Bromus rubens* occurs most frequently. The perennial grasses *Muhlenbergia porteri* and *Tridens muticus* also occur from time to time. *Sphaeralcea grossulariifolia* and *Xylorhiza tortifolia* are the most common forbs in a relatively sparse forb layer. Moss occurs sporadically, but when present has significant cover."

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

Montezuma Castle National Monument Inventory Notes: Data not available.

Montezuma Castle National Monument, Castle unit Plots: IP002 C, IP005 C, IP011 C, IP019 C, IP021 C, IP025 C

Montezuma Castle National Monument, Well unit Plots: None

Montezuma Castle National Monument, Castle unit Polygons: 6 polygons

Montezuma Castle National Monument, Well unit Polygons: 1 polygon

Local Description Authors: S. Buckley, J. Galvin, S. Studd

Citations: Kearsley, M. J. C., K. Green, M. Tukman, M. Reid, M. Hall, T. J. Ayers, and K. Christie. 2015. Grand Canyon National Park-Grand Canyon / Parashant National Monument vegetation classification and mapping project. Natural Resource Report NPS/GRCA/NRR—2015/913. National Park Service, Fort Collins, Colorado.

Rowlands, P. G. 1999. Vegetation survey of Montezuma Castle National Monument. National Park Service, Organ Pipe Cactus National Monument, Ajo, Arizona.

5. *(Larrea tridentata) / Parthenium incanum* Shrubland Association (P)

Translated name: Creosote bush / Mariola Shrubland Association
NVC name: (Similar to CEGL001274)
Identifier: NPSSODN028

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: (*Larrea tridentata*) / *Parthenium incanum* Shrubland Association

DISTRIBUTION

Montezuma Castle National Monument

This shrubland occurs in both units of the monument and is often intermixed with the similar crucifixion thorn (*Canotia holocantha*) and creosote bush (*Larrea tridentata*) shrublands.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This shrubland occurs on generally south- to southwest-facing summits, backslopes, and shoulders of mesas. The slopes are variable, ranging from 10% to 40%, and elevation ranges from 975–1,112 meters (3,200–3,650 ft). The soils are characterized as calcareous sedimentary, typically limestone. Ground cover is dominated by a mix of angular gravel and rock with occasional patches of exposed bedrock, especially on the backslopes and shoulders.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This shrubland association is characterized by a field stratum (<0.5 m) dominated by mariola (*Parthenium incanum*) and one common associate, creosote bush (*Larrea tridentata*). Vegetation cover is sparse overall, averaging only 17% cover across all species, with mariola (*P. incanum*) contributing the most, with an average of 9%. Cover values for this species are variable, ranging from 3% to 18%, but it is the most consistently dominant species within this association. Creosote bush (*L. tridentata*) is a patchy, common associate in the subcanopy, with cover ranging from completely absent to dominant, with values up to 8%. The subcanopy is not very diverse and contains only a few noteworthy, low-cover associates, including catclaw acacia (*Senegalia greggii*), Arizona juniper (*Juniperus arizonica*), red barberry (*Berberis haematocarpa*), and velvet mesquite (*Prosopsis velutina*). These species provide very patchy cover across the community, generally around 1%, but may be locally abundant in scattered locations. This is especially true of velvet mesquite (*P. velutina*) on the low-angle slopes surrounding the well, where it becomes a low-canopy dominant.

Ratany (*Krameria erecta*) and broom snakeweed (*Gutierrezia sarothrae*) are inconsistent associates in the field stratum, averaging about 1% across the community, but with rare inclusions of local dominance. A mix of suffrutescents and subshrubs are commonly found throughout the field stratum. Featherplume (*Dalea formosa*) is an occasional associate that becomes more common on slopes with exposed bedrock. Woody crinklemat (*Tiquilia canescens*) and pricklyleaf dogweed (*Thymophylla acerosa*) are small but widely distributed subshrubs within this community (and within all highly calcareous soils in the monument). Grasses are most common on slopes, with the calcareous soil supporting slim tridens (*Tridens muticus*), New Mexico feathergrass (*Hesperostipa neomexicana*), and purple threeawn (*Aristida purpurea*). As is usual in many areas of the monument, red brome (*Bromus rubens*) is present, though it tends to congregate around plant bases and does not form the homogenous patches present in the more lowland areas of the park.

This shrubland is similar to two other associations documented at the monument, a creosote bush (*L. tridentata*) shrubland and a crucifixion thorn (*Canotia holocantha*) shrubland, which often intergrade with this association.

This shrubland is differentiated from these similar associations based on consistent mariola (*P. incanum*) dominance, lack of crucifixion thorn (*C. holocantha*), and inconsistent cover of creosote bush (*L. tridentata*).

GLOBAL TYPE CONCEPT DESCRIPTION

This association comprises grasslands with scattered xeromorphic, desert shrubs, mainly creosote bush (*L. tridentata*) and mariola (*P. incanum*), occurring at or below 1,070 meters (3,500 ft) elevation in the Chihuahuan Desert of Trans-Pecos Texas. Other shrubs include American tarwort (*Flourensia cernua*), viscid acacia (*Vachellia vernicosa*), whitethorn acacia (*Vachellia constricta*), honey mesquite (*Prosopis glandulosa*), lechuguilla (*Agave lechuguilla*), and spiny hackberry (*Celtis ehrenbergiana*). Cacti and short grasses, such as gypsum grama (*Bouteloua breviseta*) and black grama (*Bouteloua eriopoda*) may be present.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Larrea tridentata*
Field (0–0.5 m)	*Parthenium incanum*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Juniperus arizonica*
Subcanopy (0.5–2 m)	*Prosopis velutina, Senegalia greggii, Canotia holocantha, Berberis haematocarpa*
Field (0–0.5 m)	*Krameria erecta, Gutierrezia sarothrae, Bromus rubens, Tiquilia canescens, Hesperostipa neomexicana, Aristida purpurea, Bouteloua eriopoda, Tridens muticus*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified from five classification plots, six mapped classification polygons, and 1 long-term monitoring plot. This type was also identified in Rowlands (1999), which used the BLP system and classified this type as 152.172 *Larrea divaricata - Parthenium incanum* association.

Global

A similar community has been described for the Trans-Pecos region in Texas (CEGL001274). However, that community is described as containing a considerable graminoid component, and other associated shrub species not seen in Arizona. However, it is possible that this type is closely related to the Texas/New Mexico community, and that further efforts to incorporate data from more projects will result in a description that covers the entire range and all its variations.

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

Montezuma Castle National Monument Inventory Notes: Data not available.

Montezuma Castle National Monument, Castle unit Plots: IP024_C

Montezuma Castle National Monument, Well unit Plots: IP010, IP011, IP017, IP022

Montezuma Castle National Monument, Castle unit Polygons: 1 polygon

Montezuma Castle National Monument, Well unit Polygons: 5 polygons

Local Description Authors: S. Buckley, J. Galvin, S. Studd

Citations: Rowlands, P. G. 1999. Vegetation survey of Montezuma Castle National Monument. National Park Service, Organ Pipe Cactus National Monument, Ajo, Arizona.

