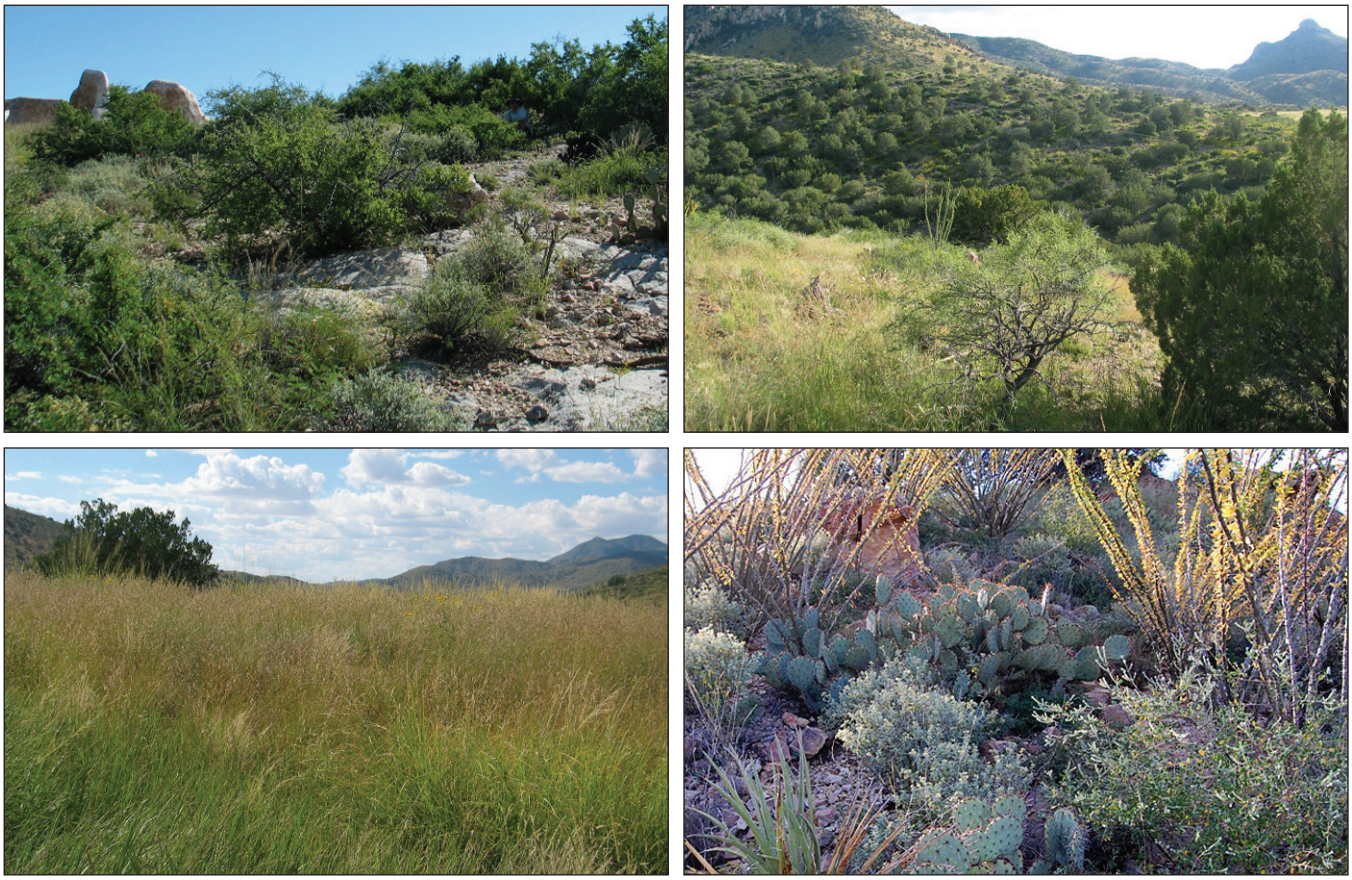
National Park Service
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Natural Resource Stewardship and Science

Vegetation Inventory, Mapping, and Classification Report, Fort Bowie National Historic Site

Natural Resource Report NPS/SODN/NRR—2013/673



ON THE COVER

Clockwise from top left: Littleleaf sumac shrubland; juniper-oak wooded shrublands; ocotillo / mariola shrubland; grama-mixed grass herbaceous area. NPS photos.

Vegetation Inventory, Mapping, and Classification Report, Fort Bowie National Historic Site

Natural Resource Report NPS/SODN/NRR—2013/673

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

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Acronyms and Abbreviations

AA	accuracy assessment
ac	acre
CEGL	Community Element Code–Global
CES	NatureServe ecological system
cm	centimeter
DOQQ	digital orthophoto quarter quadrangle
ERDAS	Earth Resources Data Analysis System
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
FOBO	Fort Bowie National Historic Site
ft	foot/feet
GCP	ground control point
GDB	geodatabase
GIS	geographic information system
GPS	global positioning system
ha	hectare
I&M	Inventory and Monitoring Program
ITIS	Integrated Taxonomic Information System
km	kilometers
m	meters
mi	miles
MMU	minimum mapping unit
NA	not applicable
NAD83	North American Datum of 1983
NCSSA	National Cartographic Standards for Spatial Accuracy
NHS	national historic site
NM	national monument
NMAS	National Map Accuracy Standards
NP	national park
NPS	National Park Service
NS	NatureServe
NVCS	National Vegetation Classification Standard (or System)
NVC	National Vegetation Classification
RMSE	root mean square error
RRQRR	Reversed Randomized Quadrant-Recursive Raster
SODN	Sonoran Desert Network (National Park Service)
sp.	species (singular)
spp.	species (plural)
TNC	The Nature Conservancy
UNESCO	United Nations Education, Science, and Cultural Organization
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator

Executive Summary

In collaboration with researchers from the University of Arizona's Office of Arid Lands Studies, Remote Sensing Center, the Sonoran Desert Network conducted a vegetation mapping and characterization effort at Fort Bowie National Historic Site (NHS) from 2008 to 2010. This project was completed under the National Park Service's Vegetation Mapping Inventory, which aims to complete baseline mapping inventories at more than 270 national park units. The vegetation map data were collected to provide park managers with a digital map product that met national standards of spatial and thematic accuracy, while also placing the vegetation into a regional and even 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.

The Fort Bowie NHS project comprised three major field phases: (1) concurrent, field-based data collection and mapping from satellite imagery (map unit delineation), (2) development of vegetation community types at the National Vegetation Classification (NVC) alliance or 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 then-current hierarchy (version 1) of the National Vegetation Classification System (NVCS) and were applied to each of the mapped areas. This classification was developed concurrently from both plot data and field-censused polygon data (map units). Accuracy assessment was completed in the fall of 2010 and consisted of a complete census of each map unit (each polygon). The assessment was conducted almost entirely by Fort Bowie NHS staff. Following accuracy assessment, the map was amended where needed and final products were developed, including this report, a digital map, and full vegetation descriptions.

Fort Bowie NHS covers only 1,000 acres yet has a relatively complex landscape, topography, and geology. A total of 16 distinct communities were described and mapped at the park. These ranged from lush riparian woodlands lining the ephemeral washes dominated by ash (*Fraxinus*), walnut (*Juglans*), and hackberry (*Celtis*) to drier upland sites typical of desert scrub and semi-desert grassland communities. These shrublands boast a diverse mixture of shrubs, succulents, and perennial grasses. In many places, the vegetation could be seen to echo the history of the fort site, with management of shrub encroachment apparent in the grasslands and the paucity of trees evidence of historic cutting for timber and firewood. Seven of the 16 vegetation types were "accepted" types within the NVC, while the others have been described here as specific to Fort Bowie NHS and are currently proposed for formal status within the NVC.

The vegetation map, designed to facilitate ecologically based natural resources management and research, 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 vegetation.

Acknowledgements

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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 two-year project (2008–2010) to classify, describe, and map vegetation at Fort Bowie National Historic Site, located in Cochise County, southeast Arizona (Figure 1-1).

The National Park Service's (NPS) Sonoran Desert Network (SODN), part of the servicewide Inventory and Monitoring (I&M) Program, organized and coordinated vegetation classification, description, and mapping at Fort Bowie National Historic Site (NHS). For Fort Bowie NHS, as well as other network parks, SODN needed baseline vegetation data upon which to develop and implement specific monitoring programs, and park managers needed baseline data and information on park vegetation resources for management purposes.

The current effort to create a new vegetation map for Fort Bowie NHS is part of the NPS Vegetation Inventory (http://science.nature.nps.gov/im/inventory/veg/index.cfm), in cooperation with the SODN and the University of Arizona's Office of Arid Lands Studies. The map is required to meet the standards of the NPS Vegetation Inventory, including a minimum mapping unit of 0.5 hectares (1.24 ac), 80% thematic accuracy per class, and spatial accuracy meeting the U.S. National Map Accuracy Standards developed by the Federal Geographic Data Committee (FGDC). However, in addition to meeting the program standards, every effort was made to provide the

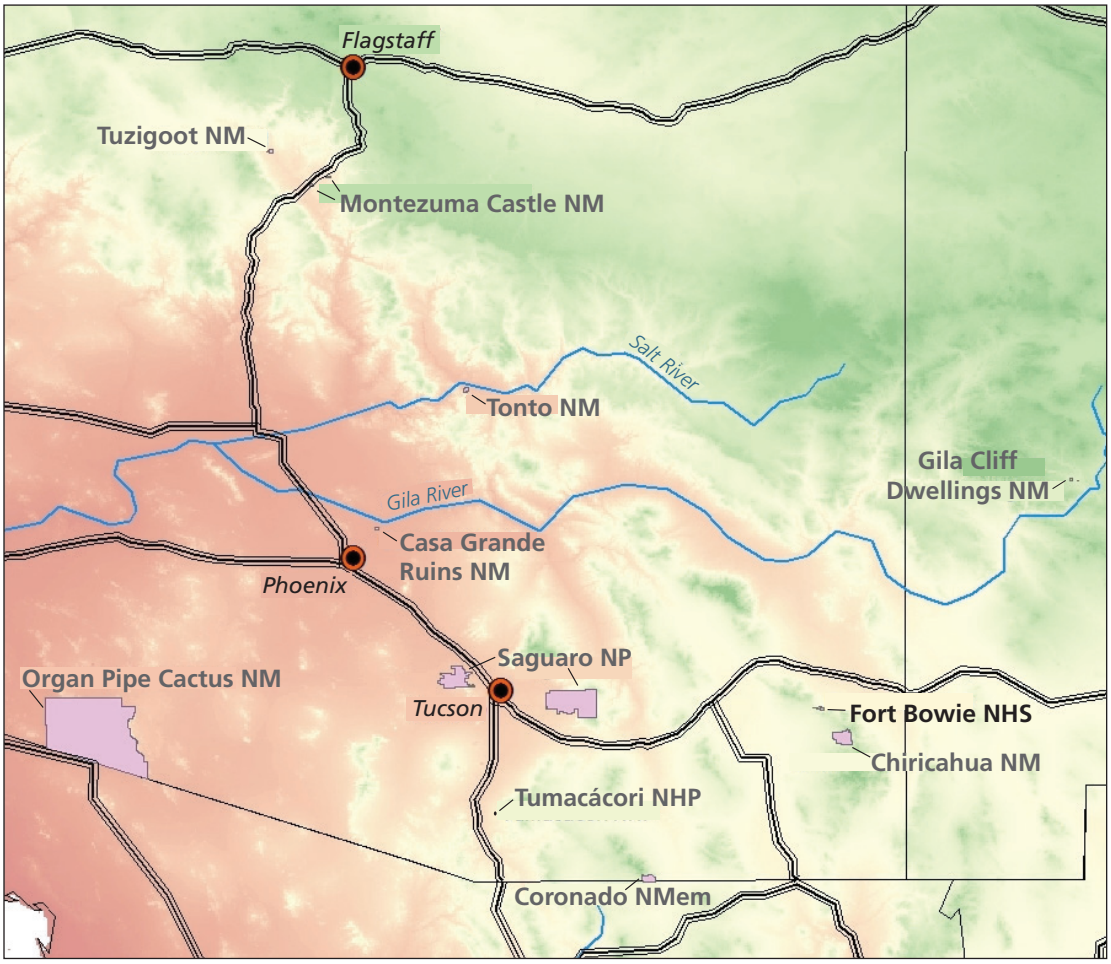


Figure 1-1. Location of Fort Bowie National Historic Site relative to the other Sonoran Desert Network parks.

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) alliance level or finer for a study area of about 557 hectares (1,376 ac), which included the 406 hectares (1,003 ac) within the park boundary plus a 100-meter buffer surrounding the unit, comprising 151 ha (373 ac); Figure 1-2. Land within the park boundary accounted for 72.9% of the project area.

Products developed for Fort Bowie National Historic Site as part of this project include:

A final report, including a dichotomous vegetation key (Appendix A) and full vegetation community type descriptions (Appendix B);

- Digital reference photos of each vegetation type (four per polygon mapped);
- A geodatabase containing mapped vegetation data, plot data and locations, 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; and
- A park-specific plant field guide with annotated checklist and voucher specimen list (not a program requirement).

1.3 The NPS Vegetation Inventory

The NPS Vegetation 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 a collaborative effort between the U.S. Geological Survey (USGS) Center for Biological Informatics and the NPS. More recently, the NPS has assumed the role as the primary funding agency, providing parks support through Inventory & Monitoring Program base funds. However, the program still serves the data products through a joint website with the USGS Vegetation Characterization Program. The guidelines developed within the former USGS/NPS program are also available there (http://www.usgs.gov/core_science_systems/csas/vip/index.htm).

The vegetation inventory program supports consistent vegetation classification, mapping, and accuracy-assessment protocols and standards across all park mapping projects. The