6. *Prosopis velutina / Bromus rubens - Hordeum murinum* Woodland and Shrubland Association (P)

Translated name: Velvet mesquite / Red brome - Mouse barley Woodland and Shrubland Association
NVC name: Not available
Identifier: NPSSODN025

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Prosopis velutina /Bromus rubens - Hordeum murinum* Woodland and Shrubland

DISTRIBUTION

Montezuma Castle National Monument

This woodland is found at both units of the monument, on the alluvial terraces and the broader floodplain immediately adjacent to Beaver Creek. This community generally forms a band between the river channel and the adjacent upland habitat.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This woodland is found along the low-gradient alluvial terraces and floodplain adjacent to Beaver Creek in both units of the monument. Elevation ranges from 944 to 1,066 meters (3,100–3,500 ft). The soils are characterized by a fine-grained alluvium, with bare soil or litter dominating the surface cover, depending on overstory vegetation.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This woodland community is characterized by dominant velvet mesquite (*Prosopis velutina*) in the low-canopy (2–5 m) and subcanopy (0.5–2 m) strata, with a field stratum (<0.5 m) dominated by annual, non-native grasses. Velvet mesquite (*Prosopis velutina*) accounts for an average of 30% cover, and ranges up to 85%. In general, this species is predominately present in a tree-like growth form, with heights ranging from 1 to 4.5 meters. However, the margins of this community tend to include more shrub-like individuals that generally coincide with a decline in overall cover. Catclaw acacia (*Senegalia greggii*) is a patchy associate, averaging 3% cover across the community, with inclusions of co-dominance. This species also ranges from small, shrubby individuals to substantial trees with heights above 5 meters. In addition, the subcanopy contains a number of shrubby, low-cover associates, that are generally found as solitary specimens scattered throughout the community, including fourwing saltbush (*Atriplex canescens*), red barberry (*Berberis haematocarpa*), and pale desert-thorn (*Lycium pallidum*).

Occasionally, when this community is present along dry river channels and undulating alluvial terraces, riparian trees, specifically Arizona sycamore (*Platanus wrightii*) and velvet ash (*Fraxinus velutina*), may be present. Typically, this variation presents as scattered, but large, remnant riparian trees, similar in composition to the nearby Arizona sycamore (*P. wrightii*) and velvet ash (*F. velutina*) riparian woodland.

The total cover of species in the field stratum ranges from 12% to 92%, with an average of 48%. Non-native grasses—specifically, red brome (*Bromus rubens*), ripgut brome (*Bromus diandrus*), cheatgrass (*Bromus tectorum*), and mouse barley (*Hordeum murinum*)—almost exclusively dominate this stratum. Dominance within this group of non-native grasses tends to vary greatly across this community, with only red brome (*B. rubens*) and mouse barley (*H. murinum*) standing out as a consistent dominants. Cheatgrass (*B. tectorum*) and ripgut brome (*B. diandrus*) can occasionally become locally dominant, with the latter appearing to prefer more mesic sites. While not as prolific as the annual grasses, native perennial grasses are found throughout this community. In rare locations, they dominate the field stratum. Sand dropseed (*Sporobolus cryptandus*) is the most consistent of these grasses,

but purple threeawn (*Aristida purpurea*), bush muhly (*Muhlenbergia porteri*), sideoats grama (*Bouteloua curtipendula*), and silver bluestem (*Bothriochloa saccharoides*) are also noteworthy. At a few locations at the Castle unit examples of this community have very little herbaceous cover and almost no non-native grasses. These areas have mature stands of mesquite and acacia in mixed patchy co-dominance, and scattered other shrubs.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Prosopis velutina, Senegalia greggii*
Subcanopy (0.5–2 m)	*Prosopis velutina, Senegalia greggii, Atriplex canescens*
Field (0–0.5 m)	*Bromus rubens, Hordeum murinum, Bromus diandrus, Bromus tectorum, Sporobolus cryptandrus*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	*Platanus wrightii, Fraxinus velutina*
Canopy (2–5 m)	*Celtis reticulata, Juniperus arizonica*
Subcanopy (0.5–2 m)	*Berberis haematocarpa, Lycium pallidum, Quercus turbinella, Larrea tridentata*
Field (0–0.5 m)	*Sporobolus cryptandrus, Marrubium vulgare, Aristida purpurea, Muhlenbergia porteri, Bouteloua curtipendula, Bothriochloa saccharoides, Ambrosia psilostachya, Sphaeralcea ambigua, Chorispora tenella, Yucca elata, Cylindropuntia leptocaulis, Gutierrezia sarothrae*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified from six classification plots and two mapped classification polygons at the Well unit, and six classification plots and nine mapped classification polygons at the Castle unit.

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

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Castle unit Plots: IP001 C, IP004 C, IP007, IP008 C, IP010 C, IP014 C

Montezuma Castle National Monument, Well unit Plots: IP007, IP012, IP014, IP015, IP018, IP019

Montezuma Castle National Monument, Castle unit Polygons: 9 polygons

Montezuma Castle National Monument, Well unit Polygons: 2 polygons

Local Description Authors: S. Buckley, J. Galvin, S. Studd

7. *Prosopis velutina (Senegalia greggii)* / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland Association (P)

Translated name: Velvet mesquite (Catclaw acacia) / Mixed Perennial Grass (Broom snakeweed) Shrubland Association
NVC name: Not available
Identifier: NPSSODN027

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Prosopis velutina* (*Senegalia greggii*) / (Mixed Perennial Grass - *Gutierrezia sarothrae*) Shrubland

DISTRIBUTION

Montezuma Castle National Monument

This shrubland is found in both units of the monument, generally covering low-angle, south-facing slopes in upland areas located on alluvial terraces just above the floodplain. At the Well unit, this type is found northwest of the developed area around the well, stretching across the flats toward the northern boundary. At the Castle unit, this type is often found in transitional areas between the groundwater-fed velvet mesquite (*Prosopis velutina*) bosque type that is marginal to the riparian forests along Beaver Creek and the drier, creosote bush (*Larrea* tridentata) -dominated shrublands higher on the mesas.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This shrubland type is found on broad, low-angle alluvial terraces and toeslopes at both units of the monument. In general, the slopes are south-facing and less than 1%, but can range as high as 15% along the margins of the alluvial terraces. Surface cover is characterized by sandy alluvium dominated by bare soil, with considerable biological and physical soil crusts throughout. Surface rock and gravel are rare surface-cover components. Litter cover is variable, depending on overstory components.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This shrubland community is characterized by a subcanopy stratum (0.5–2 m) dominated by velvet mesquite (*Prosopis velutina*) with one common associate, catclaw acacia (*Senegalia greggii*), and a field stratum (<0.5 m) composed of a variable mix of short-statured shrubs and perennial grasses. Total vegetation cover is generally high, averaging 30%, with the subcanopy (0.5–2 m) stratum and the field stratum (<0.5 m) each accounting for about one-third and half the total, respectively. Velvet mesquite (*P. velutina*) is well-distributed in a generally low-statured (1–2 m), shrub-like growth form and accounts for an average of 10% cover across the association, with areas ranging up to 30%. In general, cover of this species is greatest at the Castle unit. Catclaw acacia (*S. greggii*) is a consistent, common associate, with cover averaging 3% and ranging up to 8%. Creosote bush (*Larrea tridentata*) is a patchy associate most common at the Castle unit. Areas of increased creosote bush (*L. tridentata*) cover tend to occur on the low-angle shoulders and crests of the mesas where this community begins to transition to a creosote bush (*L. tridentata*) shrubland. Arizona juniper (*Juniperus arizonica*) is a conspicuous species across this shrubland, mainly at the Well unit, but provides little cover. Fourwing saltbush (*Atriplex canescens*) is an inconsistent associate species that is typically more common in areas of historical disturbance. A number of occasional shrub species round out the subcanopy strata, including red barberry (*Berberis haematocarpa*), Mormon tea (*Ephedra viridis*), pale desert-thorn (*Lycium pallidum*), Sonoran scrub oak (*Quercus turbinella*), and Wright's beebrush (*Aloysia wrightii*).