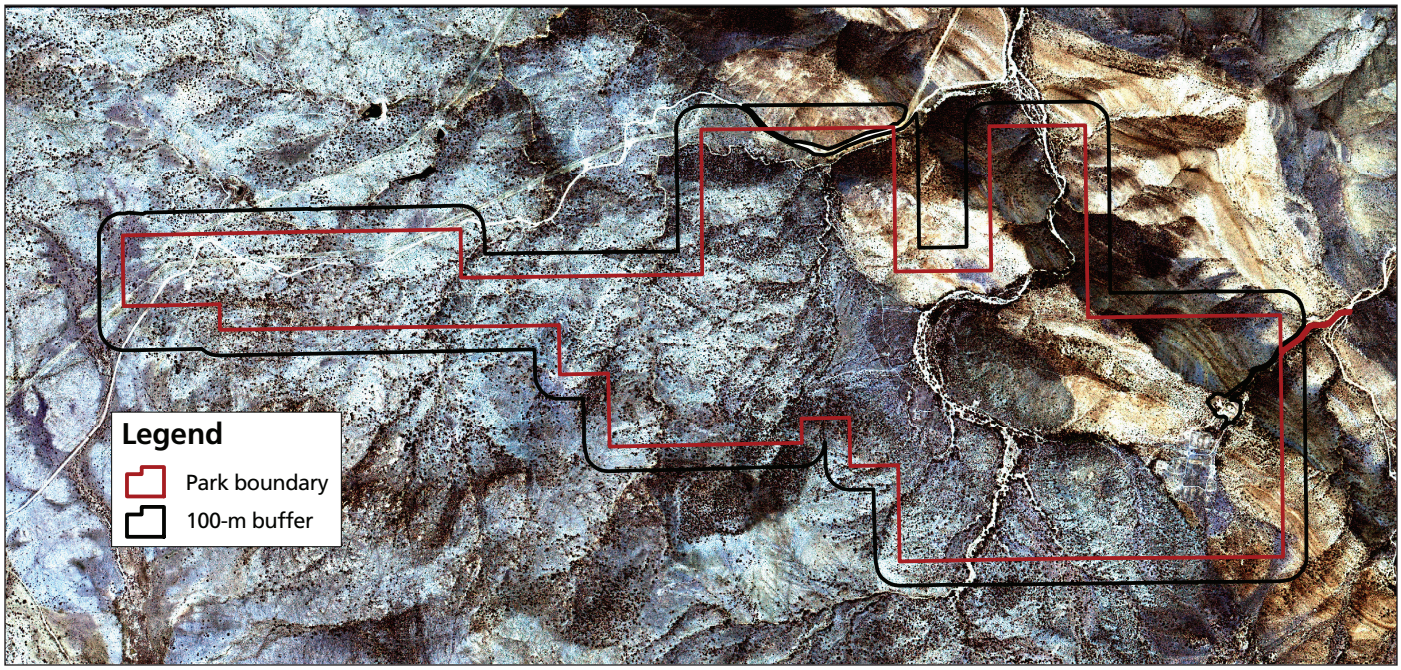


Figure 1-2. Project area showing Fort Bowie National Historic Site boundary plus 100-meter buffer. Background imagery (Digital Globe Quickbird satellite imagery) displays contrasting surface geology visible through generally sparse vegetation. The prominent drainage of Siphon Canyon winds through the eastern part of the area.

program has established guidance for all vegetation mapping projects in four documents:

- Standardized National Vegetation System (TNC and ESRI 1994a)
- Methodology for Assessing the Utility of Existing Data for Vegetation Mapping (TNC and ESRI 1996)
- Field Methods for Vegetation Mapping (TNC and ESRI 1994b)
- Accuracy Assessment Procedures (ESRI et al. 1994)

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 the FGDC standards for spatial data transfer.
- Metadata for each spatial dataset uses the FGDC metadata standard.
- Spatial data is provided with a horizontal positional accuracy that meets National Map Accuracy Standards at the 1:24,000 scale; each well-defined object within the spatial database is within 1/50 of an inch display scale or 12.2 m (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 meet or exceed 80% accuracy at the 90% confidence level.
- The minimum mapping unit (MMU) is 0.5 ha (1.24 ac).

1.4 The National Vegetation Classification Standard

Patterns of vegetation vary continuously over landscapes. Classification systems attempt to categorize those patterns by identifying and describing assemblages of plants that repeat under similar environmental conditions. The National Vegetation Classification Standard 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). At the time of its adoption, it was recognized as incomplete, 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 2007), 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. The middle three levels are new to the NVCS hierarchy and focus on largely biogeographical and habitat factors along broad, continental-to-regional topographic, edaphic, and disturbance gradients. The lower two levels are floristic, based primarily on species composition and abundance.

Table 1-1 identifies the seven original levels of version 1 of the NVCS used in this report and depicts their placement in the hierarchical relationship. Table 1-2 shows the revised version 2, which is currently being utilized by NatureServe and the Ecological Society of America vegetation panel to substantially update the structure and content of the NVCS.

Table 1-1. Summary of the National Vegetation Classification Standard hierarchical approach, Version 1.

Level	Primary basis for classification	Example
Class	Structure of vegetation	Shrubland
Subclass	Leaf phenology	Evergreen shrubland
Group	Leaf types, corresponding to climate	Extremely xeromorphic evergreen shrubland
Subgroup	Relative human impact (natural/semi-natural, or cultural)	Natural/semi-natural extremely xeromorphic evergreen shrubland
Formation	Additional physiognomic and environmental factors, including hydrology	Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland
Alliance	Dominant/diagnostic species of the uppermost or dominant stratum	*Larrea tridentata* Shrubland Alliance
Association	Additional dominant/diagnostic species from any strata	*Larrea tridentata* Monotype Shrubland

While this project was conducted under the former version, attempts have been made to include the new system placement and identifying codes of each vegetation type to the extent it is possible at the time of writing.

The NVC also distinguishes between natural and cultural vegetation, the former being determined primarily by ecological processes and the latter by regular human activity. Vegetated areas between the two, such as those influenced by both human activity (e.g., logging, fire, 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 (including this 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 (http://www.natureserve.org/explorer/), provides public access to regularly updated versions of the NVC plant community listings and descriptions. NatureServe's documentation of alliances and associations was the most accessible listing currently available. However, the plant community listings within the NVC are not yet complete and are currently being revised to fall within version 2 of the FGDC hierarchy. A new website, www.usnvc.org, posts all new descriptions as well as information on the changes to the hierarchy, and displays these vegetation type descriptions in the new hierarchy (see Table 1-2). Each vegetation association listed on this site links to a full and updated description on the NatureServe Explorer site. Where available, 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. But where information is lacking or incomplete, classification of vegetation sampled at Fort Bowie NHS is based solely on data collected during this effort, and naming conventions were developed as fitting.

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

Table 1-2. Example of the National Vegetation Classification Standard hierarchical approach, Version 2.

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

For more information on the NVC, see the NPS Vegetation Inventory (http://science.nature.nps.gov/im/inventory/veg/index.cfm) or Grossman and others (1998).

1.6 Terminology and naming conventions

Alliances and associations are based on both the dominant (i.e., greatest canopy cover) species in the upper strata 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.

Alliance names are generally based on the dominant/diagnostic species in the uppermost stratum of vegetation, though up to four species may be used, if necessary, to define the type. Associations define distinct plant compositions that repeat across the landscape, and are generally named using both the dominant species in the uppermost stratum of vegetation and one or more dominant species in lower strata (or a diagnostic species in any stratum).

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

- A hyphen with a space on either side (-) separates names of species occurring in the same stratum.
- A slash with a space on either side (/) separates names of species occurring in different strata.
- Species that occur in the uppermost stratum are listed first, followed successively by those in lower strata.
- Order of species names generally reflects decreasing levels of dominance, constancy, or indicator value.
- 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.
- 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 has been collected to support their addition.

The species nomenclature for all alliances and associations follows Kartesz (1999). Examples of association names from Fort Bowie NHS:

Fouquieria splendens / *Parthenium incanum* Shrubland

Fouquieria splendens / *Opuntia engelmannii* Shrubland

Examples of alliance names from Fort Bowie NHS:

Quercus emoryi / *Bouteloua* spp. Wooded Herbaceous Alliance

Fraxinus velutina Forest and Woodland Alliance

1.7 Project area description

1.7.1 Location and setting

Fort Bowie NHS is in Cochise County, approximately 14 miles (22.5 km) south of the town of Bowie, Arizona, and approximately 116 miles (187 km) east of Tucson (see Figure 1-1). Situated in Apache Pass, the site lies at the divide of the Chiricahua and Dos Cabezas mountain ranges. These rugged mountains are typical of the basin and range topography of the intermountain west (Scarborough 2000), with the north–south-aligned ranges separating the San Simon and Sulphur Springs valleys.

The park also lies at the crossroads of four different "life zones" that occur in this region. Here, the hot, dry Sonoran Desert meets the milder Chihuahuan Desert, and the southern Rocky Mountains abut the northern Sierra Madre Occidental. This mixing of ecotypes results in an exceptionally diverse ecosystem, which is reflected in the variety of plant and animal life that is found here (Powell et al. 2006).

Fort Bowie NHS lies at the upper elevational limit for the deserts, and in a transition zone from grassland to woodland habitat types. Desert species, such as creosotebush and mesquite, are intermixed with the grama grasslands, and a variety of cacti and succulent species dot the rocky slopes. Hillsides

consist of a mixture of chaparral and woodland species, such as mountain mahogany, manzanita, oaks, pines, and junipers. The canyon bottoms are lush riparian woodlands of velvet ash and netleaf hackberry, fed by the perennial flow from Apache and Siphon springs.