The field stratum is characterized by a diverse mix of small shrubs and perennial grasses. Broom snakeweed (*G. sarothrae*) is the most dominant small shrub across this community, providing cover that averages to 6%. However, individual cover values are highly variable, ranging from less than 1% up to 18%, with the highest cover occurring at the Well unit. Bush muhly (*Muhlenbergia porteri*), New Mexico feathergrass (*Hesperostipa neomexicana*), and tobosagrass (*Hilaria mutica*) are the most widespread perennial grasses, with highly variable cover ranging from 0% to 8%. Of these species, bush muhly (*M. porteri*) is by far the most dominant and consistent, with total average cover above 2%. There is a diverse blend of occasional forbs, grasses, and cacti, with cover typically around 1% or less, including black grama (*Bouteloua eriopoda*), globemallow (*Sphaeralcea* spp.), rose heath (*Chaetopappa ericoides*), slim tridens (*Tridens muticus*), woody crinklemat (*Tiquilia canescens*), purple threeawn (*Aristida purpurea*), Eastern Mojave buckwheat (*Eriogonum fasciculatum*), sand dropseed (*Sporobolus cryptandrus*), and Christmas cactus (*Cylindropuntia leptocaulis*).

In areas with a history of disturbance, mainly historic grazing, cover of woody, perennial species is considerably lower and species composition changes. This variation is characterized by a subcanopy dominated by sparse velvet mesquite (*P. velutina*) and fourwing saltbush (*A. canescens*) at 4% and 3%, respectively. The field stratum is characterized by dominant tobosagrass (*Hilaria mutica*) with patchy exotic grasses and forbs, including Sahara mustard (*Brassica tournefortii*), Cuman ragweed (*Ambrosia psilostachya*), red brome (*B. rubens*), and mouse barley (*Hordeum murinum*). This variation is confined to the northern boundary of the Well unit.

Due to its transitional nature, this shrubland varies greatly across its range. Its lower-elevation boundaries are adjacent to velvet mesquite (*P. velutina*) bosque heavily influenced by the riparian corridor. Its upper-elevation boundaries are adjacent to the drier and sparser creosote bush (*L. tridentata*) shrublands. As the association moves up in elevation away from the riparian area, velvet mesquite (*P. velutina*) becomes sparser and more shrublike, while creosote bush (*L. tridentata*) becomes increasingly common until it is dominant.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Prosopis velutina*
Subcanopy (0.5–2 m)	*Prosopis velutina, Senegalia greggii*
Field (0–0.5 m)	*Gutierrezia sarothrae, Muhlenbergia porteri, Hilaria mutica*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Juniperus arizonica*
Subcanopy (0.5–2 m)	*Senegalia greggii, Larrea tridentata, Berberis haematocarpa, Aloysia wrightii, Krascheninnikovia lanata*
Field (0–0.5 m)	*Sporobolus cryptandrus, Astragalus allochrous, Tiquilia canescens, Bromus rubens, Dasyochloa pulchella, Bouteloua eriopoda, Hesperostipa neomexicana, Chaetopappa ericoides, Sporobolus cryptandrus*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified from six classification plots and eight mapped classification polygons at the Well unit, and four classification plots and four mapped classification polygons at the Castle unit.

This type was recognized by Rowlands (1999), who classified it within the BLP system as a *Gutierrezia sarothrae - Prosopis velutina* association (BLP 143.165), within the shrub–scrub disclimax series. The presence of *G. sarothrae* may indicate frequent disturbance. As such, this type may be a disturbed variation of what might otherwise be mesquite bosque or mesquite shrubland.

Global

There is no global description for this association. A number of described associations have velvet mesquite (*P. velutina*) as a dominant in the Apacherian-Chihuahuan desert scrub types, but none are described as having broom snakeweed (*G. sarothrae*) as the secondary dominant (see, for example, CEGL001388 *Prosopis velutina - Acacia greggii* Shrubland).

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

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Castle unit Plots: IP009 C, IP020 C, IP023 C, IP027 C

Montezuma Castle National Monument, Well unit Plots: IP001, IP004, IP006, IP008, IP015, IP018

Montezuma Castle National Monument, Castle unit Polygons: 4 polygons

Montezuma Castle National Monument, Well unit Polygons: 8 polygons

Local Description Authors: S. Buckley, J. Galvin, S. Studd

8. *Larrea tridentata* Shrubland Association (P)

Translated name: Creosote bush Shrubland Association
NVC name: Not available (see classification notes)
Identifier: NPSSODN029

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Larrea tridentata* Shrubland

DISTRIBUTION

Montezuma Castle National Monument

This shrubland association is found in both units of the monument, generally spanning the low-angle shoulders and crests of the mesas and occasionally along alluvial terraces adjacent to the floodplain of Beaver Creek.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This shrubland type spans the low-angle shoulders and crests of mesas with variable aspects, and occasionally the toeslopes/alluvial fans adjacent to Beaver Creek. Slopes are low-angle, typically under 10%, with elevation ranging from 990 to 1,043 meters (3,250–3,425 ft). Surface cover is typically dominated by a mix of gravel and bare soil, with higher rock cover where slopes increase. Notably, the soils are covered in high proportions of biological crusts in some areas. At the Castle unit, this shrubland is well-distributed on both sides of the creek, occupying the drier areas upslope of the adjacent velvet mesquite (*Prosopis velutina*) shrublands. At the Well unit, it is restricted to a small mesa top along the northwest boundary.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This shrubland community is characterized by a subcanopy (0.5–2 m) dominated by creosote bush (*Larrea tridentata*) and a diverse but inconsistent mix of additional shrubs and perennial grasses. Total vegetation cover in the subcanopy is variable, ranging from 10% up to 45%, with creosote bush (*L. tridentata*) accounting for an average of 10% and ranging up to 20%. Catclaw acacia (*Senegalia greggii*) provides an inconsistent, low cover across the community, averaging about 2%, with rare inclusions of increased cover where it competes for dominance with creosote bush (*L. tridentata*). Velvet mesquite (*P. velutina*) is another occasional species that is most common along boundaries shared with velvet mesquite (*P. velutina*) shrubland association. Fourwing saltbush (*Atriplex canescens*) is a very inconsistent species that is a common associate in one small area at the Castle unit. Arizona juniper (*Juniperus arizonica*) provides sparse but conspicuous cover across the landscape.

The field stratum is a diverse, low-cover mix of small shrubs and perennial grasses, with total cover averaging less than 10%. These species are very patchy and help create a number of sub-types in which one or two species characterize the field stratum. Broom snakeweed (*G. sarothrae*) is the most common perennial component of the field layer, including scattered areas of dominance with cover approaching 10%, but averaging only 2% across the monument. Littleleaf ratany (*Krameria erecta*) and winterfat (*Krascheninnikovia lanata*) are two other sparse shrubs with occasional areas of noteworthy cover that are often intermixed with broom snakeweed (*G. sarothrae*). In general, these species are most prolific on the lower-angle mesa tops in both units of the monument. Numerous perennial grasses, including purple threeawn (*Aristida purpurea*), bush muhly (*Muhlenbergia porteri*), sand dropseed (*Sporobolus cryptandrus*), tobosagrass (*Hilaria mutica*), and black grama (*Bouteloua eriopoda*), provide very inconsistent cover throughout. These species are absent from many areas of this shrubland but will sporadically appear and provide conspicuous ground cover. As with many of the associations throughout the monument, red brome (*Bromus rubens*) is present, with the highest cover occurring in areas close to the floodplain.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Prosopis velutina*
Subcanopy (0.5–2 m)	*Larrea tridentata, Senegalia gregii*
Field (0–0.5 m)	*Gutierrezia sarothrae*, *Krameria erecta*, *Bromus rubens*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Juniperus arizonica*
Subcanopy (0.5–2 m)	*Atriplex canescens, Krascheninnikovia lanata, Berberis haematocarpa*
Field (0–0.5 m)	*Aristida purpurea, Dasyochloa pulchella, Yucca elata, Cylindropuntia leptocaulis, Bouteloua eriopoda, Tiquilia canescens, Chaetopappa ericoides, Muhlenbergia porteri, Bromus rubens*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

At the Well unit, this association was classified from one classification plot and one mapped classification polygon. At the Castle unit, it was classified based on three classification plots, nine mapped classification polygons, and two polygons created during the initial validation phase. Several other *Larrea tridentata*-dominated or co-dominated shrublands have been described within the NVC (see CEGL005145), but further classification work is need to expand them to their full range. At this time, none adequately captures this community as it is observed at Montezuma Castle National Monument.

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

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Castle unit Plots: IP022 C, V202_005, V201_006

Montezuma Castle National Monument, Well unit Plots: IP006

Montezuma Castle National Monument, Castle unit Polygons: 11 polygons

Montezuma Castle National Monument, Well unit Polygons: 1 polygon

Local Description Authors: S. Buckley, J. Galvin, S. Studd

9. Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna Association (PS)

Translated name: Mixed Shrub / New Mexico feathergrass Shrub Savanna Association
NVC name: Not available
Identifier: NPSSODN033

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: Mixed Shrub / *Hesperostipa neomexicana* Shrub Savanna

DISTRIBUTION

Montezuma Castle National Monument

This shrub savanna is known from one location along the north-central boundary of the Castle unit.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This shrub savanna community spans the northeast-facing backslope of a mesa at 1,020 meters (3,350 ft). The slopes are variable, generally falling between 10% and 40%. The surface is characterized by loose soil, as well as calcareous gravel and rock fragments of various sizes with the occasional small bedrock outcrop.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This shrub savanna is characterized by a subcanopy (0.5–2 m) dominated by a low-cover mix of shrubs, and a field stratum (<0.5 m) dominated by New Mexico feathergrass (*Hesperostipa neomexicana*). Typically, cover of shrub species is around 5%, split between creosote bush (*L. tridentata*), fragrant sumac (*Rhus aromatica*), red barberry (*Berberis haematocarpa*), Mormon tea (*Ephedra* viridis), and catclaw acacia (*Senegalia greggii*). Distribution of these species varies, with creosote bush (*L. tridentata*) occasionally present as the sole dominant. The other three species, when present, are large and well-spaced individuals, usually more than 2 meters tall.

The field stratum is characterized by a matrix of native perennial grasses, with cover approaching 30%. New Mexico feathergrass (*H. neomexicana*) is the clear dominant, providing cover around 20%. Sideoats grama (*Bouteloua curtipendula*), slim tridens (*Tridens muticus*), and purple threeawn (*Aristida purpurea*) are consistent, but low-cover, associates. A mix of subshrubs, including littleleaf ratany (*Krameria erecta*) and featherplume (*Dalea formosa*), provide consistent low cover throughout. Red brome (*Bromus rubens*) is a consistent associate throughout this community.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Larrea tridentata, Senegalia greggii, Berberis haematocarpa, Ephedra viridis*
Field (0–0.5 m)	*Hesperostipa neomexicana, Dalea formosa, Krameria erecta*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	*Gutierrezia sarothrae, Aristida purpurea, Tridens mutica, Bromus rubens*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association, classified from one mapped classification polygon at the Castle unit, has been classified as a "park special." This identifier means that this plant assemblage is thought to be an expression of local conditions rather than a community expected to repeat across the larger landscape.

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

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Castle unit Plots: None

Montezuma Castle National Monument, Well unit Plots: None

Montezuma Castle National Monument, Castle unit Polygons: 1 polygon

Montezuma Castle National Monument, Well unit Polygons: None

Local Description Authors: S. Buckley, J. Galvin, S. Studd

10. *Celtis reticulata - Salix exigua / (Schoenoplectus tabernaemontani) / Bromus diandrus* Riparian Woodland Association (PS)

Translated name: Netleaf hackberry - Narrowleaf willow / (Softstem bulrush) / Ripgut brome Riparian Woodland Association
NVC name: Not available
Identifier: NPSSODN026

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Celtis reticulata - Salix exigua / (Schoenoplectus tabernaemontani) / Bromus diandrus* Riparian Woodland

DISTRIBUTION

Montezuma Castle National Monument

This riparian woodland community is restricted to areas within the well feature at the Well unit of the monument.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This riparian woodland community spans the steep, north-facing slope and low-angle, water-saturated soils within the well feature at 1,135 meters (3,725 ft). Ground cover is characterized by the presence of limestone outcrops and boulders—especially toward the uphill end community, where a large cliff band dominates the landscape, with dense litter cover throughout.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This community is described as a "park special," meaning it is recognized as a unique suite of plants due directly to the unique well environment and long history of anthropogenic use. This riparian woodland community is characterized by three distinct bands of vegetation, transitioning from an area of facultative and obligate wetland species at the water's edge to a more terrestrial community on the higher slopes surrounding the well. Overall, this community is defined by a canopy stratum (>2 m) dominated by netleaf hackberry (*Celtis reticulata*) and narrowleaf willow (*Salix exigua*), with dominant ripgut brome in the field stratum (<0.5). Netleaf hackberry (*Celtis reticulata*) is generally present in a tree-like growth form, with cover approaching 45% and heights up to 7 meters. This species occupies the most terrestrial and largest band of vegetation within this community. Narrowleaf willow (*Salix exigua*) provides around 20% cover in a dense, homogeneous band situated between the netleaf hackberry (*Celtis reticulata*) woodland and the herbaceous, obligate wetland species at water's edge. In general, this species is present in a tree-like growth form, with an average height of 3.5 meters. Other noteworthy canopy species include Arizona walnut (*Juglans major*), which is present as a single, large individual situated near the outflow of the well, and Bonpland willow (*Salix bonplandiana*).

The subcanopy stratum is defined by an assortment of low-cover shrubs. Within the more terrestrial area, Mormon tea (*Ephedra viridis*) and pale desert-thorn (*Lycium pallidum*) are conspicuous, but lower-cover, associates that are intermixed with smaller, more shrub-like netleaf hackberry (*Celtis reticulata*). The band of vegetation at water's edge is dominated by softstem bulrush (*Schoenoplectus tabernaemontani*). Another conspicuous species, western poison ivy (*Toxicodendron rydbergii*), provides noteworthy cover throughout this community, especially within the dense band of narrowleaf willow (*Salix exigua*).

The field stratum is defined by dominant ripgut brome (*Bromus diandrus*), providing around 8% cover throughout the woodland portion, and an assortment of facultative and obligate wetland species at water's edge. These species include, but are not limited to, horsetail (*Equisetum* sp.), spikerush (*Eleocharis* sp.), scratchgrass (*Muhlen-*

bergia asperifolia), and whorled marshpennywort (*Hydrocotyle verticillata*). While most of this community is restricted to the northern slope, the wetland species form a narrow ring at water's edge throughout the well feature.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	*Celtis reticulata, Juglans major*
Canopy (2–5 m)	*Celtis reticulata, Salix exigua*
Subcanopy (0.5–2 m)	*Schoenoplectus tabernaemontani, Toxicodendron rydbergii*
Field (0–0.5 m)	*Bromus diandrus*

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	*Salix bonplandiana*
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Lycium pallidum, Ephedra viridis, Artemisia ludoviciana*
Field (0–0.5 m)	*Eleocharis* sp., *Equisetum* sp., *Muhlenbergia asperifolia, Hydrocotyle verticulata*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified from one draft classification polygon, an accuracy assessment point.