Much of the park shows the impacts of human disturbance. The long history of human use by the Apaches, soldiers, and, later, ranchers, has contributed to the complexes of vegetation found at the site today. In many areas, weedy species proliferate through what were likely pristine mid-elevation grasslands, and historic land uses, such as woodcutting, have lessened the extent of large mature woody upland species.

Development of the fort, itself, changed the area, and grazing, water diversion, mining, and fire suppression have added to habitat degradation. Grazing and water diversion have altered the riparian area and hydrology around Apache Spring. Non-native grasses have invaded much of the area, and suppression of fire, along with grazing, has increased the intrusion of woody species, such as mesquite, into the uplands. Roads in the area have altered natural runoff patterns and provided a pathway for the invasion of some exotic plant species.

Despite these disturbances to natural habitat, the area is one of astounding diversity; some 30 species of reptiles, 65 mammal species, and more than 150 species of birds are found in this area (Powell et al. 2006).

1.7.2 Park establishment and purpose

Authorized in 1964 and established in 1972, the mission of Fort Bowie NHS is to protect and interpret the remains of a key territorial military fort, the Butterfield trans-regional stage route, and commemorate the "tragic clash of cultures that characterized America's western expansion" (NPS 1975) —in this case, expansion into the heartland of the Chiricahua Apache. The 404-hectare (998 ac) unit preserves the stabilized (but unrestored) remains of two successive forts, Butterfield Stage and U.S. Indian Agent stations, early mining works, and a military cemetery containing the remains of combatants from both sides of the (at times) violent conflict (Figure 1-3). For more than 30 years, Fort Bowie and Apache Pass were the focal point of military actions that culminated in the surrender of Geronimo in 1886 and the relocation of the Chiricahua Apaches to Florida and Alabama.

1.7.3 Climate, geology, and hydrology

The area experiences a bimodal pattern of precipitation typical of the Sonoran Desert/Apache Highlands ecoregions, with heavy monsoon storms in summer and lighter, slower rains during the winter months. On average, one-half of the annual precipitation falls between July and September (Powell et al. 2006), accompanied by high temperatures often exceeding 40°C.

The park's geology is characterized by a diversity of geological substrates, including limestone, granite, and metamorphic rock (Warren et al. 1992). The Apache Pass Fault, an area of Precambrian Cretaceous limestone atop Precambrian granite, bisects the park from the southeast to northwest. This fault is the major geologic feature in the area and can be traced across the mountains for nearly 38 miles (61 km) (Bezy 2001).

Lying between 4,575 and 5,200 feet (1,400–1,600 m) in elevation, Fort Bowie NHS contains three steep-gradient ephemeral riparian systems (Siphon Canyon, Cutoff Canyon, Willow Gulch) in a matrix of rolling hills and an alluvial terrace, the Triangular Valley (see Figure 1-3). The park has one major (and other minor) perennial water source, Apache Spring, which is thought to have been important in attracting humans to inhabit this area. The fault described above provides the fissure from which Apache Spring rises. Siphon Canyon and Willow Gulch have ephemeral flow during periods of high precipitation.

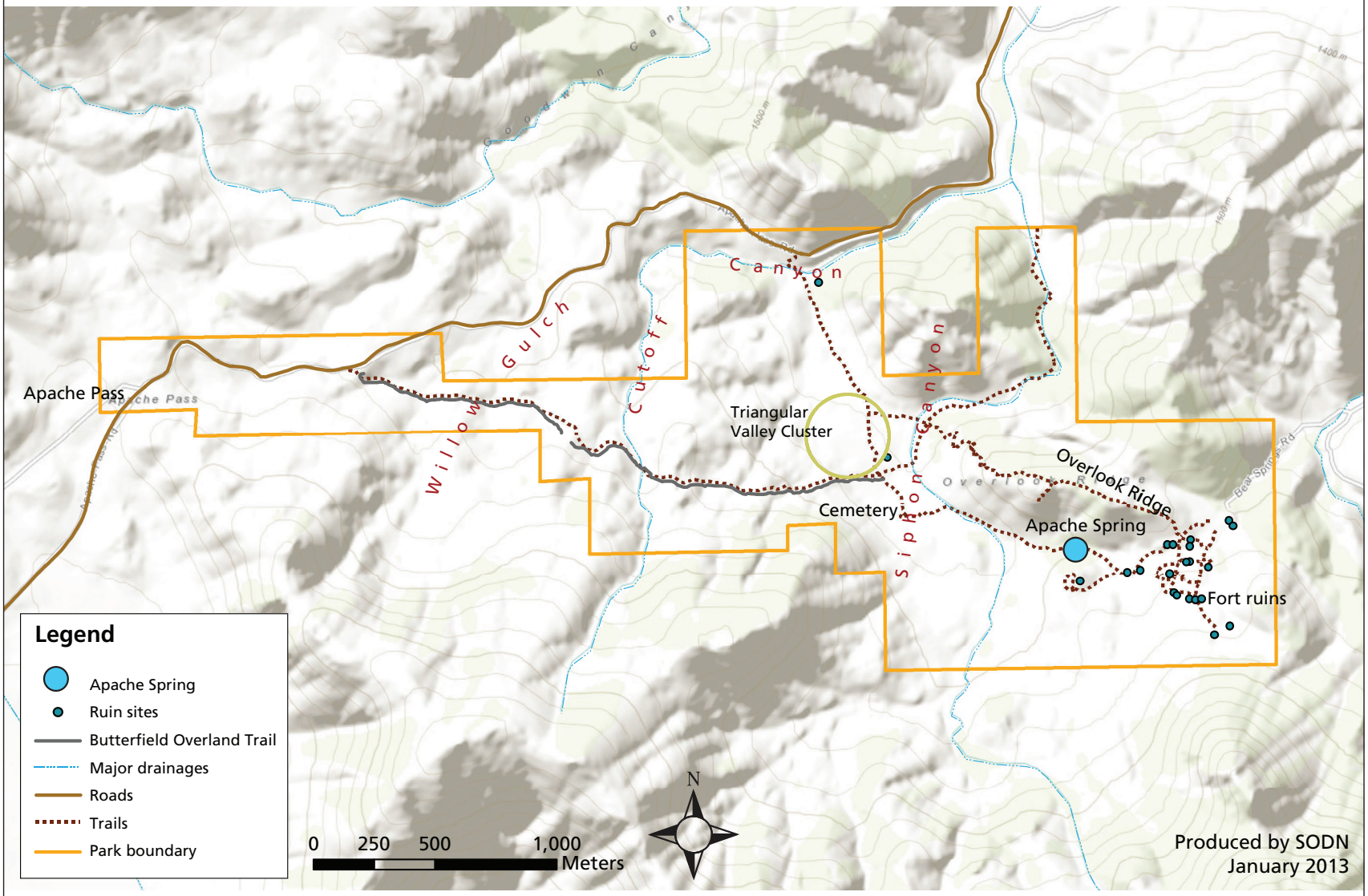
1.7.4 Vegetation

Fort Bowie NHS has high floristic diversity for its size, with almost 600 plant species, subspecies, and varieties documented (http://swbiodiversity.org/seinet/checklists/checklist.php?cl=2528). In large part, this diversity is explained by the park's geographical situation and geology (see Sections 1.7.1 and 1.7.3). To the east of the Apache Pass fault line, where limestone dominates, vegetation has primarily Chihuahuan Desert

Fort Bowie National Historic Site
Arizona

National Park Service
U.S. Department of the Interior

Topography and Landmarks



Sources: ESRI, DeLorme, NAVTEO, TomTOm, Intermap, iPC, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, ESRI Japan, METI, ESRI China (Hong Kong), GIS User Community

Figure 1-3. Topography and landmarks, Fort Bowie National Historic Site.

affinities, while to the west, on granitic soils, one finds vegetation more characteristic of the Apacherean floristic region as described by McLaughlin (1986).