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

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Castle unit Plots: None

Montezuma Castle National Monument, Well unit Plots: None

Montezuma Castle National Monument, Castle unit Polygons: None

Montezuma Castle National Monument, Well unit Polygons: 1 polygon

Local Description Authors: S. Buckley, J. Galvin, S. Studd

11. *Typha domingensis (Schoenoplectus tabernaemontani)* Herbaceous Association (P)

Translated name: Southern cattail (Softstem bulrush) Herbaceous Association
NVC name: Not available
Identifier: NPSSODN034

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *Typha domingensis* (*Schoenoplectus tabernaemontani*) Herbaceous

DISTRIBUTION

Montezuma Castle National Monument

This provisional herbaceous community is present in small patches throughout the watercourse of Beaver Creek, at both units of the monument. The only large, consistent patch spans a stretch of the creek at the north end of the Castle unit.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This herbaceous community spans low-angle, usually still, stretches of Beaver Creek at 975 meters (3,200 ft). Ground cover ranges from water-saturated soils, often covered with dead cattail stems, at the margins of the creek to areas of standing water. This community can cover the entire width of the watercourse at times, but is generally confined to its margins.

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This local described herbaceous community is defined by a subcanopy stratum (0.5–2 m), dominated by southern cattail (*Typha domingensis*) and one common associate, softstem bulrush (*Schoenoplectus tabernaemontani*). Southern cattail (*T. domingensis*) forms a dense matrix, up to 2.5 m tall, with cover often approaching 90%. Softstem bulrush (*S. tabernaemontani*) provides far less cover but is a conspicuous associate species, especially at the margins of the community. This community is often in close proximity to the nearby riparian woodlands. As such, it often contains occasional large tree species—specifically, Goodding's willow (*Salix gooddingii*), Arizona sycamore (*Platanus wrightii*), and Arizona ash (*Fraxinus velutina*).

The field stratum (<0.5 m) contains a diverse, low-cover mix of obligate and facultative wetland species, including Parish's spikerush (*Eleocharis parishii*), fescue (*Schedonorus* spp.), smooth horsetail (*Equisetum laevigatum*), field horsetail (*Equisetum arvense*), wild mint (*Mentha arvensis*), swamp carex (*Carex senta*), and Rocky mountain rush (*Juncus saximontanus*). These species are very sparse and are usually only present at the margins of the community where southern cattail (*T. domingensis*) is less common.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Typha domingensis, Schoenoplectus tabernaemontani*
Field (0–0.5 m)	None

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Platanus wrightii, Salix goodingii, Fraxinus velutina*
Subcanopy (0.5–2 m)	None
Field (0–0.5 m)	*Eleocharis parishii, Schedonorus* spp., *Equisetum laevigatum, Equisetum arvense, Mentha arvensis, Carex senta, Juncus saximontanus*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified from one mapped classification polygon.

Global

No description at the macrogroup, group, or association level currently exists for this association type. It is likely that the association described for Montezuma Castle National Monument will be placed within the *Prosopis glandulosa* / *Typha domingensis* - *Schoenoplectus pungens* Southwestern North American Warm Desert Freshwater Shrub & Marsh Division (D032) once the division and sub-categories are fully described.

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

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Castle unit Plots: None

Montezuma Castle National Monument, Well unit Plots: None

Montezuma Castle National Monument, Castle unit Polygons: 1 polygon

Montezuma Castle National Monument, Well unit Polygons: None

Local Description Authors: S. Buckley, J. Galvin, S. Studd

12. *(Prosopis velutina) / Hordeum murinum - Bromus rubens - Bromus diandrus* Ruderal Shrub Savanna (PS)

Translated name: (Velvet mesquite) / Mouse barley - Red brome - Ripgut brome **Ruderal** Shrub Savanna
NVC name: Not available
Identifier: NPSSODN032

NVC CLASSIFICATION

Division: --
Macrogroup: --
Group: --
Association: *(Prosopis velutina) / Hordeum murinum - Bromus rubens - Bromus diandrus* Shrub Savanna Disturbed

DISTRIBUTION

Montezuma Castle National Monument

This disturbed shrub savanna occurs in areas in the southwest corner of the Well unit.

ENVIRONMENTAL DESCRIPTION

Montezuma Castle National Monument

This shrub savanna community occurs on the low-angle, heavily disturbed floodplain immediately adjacent to Beaver Creek, at 1,060 meters (3,477 ft). The main occurrence spans a large, fallow pasture that was grazed by cattle until 1993 (Rowlands 1999).

VEGETATION DESCRIPTION

Montezuma Castle National Monument

This community is described as a "park special," meaning it is recognized as a unique suite of plants resulting from a long history of disturbance. This shrub savanna community is characterized by patchy, low-cover velvet mesquite (*Prosopis velutina*) in the canopy strata (0.5–5 m) and a field stratum (<0.5 m) dominated by a mix of exotic annual grasses. Velvet mesquite (*P. velutina*) is generally patchy, with variable cover averaging 11% across the community with small patches ranging up to 21% and areas completely devoid of this species. In general, this species has a tree-like growth-form, with heights up to 4 meters. Emory's baccharis (*Baccharis emoryi*) is an occasional associate throughout this community.

The field stratum is defined by a diverse matrix of non-native grasses and forbs, dominated by mouse barley (*Hordeum murinum*), red brome (*Bromus rubens*), ripgut brome (*Bromus diandrus*), and Russian thistle (*Salsola* spp.). Cover of these species is variable throughout, ranging from 10% up to 60%, with mouse barley (*Hordeum murinum*) providing the highest and most consistent cover throughout. In the less disturbed sections of this community, native grasses, including silver bluestem (*Bothriochloa saccharoides*), spidergrass (*Aristida ternipes*), green sprangletop (*Leptochloa dubia*), and sand dropseed (*Sporobolus cryptandrus*), provide low cover. Other noteworthy non-native species include horehound (*Marrubium vulgare*) and Johnsongrass (*Sorghum halepense*).

Park staff has been working to restore this area to a mesquite bosque. Their management practices have included exotic plant removal, mainly Johnsongrass (*S. halepense*), horehound (*M. vulgare*), and Russian thistle (*Salsola* spp.), as well as planting native species, such as fourwing saltbush (*Atriplex canescens*), desert willow (*Chilopsis linearis*), big sacaton (*Sporobolus wrightii*), netleaf hackberry (*Celtis reticulata*), and red barberry (*Berberis haematocarpa*).

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available.

MOST ABUNDANT SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	*Prosopis velutina*
Subcanopy (0.5–2 m)	*Prosopis velutina*
Field (0–0.5 m)	*Hordeum murinum, Bromus rubens, Bromus diandrus, Salsola* spp.

OTHER NOTEWORTHY ASSOCIATE SPECIES

Montezuma Castle National Monument

Stratum	Species
Canopy (> 5 m)	None
Canopy (2–5 m)	None
Subcanopy (0.5–2 m)	*Baccharis emoryi*
Field (0–0.5 m)	*Bothriochloa saccharoides, Aristida ternipes, Leptochloa dubia, Sporobolus cryptandrus, Marrubium vulgare, Sorghum halepense*

CLASSIFICATION COMMENTS

Montezuma Castle National Monument

This association was classified from three draft classification polygons, two accuracy assessment points, and two intermediate plots.

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

Montezuma Castle National Monument Inventory Notes: Data are not available.

Montezuma Castle National Monument, Castle unit Plots: None

Montezuma Castle National Monument, Well unit Plots: IP014, IP019

Montezuma Castle National Monument, Castle unit Polygons: None

Montezuma Castle National Monument, Well unit Polygons: 3 polygons

Local Description Authors: S. Buckley, J. Galvin, S. Studd

Citations: Rowlands, P. G. 1999. Vegetation survey of Montezuma Castle National Monument. National Park Service, Organ Pipe Cactus National Monument, Ajo, Arizona.

Appendix G: Plant Species Observed

Table G-1. List of all plant species observed during intermediate plot data collection and polygon-scale data collection at Montezuma Castle National Monument, 2010–2014.

Family	Scientific name	Castle unit†			Well unit†		
		AA	CP	Polygon	AA	CP	Polygon
Amaranthaceae	*Atriplex canescens*	X	X	X	X	X	X
Amaranthaceae	*Krascheninnikovia lanata*	–	X	X	–	X	–
Amaranthaceae	*Salsola kali**	–	**X**	**X**		**X**	
Amaranthaceae	*Salsola tragus**	**X**	–	–	**X**	**X**	–
Anacardiaceae	*Rhus aromatica*	X	X	X	X	X	X
Anacardiaceae	*Toxicodendron radicans*	–	–	–	X	–	–
Apocynaceae	*Amsonia tomentosa* var. *stenophylla*	X	–	–	–	–	–
Araliaceae	*Hydrocotyle verticillata*	–	–	–	X	–	–
Asparagaceae	*Nolina microcarpa*	–	–	–	X	X	–
Asparagaceae	*Yucca baccata*	–	–	X	X	X	–
Asparagaceae	*Yucca elata*	X	X	X	X	X	X
Asteraceae	*Acourtia wrightii*	X	X	–	X	X	–
Asteraceae	*Ageratina herbacea*	–	–	–	–	X	–
Asteraceae	*Ambrosia confertiflora*	–	–	–	–	X	–
Asteraceae	*Ambrosia monogyra*	X	X	X	–	–	–
Asteraceae	*Ambrosia psilostachya*	–	X	–	X	–	–
Asteraceae	*Artemisia carruthii*	X	X	–	–	X	–
Asteraceae	*Artemisia ludoviciana*	X	X	–	X	X	–
Asteraceae	*Baccharis brachyphylla*	–	X	–	–	–	–
Asteraceae	*Baccharis pteronioides*	–	X	–	–	X	–
Asteraceae	*Baccharis salicifolia*	–	–	X	–	X	–
Asteraceae	*Baccharis salicina*	X	X	–	X	X	X
Asteraceae	*Baccharis sarothroides*	X	X	X	X	–	–
Asteraceae	*Baileya multiradiata*	–	–	–	X	–	–
Asteraceae	*Baileya pleniradiata*	–	X	–	–	X	–
Asteraceae	*Brickellia californica*	X	X	–	X	X	–
Asteraceae	*Brickellia floribunda*	X	X	–	X	X	–
Asteraceae	*Centaurea melitensis**	–	–	–	–	**X**	–
Asteraceae	*Chaetopappa ericoides*	X	X	X	X	X	–
Asteraceae	*Cirsium*	–	X	–	X	X	–
Asteraceae	*Dieteria canescens*	X	X	–	–	–	–
Asteraceae	*Encelia frutescens*	X	–	–	–	–	–
Asteraceae	*Encelia virginensis*	–	X	–	–	X	–
Asteraceae	*Ericameria nauseosa* var. *bigelovii*	–	X	–	–	–	–
Asteraceae	*Erigeron concinnus*	–	X	–	–	–	–
Asteraceae	*Erigeron divergens*	X	X	–	–	X	–
Asteraceae	*Erigeron flagellaris*	–	–	–	–	X	–

Table G-1. List of all plant species observed during intermediate plot data collection and polygon-scale data collection at Montezuma Castle National Monument, 2010–2014, cont.

Family	Scientific name	Castle unit†			Well unit†		
		AA	CP	Polygon	AA	CP	Polygon
Asteraceae	*Erigeron oreophilus*	X	–	–	–	–	–
Asteraceae	*Gaillardia pinnatifida*	–	–	–	–	X	–
Asteraceae	*Grindelia squarrosa*	–	–	–	–	X	–
Asteraceae	*Gutierrezia sarothrae*	X	X	X	X	X	X
Asteraceae	*Malacothrix glabrata*	–	–	–	–	X	–
Asteraceae	*Melampodium leucanthum*	X	X	–	X	X	–
Asteraceae	*Parthenium incanum*	X	X	X	X	X	X
Asteraceae	*Senecio lemmonii*	–	–	–	–	X	
Asteraceae	*Solidago wrightii*	–	X	–	–	–	–
Asteraceae	*Sonchus asper**	–	–	–	–	**X**	–
Asteraceae	*Stephanomeria*	X	–	–	–	–	–
Asteraceae	*Stephanomeria pauciflora*	–	X	–	–	–	–
Asteraceae	*Stephanomeria tenuifolia*	–	X	–	–	X	–
Asteraceae	*Taraxacum*	–	–	–	X	–	–
Asteraceae	*Thymophylla acerosa*	X	X	X	X	X	–
Asteraceae	*Thymophylla pentachaeta*	–	–	–	X	–	–
Asteraceae	*Tragopogon dubius**	–	–	–	–	**X**	–
Asteraceae	*Xanthisma gracile*	X	–	–	–	X	–
Asteraceae	*Xanthisma spinulosum*	–	–	–	X	–	–
Asteraceae	*Xanthium strumarium*	X	X	–	–	X	–
Berberidaceae	*Berberis haematocarpa*	X	X	X	X	X	X
Betulaceae	*Alnus oblongifolia*	X	X	X	X	X	X
Bignoniaceae	*Chilopsis linearis*	X	X	X	X	X	–
Brassicaceae	*Brassica tournefortii**	–	**X**	–	–	**X**	**X**
Brassicaceae	*Chorispora tenella*	X	–	–	–	–	–
Brassicaceae	*Matthiola longipetala*	X	–	–	–	–	–
Cactaceae	*Cylindropuntia leptocaulis*	X	X	X	X	X	–
Cactaceae	*Echinocereus fasciculatus*	–	X	–	–	X	–
Cactaceae	*Escobaria vivipara*	–	–	–	–	X	–
Cactaceae	*Opuntia engelmannii*	X	X	–	X	X	X
Cactaceae	*Opuntia phaeacantha*	X	X	–	X	X	–
Cannabaceae	*Celtis laevigata*	–	X	X	–	X	X
Cannabaceae	*Celtis reticulata*	X	–	–	X	–	–
Celastraceae	*Canotia holocantha*	X	X	X	X	–	X
Commelinaceae	*Tradescantia leiandra*	–	–	–	X	–	–
Convolvulaceae	*Evolvulus nuttallianus*	–	–	–	–	X	–
Cucurbitaceae	*Cucurbita foetidissima*	–	–	–	X	–	–
Cupressaceae	*Juniperus monosperma*	X	X	X	X	X	X
Cupressaceae	*Juniperus osteosperma*	–	X	–	X	X	X
Cyperaceae	*Carex senta*	X	–	–	X	X	–

Table G-1. List of all plant species observed during intermediate plot data collection and polygon-scale data collection at Montezuma Castle National Monument, 2010–2014, cont.