The park's vegetation is largely composed of savanna and desert grassland (66%) and shrubland types (23%), with dense woodland and forest strips (11%) being confined to the narrow ephemeral drainages. Wooded shrublands (shrublands with ~10% tree cover) and chaparral types are common on northerly facing, rocky slopes. Many communities consist of a diverse mix of chaparral and woodland species, such as juniper, mountain mahogany, scrub oak, pine, and succulents. Low elevations in the park and surrounding areas support more typical desert species, such as creosotebush (*Larrea tridentata*). Historic grazing and fire suppression have impacted the vegetation of the site, with non-native grass invasion and mesquite expansion into the grama (*Bouteloua* spp.) -dominated grasslands.

1.7.5 Previous vegetation studies

In 1992, the NPS Cooperative National Park Resources Studies Unit at the University of Arizona published *Vegetation and Flora of Fort Bowie National Historic Site, Arizona* (Warren et al. 1992). The report accomplished two main goals: (1) it developed a checklist of vascular plant species based primarily on five years of field sampling by Marina and Wilton "Bill" Hoy, and some additional collections made during mapping field work, and (2) it produced a vegetation map of plant associations. Thirty-six relevés were sampled using a modified Braun-Blanquet method, from which 11 associations were described and mapped. Warren identified, described, and numbered the associations following Brown's *Biotic Communities of the American Southwest: United States and Mexico* (Brown 1982). While Warren's map and vegetation descriptions were helpful in determining many of the associations to be expected at Fort Bowie NHS, the associations did not cross-walk, one-to-one, to the NVC, and were used for reference only in this report.

During 2008, SODN established 13 long-term vegetation and soils monitoring plots at Fort Bowie NHS. The data from these plots were referenced in addition to other vegetation mapping data in developing the vegetation classification for this report (see Figure 2-3). These plots were marked and will be re-sampled every five years in order to monitor change in species cover and composition over time. A report (Hubbard et al. 2010) is available detailing the status of the vegetation based on these data.

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 September 27, 2007, at the U.S. Forest Service station in Sierra Vista, Arizona. As Fort Bowie NHS is administered jointly with two other Southeast Arizona parks, Chiricahua National Monument and Coronado National Memorial, the meeting addressed the work plan for all three units. Representatives from the U.S. Geological Survey and from land management agencies neighboring the three units were present, including the U.S. Army, U.S. Forest Service, and Arizona State Parks. The goals of this meeting were to discuss the logistics of the effort, identify any site-specific needs or modifications to the standard mapping process, and 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 future cross-walking, should similar projects be undertaken.

The successful completion of this project was the result of the combined efforts of the NPS Sonoran Desert Network and University of Arizona Office of Arid Lands Studies (OALS). Fort Bowie NHS personnel provided invaluable logistical support for all field-based components of the project. The OALS was responsible for the core technical preparation, including the purchase and orthorectification of the satellite imagery and drafting of the initial polygons. OALS staff conducted several site visits to develop image signatures and assisted in field mapping and final reporting. SODN staff conducted data collection for classification, performed ground mapping of vegetation, drafted vegetation alliance descriptions, and prepared the 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 technical guidance and support documents found at http://science.nature.nps.gov/im/inventory/veg/guidance.cfm. However, our approach departed somewhat from traditional practices. Rather than have ecologists collect plot data to develop a classification, then have photo interpreters delineate polygons solely using imagery, 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 Fort Bowie is relatively small, this method worked well and was achieved by way of a census.

Provisional, or draft, polygons were created from the interpretation of high-spatial-resolution satellite imagery and field reconnaissance, and were characterized at a level approximating the formation level in the new classification hierarchy (see Table 1-2). These polygons served as the starting point for field sampling and were then modified (split, merged, or otherwise edited) into alliance- or association-level floristic-based polygons.

2.1.3 Digital imagery acquisition and processing

The imagery used for this project was acquired by DigitalGlobe Inc.'s Quickbird satellite in April 2005, as a new, tasked acquisition for a different project. Image preprocessing and initial interpretation to the vegetation formation level were done at the Arizona Remote Sensing Center, University of Arizona. The imagery product purchased was the "Ortho-ready Standard" bundle of four spectral bands (blue, green, red, and near-infrared—i.e., the multi-spectral image) at 2.4-m spatial resolution, plus the broadband panchromatic data at 0.6-m resolution. This imagery is intended to be orthorectified by the user and is only coarsely georegistered, with a nominal spatial accuracy of 23 m (75 ft) CE90 (circular error of 90%), meaning that 90% of features in the imagery must be within 23 meters of their true location on the ground. More information about the general specifications of this imagery can be found at http://www.digitalglobe.com/ or,

more specifically, at http://www.digitalglobe.com/product/standard_imagery.shtml.

The geographic area of coverage purchased was large, including Chiricahua National Monument, Fort Bowie NHS, and the mountainous area between the two. The imagery was acquired in two swaths (Pan swath 1 and Multi swath 1, and Pan swath 2 and Multi swath 2 in Table 2-1) on April 15 and 20, 2005. The larger of the two swaths of imagery was initially too big to work with in ERDAS Imagine v.8.7 (>2GB), so the image was subset in ENVI software prior to georectification and analysis.

The two imagery swaths were orthorectified with ERDAS (Leica) OrthoBase software, using a USGS National Elevation Dataset DEM, field-collected GPS coordinates of ground control points (GCPs), and the Quickbird Rational Polynomial Coefficient model. During the rectification process, the coordinates of GCP locations were entered into a table and compared to image coordinates for the same control point locations. An optimal set of GCPs was selected for each image and the images were rectified using a polynomial model with cubic convolution resampling. The number of GCPs used, and RMS (root mean square) errors (in pixels) are shown in Table 2-1.

Following orthorectification, the multispectral imagery was pan-sharpened for visual interpretation, using the resolution merge tool in ERDAS Imagine. Principal components and cubic convolution were selected as merge parameters. Pan-sharpening is the process of merging the high-resolution, 0.6-m panchromatic image with the 2.4-m multispectral image to produce a multispectral image with 0.6-m resolution. The draft formation-level map was produced through visual interpretation of the pan-sharpened imagery and heads-up digitizing in ArcGIS to delineate polygons.

Table 2-1. Imagery orthorectification root mean square (RMS) errors (pixels).

Image name	Panchromatic swath		Multispectral swath	
	1	2	1	2
GCPs used for rectification	6	5	9	3
RMS Error X	3.4848	3.2309	0.6149	0.4475
RMS Error Y	2.6593	3.4802	0.7076	0.4356
Total RMS Error	**4.3835**	**4.7488**	**0.9374**	**0.6245**

Eight formations were identified, based on the percentages of tree, shrub, and herbaceous cover present, following the formation key we had previously developed (Appendix C): forest, woodland, intermittently flooded woodland, wooded shrubland, shrubland, wooded herbaceous, shrub herbaceous, and herbaceous. Each polygon in the draft formation map (Figure 2-1) was assigned a unique alphanumeric identifier for reference throughout the project. When formation polygons were split (see Section 2.1.4), new daughter polygons were given appropriate IDs, but still traceable to the parent.

We prepared an index of 11×17-inch hardcopy prints of the tentative formation polygons overlaid on the background imagery, at 1:4,000 scale with a 100-m UTM grid, for use in the field-based vegetation alliance mapping. These prints correlated to a grid of numbered "submaps" that facilitated tracking and field planning, shown by the thin black lines in Figure 2-1. The field team also had the digital formation map and the imagery available on handheld GPS-linked computers, with the useful ability to zoom for viewing at multiple scales.

2.1.4 Field data collection: Polygons

All data were collected by an NPS crew of four people, working either in pairs or altogether. This crew had been working on vegetation mapping at other SODN parks (Chiricahua and Tonto national monuments) for several months and was proficient in all mapping and classification methodologies. Field-based mapping and data collection for classification were conducted during one week in January and eight weeks in September and October 2008. The latter dates were most appropriate for capturing vegetation in the prime post-monsoon growing season.

Working in teams of two or more to facilitate a multiple-observer, consensus-based approach, the field crew visited each of the formation polygons on the draft map of the study area. Assisted by hardcopy prints and spatial data loaded on GPS-linked handheld computers (RECONS), the field crew

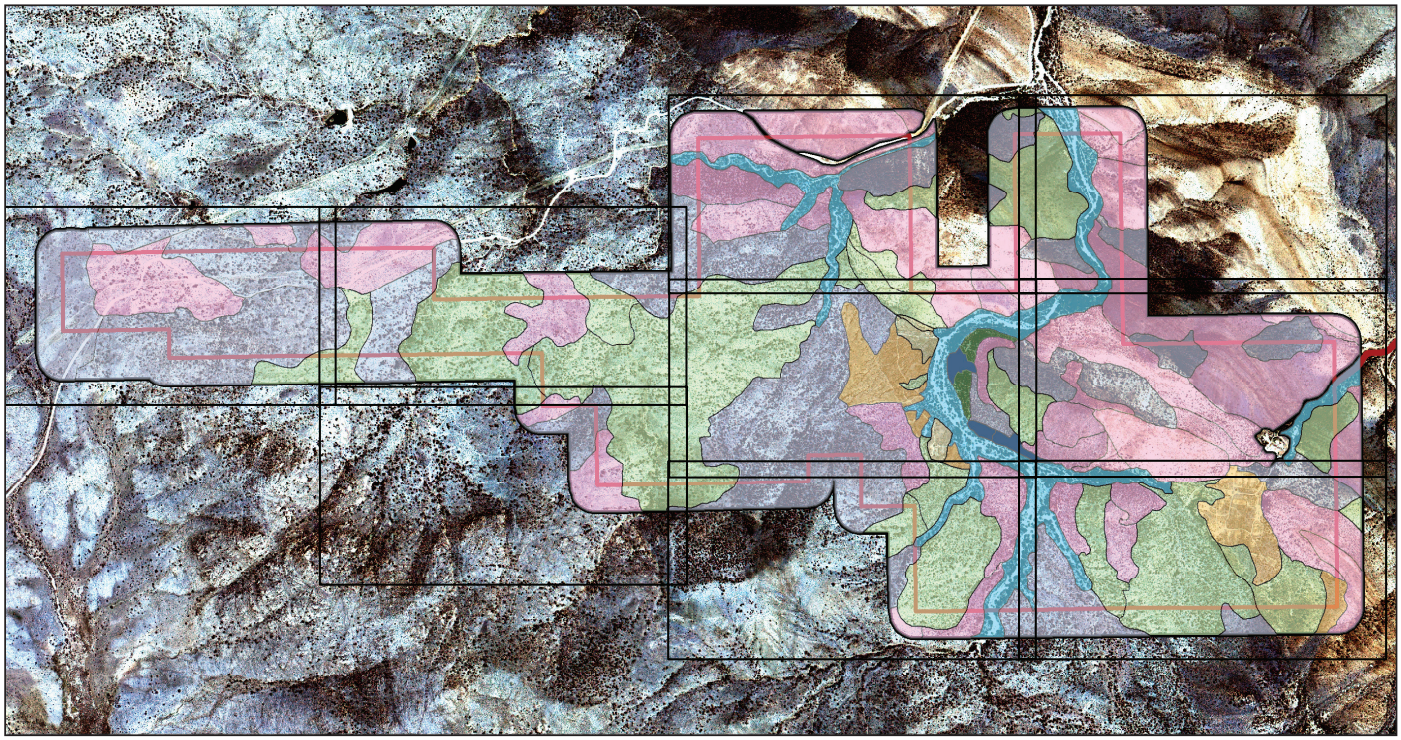


Figure 2-1. Initial draft polygons representing visible structural differences in vegetation, as interpreted from the Quickbird imagery.

walked the boundary (where necessary) and interior of each polygon to make a careful visual assessment. They determined whether the image interpreters had labeled the polygon structural type correctly (shrubland vs. woodland, for example) and whether its boundary needed any modifications. Each polygon was assessed to determine if it was sufficiently homogeneous in terms of species composition to be considered a single community type, or if it needed to be split into more than one alliance (or association) or, conversely, merged with a neighboring, similar polygon. Boundary modifications and splits were sketched on the hardcopy prints and explained in words on field datasheets (Appendix D).

From this point forward, work focused on the alliance-level polygons created. The crews collected semi-quantitative data on canopy cover of all vascular plant species in each of four height strata: 0–0.5 m, 0.5–2 m, 2–5 m, and >5 m. Plant average height,

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

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

dominance rank (of the top three most abundant species), lifeform, associated species present, disturbance types (using the NVC constrained vocabulary), and a range of soil and landscape characteristics were also recorded for each polygon (Table 2-2). A sequence of four representative photographs were taken in the four cardinal directions from near the center of the polygon, which was marked with a GPS point for future repeat photography. The narrative section of the datasheet was used to write a description of the tentative alliance type of the polygon, noting the ways by which this alliance/area differed from the adjacent areas, and any topographic features contributing to the divisions of floristic similarities. When a species could not be identified in the field, plant material was collected and pressed for later identification. The PLANTS database (http://plants.usda.gov) was the taxonomic authority used in this project.

Polygon boundary edits were transferred from the paper maps used in the field to the digital shapefiles each week using ArcMap GIS software. Field edits were also transferred to a set of master paper maps that did not go into the field; these will be archived along with the datasheets. The polygons were contained in a field geodatabase structure (.mdb), enabling topography rules and relationships to be established. The geodatabase was archived each week to ensure no loss of data and to allow for reversion or retrieval if needed. Strict nomenclature was enforced for polygons, and a unique name was assigned to each polygon. The names reflected the verified physiognomic formation type by a prefix of representative letters (W = Woodland, SS = shrub savanna, etc.) followed by a number.

2.1.5 Field data collection: Classification plots

The 2009 "Standards for associations and alliances of the U.S. National Vegetation Classification" (Jennings et al. 2009) stated the need for vegetation units to be sampled and described through the use of plot data. The authors recommend that plots be distributed in homogenous areas so as to minimize sampling in areas with high physiognomic, floristic, and environmental variation, which would make interpretation of the plot data difficult. Determination of plot locations can be achieved via subjective or objective means; however, the former method necessitates prior knowledge of the various types to be sampled and the latter can provide a less-biased set of plots. One further consideration was that objectively placed plots may miss rare or unusual types. We decided, therefore, to sample primarily by objectively locating plots but to subjectively add a smaller number of plots to account for any under- or unsampled areas.

An initial set of fourteen 20×50-m plots were sampled in an attempt to collect data for each preliminary alliance type (not necessarily each polygon) identified from the field-based polygon data (Figure 2-2). Plot locations were preselected with the spatially balanced RRQRR (Reversed Randomized Quadrant-Recursive Raster) algorithm, to provide an objective, parkwide sampling basis for vegetation classification (Theobald et al. 2007). The generated point was used as any corner for the plot; however, the protocol allowed the crew to evaluate the area for representativeness of the surrounding vegetation and homogeneity, and to move the point if necessary.

The protocol also allowed for the plot to be laid out in a way that best captured the community being sampled, both in terms of direction and plot shape. For example, in riparian areas, where vegetation influenced by hydrology is often restricted to narrow bands, the plots measured 10×100 m. In some community types and topographically complex areas, square plots measuring 31.6 m (103.7 ft) per side were used, considerably improving the field mapper's ability to view the entire area more or less simultaneously when estimating species cover and dominance.