Family	Scientific name	Castle unit†			Well unit†		
		AA	CP	Polygon	AA	CP	Polygon
Cyperaceae	*Eleocharis palustris*	X	–	–	–	–	–
Cyperaceae	*Eleocharis parishii*	–	X	–	–	–	–
Cyperaceae	*Eleocharis rostellata*	–	–	–	–	–	X
Cyperaceae	*Schoenoplectus tabernaemontani*	X	–	–	X	–	–
Boraginaceae	*Tiquilia canescens*	X	X	X	X	X	–
Ephedraceae	*Ephedra viridis*	X	X	X	X	X	X
Equisetaceae	*Equisetum arvense*	X	–	–	–	–	–
Equisetaceae	*Equisetum hyemale*	–	–	–	–	X	–
Equisetaceae	*Equisetum laevigatum*	X	–	–	X	–	X
Euphorbiaceae	*Euphorbia*	–	X	–	–	X	–
Euphorbiaceae	*Euphorbia lucida*	–	–	–	–	X	–
Fabaceae	*Acmispon rigidus*	–	–	–	–	X	–
Fabaceae	*Amorpha fruticosa*	X	X	X	–	–	–
Fabaceae	*Astragalus allochrous*	–	X	–	–	X	–
Fabaceae	*Astragalus calycosus*	–	X	–	–	X	–
Fabaceae	*Calliandra humilis*	X	–	–	X	–	–
Fabaceae	*Dalea formosa*	X	X	X	X	X	X
Fabaceae	*Hoffmannseggia drepanocarpa*	–	X	–	–	X	–
Fabaceae	*Lathyrus eucosmus*	–	X	–	–		–
Fabaceae	*Lotus corniculatus**	–	–	–	–	**X**	–
Fabaceae	*Medicago minima**	–	–	–	–	**X**	–
Fabaceae	*Medicago polymorpha**	–	–	–	**X**	–	–
Fabaceae	*Melilotus albus**	**X**	–	–		–	–
Fabaceae	*Melilotus indicus**	–	–	–	**X**	–	–
Fabaceae	*Melilotus officinalis**	**X**	**X**	–		**X**	–
Fabaceae	*Mimosa aculeaticarpa*	–	X	X	X	X	X
Fabaceae	*Mimosa aculeaticarpa var. biuncifera*	–	–	–	X	–	–
Fabaceae	*Phaseolus angustissimus*	–	–	–		X	–
Fabaceae	*Prosopis velutina*	X	X	X	X	X	X
Fabaceae	*Rhynchosia senna*	–	–	–	–	X	–
Fabaceae	*Senegalia greggii*	X	X	X	X	X	X
Fabaceae	*Senna bauhinioides*	X	X	–	X	X	–
Fabaceae	*Senna covesii*	–	X	–	–	X	–
Fabaceae	*Vicia ludoviciana*	–	–	–	–	X	–
Fagaceae	*Quercus turbinella*	–	–	–	X	X	X
Geraniaceae	*Erodium cicutarium**	–	**X**	–	–	**X**	–
Geraniaceae	*Erodium texanum*	–	–	–	–	X	–
Grossulariaceae	*Ribes aureum*	–	–	–	X	X	–
Juglandaceae	*Juglans major*	X	X	X	X	X	X
Juncaceae	*Juncus saximontanus*	–	–	–	–	X	–

Table G-1. List of all plant species observed during intermediate plot data collection and polygon-scale data collection at Montezuma Castle National Monument, 2010–2014, cont.

Family	Scientific name	Castle unit†			Well unit†		
		AA	CP	Polygon	AA	CP	Polygon
Krameriaceae	*Krameria erecta*	X	X	X	X	X	X
Krameriaceae	*Krameria lanceolata*	X	–	–	X	–	–
Lamiaceae	*Hedeoma*	–	–	–	–	X	–
Lamiaceae	*Hedeoma drummondii*	–	–	–	–	X	–
Lamiaceae	*Hedeoma nana*	–	X	–	–	–	–
Lamiaceae	*Marrubium vulgare**	**X**	**X**	**X**	**X**	**X**	–
Lamiaceae	*Mentha spicata**	**X**	**X**	–	–	**X**	–
Liliaceae	*Calochortus flexuosus*	–	–	–	–	X	–
Linaceae	*Linum puberulum*	–	–	–		X	–
Malvaceae	*Sphaeralcea*	X	X	X	X	X	X
Malvaceae	*Sphaeralcea ambigua*	X	–	–	–	–	–
Nyctaginaceae	*Allionia incarnata*	X	X	–	–	X	–
Nyctaginaceae	*Mirabilis albida*	–	–	–	–	X	–
Nyctaginaceae	*Mirabilis multiflora*	–	X	–	–	X	–
Oleaceae	*Forestiera pubescens*	–	–	X	X	–	–
Oleaceae	*Fraxinus pennsylvanica*	–	–	X	–	–	–
Oleaceae	*Fraxinus velutina*	X	X	X	X	X	X
Oleaceae	*Menodora scabra*	X	–	–	–	–	–
Onagraceae	*Oenothera pallida*	–	–	–	–	X	–
Onagraceae	*Oenothera suffrutescens*	–	X	X	–	X	–
Orchidaceae	*Epipactis gigantea*	–	–	X	–	–	–
Orobanchaceae	*Castilleja*	–	–	–	–	X	–
Phrymaceae	*Mimulus guttatus*	–	–	–	–	X	–
Plantaginaceae	*Linaria dalmatica*	X	X	–	–	–	–
Plantaginaceae	*Penstemon*	–	X	–	–	X	–
Plantaginaceae	*Penstemon barbatus*	–	–	–	–	X	–
Plantaginaceae	*Penstemon pseudospectabilis*	X	X	–	–	–	–
Plantaginaceae	*Plantago lanceolata**	–	**X**	–	**X**	**X**	–
Platanaceae	*Platanus wrightii*	X	X	X	X	X	X
Poaceae	*Aegilops cylindrica**	–	–	–	–	**X**	–
Poaceae	*Aristida hamulosa*	–	–	–	–	X	–
Poaceae	*Aristida purpurea*	X	X	X	X	X	X
Poaceae	*Aristida schiedeana*	–	–	–	–	X	–
Poaceae	*Aristida ternipes*	X	X	–	X	X	–
Poaceae	*Avena fatua**	–	–	–	–	**X**	–
Poaceae	*Bothriochloa barbinodis*	X	–	–	–	X	–
Poaceae	*Bothriochloa saccharoides*	–	–	–	X	–	–
Poaceae	*Bouteloua curtipendula*	X	X	X	X	X	X
Poaceae	*Bouteloua eriopoda*	X	–	X	X	X	X
Poaceae	*Bromus arvensis**	–	–	–	–	**X**	–

Table G-1. List of all plant species observed during intermediate plot data collection and polygon-scale data collection at Montezuma Castle National Monument, 2010–2014, cont.

Family	Scientific name	Castle unit†			Well unit†		
		AA	CP	Polygon	AA	CP	Polygon
Poaceae	*Bromus catharticus**	–	–	–	–	**X**	–
Poaceae	*Bromus diandrus**	**X**	**X**	**X**	**X**	**X**	**X**
Poaceae	*Bromus inermis**	**X**	**X**	–	–	**X**	–
Poaceae	*Bromus japonicus**	–	**X**	–	–	–	–
Poaceae	*Bromus rubens**	**X**	**X**	**X**	**X**	**X**	**X**
Poaceae	*Bromus tectorum**	**X**	**X**	**X**	–	**X**	**X**
Poaceae	*Cynodon dactylon**	**X**	**X**	–	**X**	**X**	–
Poaceae	*Dasyochloa pulchella*	X	X	–	X	X	–
Poaceae	*Elymus elymoides*	X	X	–	X	X	–
Poaceae	*Elymus glaucus*	–	–	–	X	–	–
Poaceae	*Elymus trachycaulus*	–	X	–	–	X	–
Poaceae	*Eragrostis curvula**	–	**X**	–	**X**	**X**	–
Poaceae	*Eragrostis lehmanniana**	–	–	–	–	**X**	–
Poaceae	*Erioneuron pilosum*	X	–	–	X	–	–
Poaceae	*Erioneuron pilosum var. longearistatum*	–	X	X	–	X	–
Poaceae	*Hesperostipa neomexicana*	X	X	X	X	X	X
Poaceae	*Hilaria belangeri*	–	X	–	–	–	–
Poaceae	*Hilaria mutica*	X	X	X	X	X	X
Poaceae	*Hordeum marinum**	–	**X**	**X**	–	–	–
Poaceae	*Hordeum murinum**	**X**	**X**	**X**	**X**	**X**	**X**
Poaceae	*Leptochloa dubia*	–	–	–	X	–	–
Poaceae	*Lolium perenne*	X	–	–	–	–	–
Poaceae	*Muhlenbergia polycaulis*	–	–	–	X	–	–
Poaceae	*Muhlenbergia porteri*	X	X	X	X	X	X
Poaceae	*Muhlenbergia repens*	–	–	–	X	–	–
Poaceae	*Muhlenbergia rigens*	X	–	–	–	–	–
Poaceae	*Pascopyrum smithii*	–	X	–	–	X	–
Poaceae	*Paspalum dilatatum*	–		–	X	–	–
Poaceae	*Paspalum distichum*	–	X	–	–	X	–
Poaceae	*Poa fendleriana*	–	X	–	X	X	–
Poaceae	*Poa pratensis**	–	–	–	**X**	–	–
Poaceae	*Schedonorus arundinaceus**	**X**	**X**	–	–	**X**	**X**
Poaceae	*Scleropogon brevifolius*	–	–	–	–	X	–
Poaceae	*Setaria leucopila*	–	–	–	X	X	–
Poaceae	*Sorghum halepense**	**X**	**X**	–	**X**	**X**	–
Poaceae	*Sporobolus contractus*	X	X	–	X	–	–
Poaceae	*Sporobolus cryptandrus*	X	X	X	X	X	–
Poaceae	*Tridens muticus*	X	X	X	X	X	X
Polemoniaceae	*Ipomopsis longiflora*	–	–	–	–	X	–

Table G-1. List of all plant species observed during intermediate plot data collection and polygon-scale data collection at Montezuma Castle National Monument, 2010–2014, cont.

Family	Scientific name	Castle unit†			Well unit†		
		AA	CP	Polygon	AA	CP	Polygon
Polygalaceae	*Polygala scoparioides*	X	–	–	X	X	–
Polygalaceae	*Rhinotropis rusbyi*	X	–	–	–	X	–
Polygonaceae	*Eriogonum fasciculatum*	–	X	X	X	X	–
Polygonaceae	*Eriogonum microthecum*	X	–	–	–	–	–
Polygonaceae	*Eriogonum polycladon*	X	–	–	–	–	–
Polygonaceae	*Eriogonum trichopes*	X	–	–	X	–	–
Polygonaceae	*Eriogonum wrightii*	X	X	–	X	X	–
Polygonaceae	*Rumex crispus**	–	**X**	–	–	–	–
Ranunculaceae	*Delphinium scaposum*	–	X	–	–	X	–
Rhamnaceae	*Ceanothus greggii*	–	X	–	–	–	–
Rhamnaceae	*Rhamnus californica*	–	X	–	X	–	–
Rhamnaceae	*Ziziphus obtusifolia*	X	X	X	X	X	X
Rosaceae	*Purshia mexicana var. stansburyana*	–	X	–	–	–	–
Rubiaceae	*Galium microphyllum*	–	–	–	–	X	–
Rutaceae	*Thamnosma texana*	–	X	X	–	X	–
Salicaceae	*Populus fremontii*	X	–	–	X	X	X
Salicaceae	*Salix bonplandiana*	–	–	–	X	–	–
Salicaceae	*Salix exigua*	–	–	–	X	X	X
Salicaceae	*Salix gooddingii*	X	X	X	X	–	–
Salicaceae	*Salix laevigata*	–	–	–	–	X	–
Sapindaceae	*Sapindus saponaria*	–	X	–	X	–	–
Simaroubaceae	*Ailanthus altissima*	X	–	–	–	–	–
Solanaceae	*Datura wrightii*	X	X	–	X	X	–
Solanaceae	*Lycium pallidum*	X	X	–	X	X	X
Solanaceae	*Solanum*	–	–	–	X	–	–
Solanaceae	*Solanum elaeagnifolium*	X	X	–	X	X	–
Typhaceae	*Typha domingensis*	X	–	–	X	X	–
Verbenaceae	*Aloysia wrightii*	X	–	–	X	X	X
Vitaceae	*Vitis arizonica*	–	–	X	X	–	–
Zygophyllaceae	*Larrea tridentata*	X	X	X	X	X	X

†AA = accuracy assessment; CP = classification plot

*Non-native species

Appendix H: 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 H-1. All data re 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: 24 polygon features, 13 at the Castle unit and 11 at the Well unit, each attributed with association scientific name, NVC code, association common name, and park unit. These polygons include expanses of sparsely vegetated bedrock, park facilities, and area of open water. Polygons were dissolved by association at each unit, meaning that each association is a single multi-part polygon. 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: 49 point locations, 23 at the well unit and 26 at the castle unit. These data were collected in the field. This table is related to tPlotEvents, which lists basic information on plot location and shape, date sampled, soil-cover characteristics, and total cover by strata for vegetation.

tPlotEvents is in turn 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 access.

VegPoly_Photopoints: these are locations where photos were taken during the mapping phase. These were recorded in the field on handheld Trimble GPS units and subsequently merged and imported into the GDB. As the final map is dissolved by association at each unit, polygons may contain numerous photo points that were origionally associated to separate polygons.

Feature class attachments:

File attachments were created for three feature classes in the GBD, the veg_polys, plot_locations and VegPoly_PhotoPoints. In ArcMap 10, this attachment function allows for photos or other files to be embedded into the GDB such that they are always accessible through the ArcMap environment. Photos were attached to each plot point (one photo) and each polygon photo point (four, one in each cardinal 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 any photo point and a window opens showing a small icon of the attachment as well as displaying the attributes of the feature.

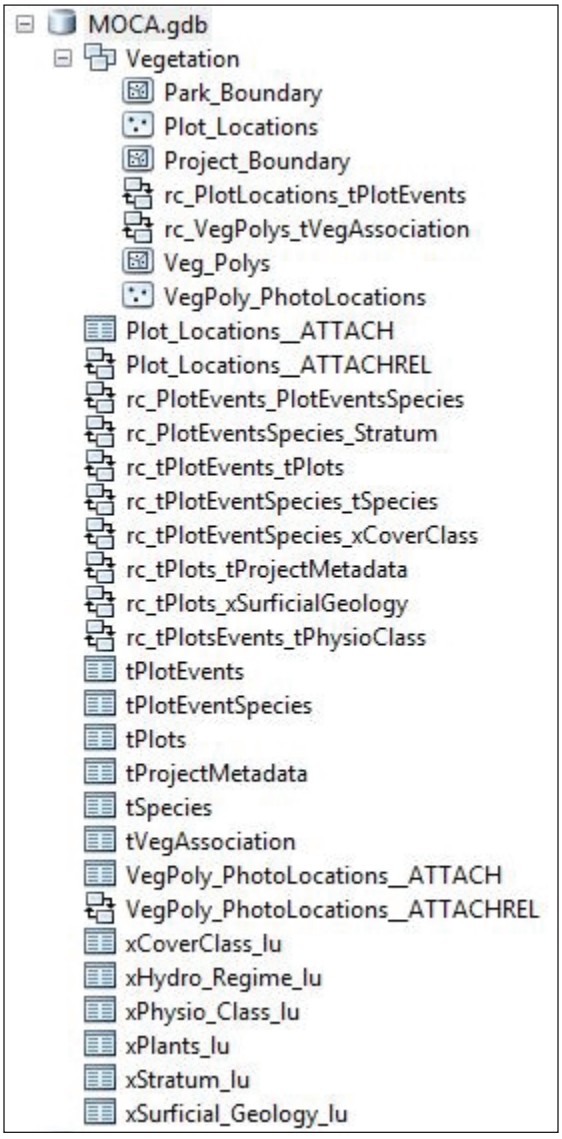


Figure H-1. Geodatabase schema.

Geodatabase:

- MOCA.gdb

Feature Dataset:

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

Feature Classes:

- Park_Boundary - Unit boundary
- Plot_Locations - Plot corners (also used as plot photo points for feature attachments).
- Project_Boundary - extent of mapped area (park boundary with a buffer).
- Veg_Polys - 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
- 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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