The same vegetation cover and dominance information was recorded in the plots as in the polygons, differing only in scale of observation (see Table 2-2). The plots provided a uniform, fixed scale of observation to supplement and corroborate the extensive area covered with the polygon observations. Making accurate visual estimates of the canopy cover of several species in large polygons can be difficult, and a set of plot data can address this difficulty to the extent that the plots are

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Location of vegetation sampling plots

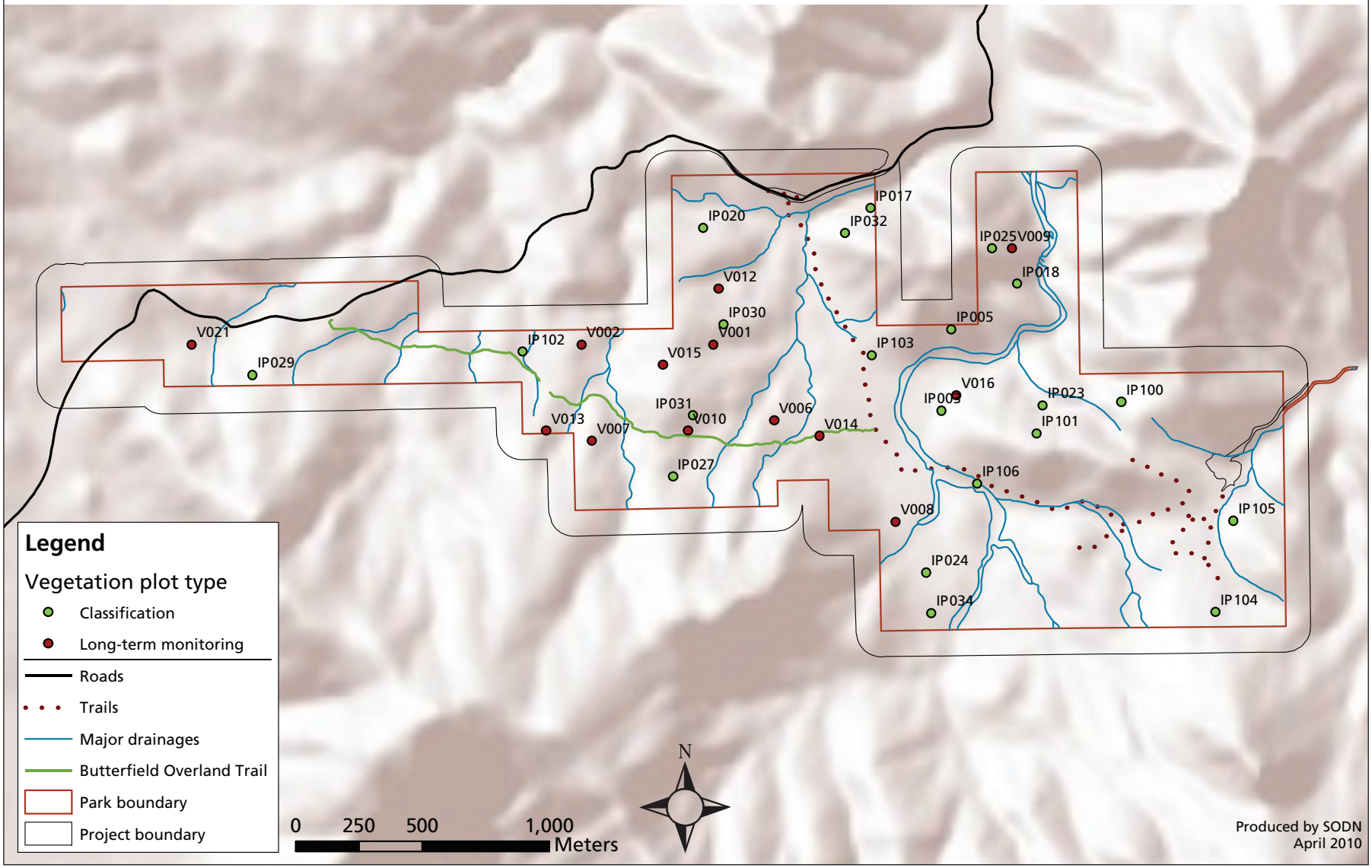


Figure 2-2. Location of vegetation sampling plots.

representative of the polygon or alliance type as a whole. Using this multi-scale approach, we found that evaluating both polygons and plots provided the most robust and useful dataset for characterizing alliances.

After establishing the plot, the bearings of the 20-m and 50-m tapes from the origin corner were recorded on the datasheet, the polygon in which the plot fell was noted, and a representative photograph was taken from the origin. These plots were not permanently marked, other than by a GPS point. Plot and polygon data were reviewed by way of a manual ordination (grouping), and it was determined that an additional seven subjectively placed plots were needed in order to characterize vegetation that was deemed undersampled. In total, 21 new classification plots were sampled. Blank example datasheets are shown in Appendix D.

2.1.6 Plot and polygon data management

All plot and polygon data were entered into a Microsoft Access (2007) database created by the SODN data manager. The digital data were subsequently quality-checked for accuracy against the original datasheets, and any transcription errors were rectified prior to analysis. Data were also validated by an alternate mapping-team member for logical errors or unusual species entries. These processes follow 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. In 2010, the original sheets were moved into permanent storage at the Western Archeological Conservation Center, in Tucson, Arizona. Datasheet copies will remain at the SODN office.

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

2.2 Vegetation classification analysis

The classification analysis was completed by way of manual, subjective placement of each polygon and plot into groupings representative of NVC associations or alliances (when known, or into proposed types when not known). Polygon- and plot-level data were evaluated by the two project ecologists and the mapping team lead biologist to assess the compositional similarities or differences between each area mapped. Final 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. Final types were then matched to the most similar and suitable alliances or associations as described by and available through NatureServe Explorer (http://www.natureserve.org/ and usnvc.org). Where no corollary was found to a mapped type within the NatureServe database, description was limited to the study-area locality rather than including details on the type as it occurs across its broader geographic range. SODN-specific codes were assigned to distinguish these from accepted types.

2.3 Results

2.3.1 Classification results

In the final map, there are 16 vegetation alliances or associations attributed to 74 polygons (Figure 2-3). For each, there is a one-to-one correlation between the alliance or association and map units (polygons). Table 2-3 shows each vegetation community type, the number of polygons attributed with that type, and the total area.

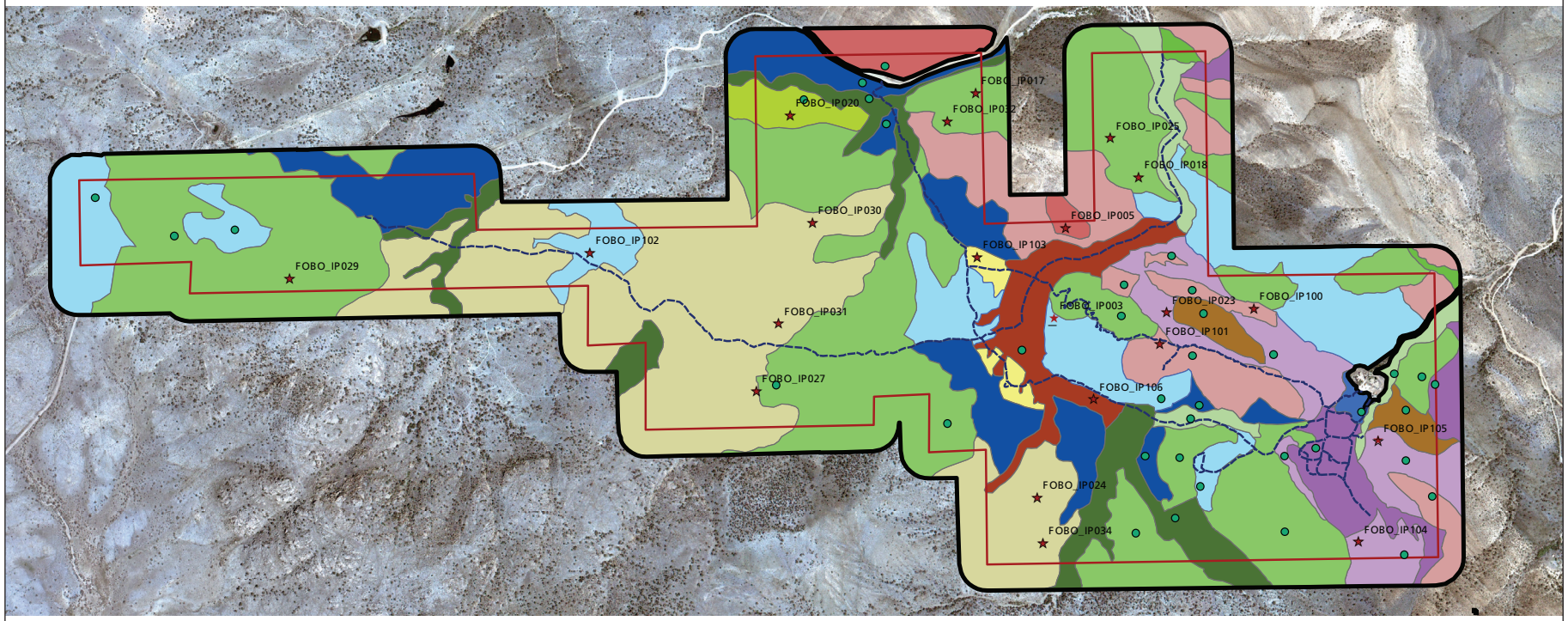
The initial round of classification led to the identification of 16 preliminary types, four of which were described at the association level, and 12 at the alliance level. Two alliances were determined, on a second review, to be very similar in species composition to

Facing page: Figure 2-3. Final vegetation inventory map, Fort Bowie National Historic Site.

Fort Bowie National Historic Site
Arizona

National Park Service
U.S. Department of the Interior

Vegetation Inventory Map



Legend

- Plot location
- Photopoint location
- Trail
- Park boundary
- Project boundary

Map units

- *Fraxinus velutina* Forest and Woodland Alliance (P)
- *Celtis laevigata* var. *reticulata* - *Juglans major* Woodland (P)
- *Pinus edulis* - *Juniperus* spp. Woodland Alliance
- *Quercus emoryi* - *Juniperus monosperma* Woodland Alliance (P)
- *Prosopis* (*glandulosa, velutina*) Wooded Shrubland Alliance (P)
- [*Juniperus monosperma* - *Quercus emoryii* / Mixed Shrub Wooded Shrubland Alliance (P)
- *Rhus microphylla* Shrubland Alliance
- *Prosopis* (*glandulosa, velutina*) Shrubland Alliance
- *Quercus turbinella* Shrubland Alliance
- *Larrea tridentata* Shrubland
- *Fouquieria splendens* / *Parthenium incanum* Shrubland
- *Fouquieria splendens* / *Opuntia engelmannii* Shrubland (P)
- *Quercus emoryii* / *Bouteloua* spp. Wooded Herbaceous
- *Rhus microphylla* / *Bouteloua* spp. Shrub Herbaceous Alliance (P)
- *Prosopis* (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance (P)
- *Bouteloua* spp. - Mixed Grass Herbaceous Alliance (P)

0 125 250 500 750 1,000 Meters

Produced by Sonoran Desert Network, December 2012

Table 2-3. Summary of final map classes, including total number and area of polygons (map units).

Map class name	Common name	Abbreviation	No. polygons	Acres	
				Total	% of total
Woodland					
Fraxinus velutina Forest and Woodland Alliance (P)	Velvet ash Forest and Woodland Alliance	FRAVEL Forest and Woodland	3	26	2%
Celtis laevigata var. *reticulata* - *Juglans major* Woodland (P)	Netleaf hackberry - Arizona walnut Woodland	CELLAE-JUGMAJ Woodland	1	41	3%
Pinus edulis - *Juniperus* spp. Woodland Alliance	Two-needle pinyon - Juniper spp. Woodland Alliance	PINEDU-JUN Woodland	2	16	1.2%
Quercus emoryi - *Juniperus monosperma* Woodland Alliance (P)	Emory oak - One-seed juniper Woodland Alliance	QUEEMO-JUNMON Woodland	4	68	5%
		Woodland total	***10***	***151***	***5%***
Wooded Shrubland					
Prosopis (*glandulosa, velutina*) Wooded Shrubland Alliance	Mesquite (honey/velvet) Wooded Shrubland Alliance	Prosopis Wooded Shrubland	1	3	0.2%
[*Juniperus monosperma* - *Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance (P)	[One-seed juniper - Emory oak] / Mixed shrub Wooded Shrubland Alliance	JUNMON-QUEEMO Wooded Shrubland	16	436	32%
		Wooded Shrubland total	***17***	***439***	***32%***
Shrubland					
Rhus microphylla Shrubland Alliance	Littleleaf sumac Shrubland Alliance	RHUMIC Shrubland	4	65	5%
Prosopis (*glandulosa, velutina*) Shrubland Alliance (P)	Mesquite (honey/velvet) Shrubland Alliance	Prosopis Shrubland	9	108	8%
Quercus turbinella Shrubland Alliance	Sonoran scrub oak Shrubland Alliance	QUETUR Shrubland	1	14	1.0%
Larrea tridentata Shrubland	Creosote bush Shrubland	LARTRI Shrubland	2	5	0.4%
Fouquieria splendens / *Parthenium incanum* Shrubland	Ocotillo / Mariola Shrubland	FOUSPL-PARINC Shrubland	11	101	7%
Fouquieria splendens / *Opuntia engelmannii* Shrubland (P)	Ocotillo / Engelmann's pricklypear Shrubland	FOUSPL-OPUENG Shrubland	2	24	2%
		Shrubland total	***29***	***317***	***23%***
Herbaceous					
Quercus emoryi / *Bouteloua* spp. Wooded Herbaceous	Emory oak / Mixed grama Wooded Herbaceous	QUEEMO/Bouteloua Wooded Herbaceous	4	261	19%
Rhus microphylla / *Bouteloua* spp. Shrub Herbaceous Alliance (P)	Littleleaf sumac / Mixed grama Shrub Herbaceous Alliance	RHUMIC/Bouteloua spp. Shrub Herbaceous	3	38	3%
Prosopis (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance (P)	Mesquite (honey/velvet) / Mixed grama Shrub Herbaceous Alliance	Prosopis/Bouteloua Shrub Herbaceous	8	155	11%
Bouteloua spp. - Mixed Grass Herbaceous Alliance (P)	Grama spp. Mixed grass Herbaceous Alliance	Bouteloua-Mixed Grass Herbaceous	3	9	0.7%
		Herbaceous total	***18***	***463***	***34%***
Total			**74**	**1,310**	**---**

Map units marked with a (P) are proposed vegetation types, not yet formally accepted within the NVC.

another type and were therefore aggregated into the other type, with modification made to the descriptions to accommodate the changes. In both of these cases, most species were exactly the same but there were small differences in the relative abundances of the dominant species or in the attributed structural formation. The resulting 14 types were attributed to the polygons (map units) and subsequently used during the accuracy assessment phase.

Accuracy assessment field work conducted in spring 2010 revealed the need for two new types to be described, *Larrea tridentata* Shrub-land and *Rhus microphylla* / *Bouteloua* spp. Shrub Herbaceous, the latter being an additional structural type (physiognomic variant) within an existing floristic community rather than a new community type. The *Larrea tridentata* shrubland was an entirely new community type. More information on accuracy assessment results and resolution of inconsistencies is provided in Chapter 3. Of the 16 final types, seven are currently accepted and described within the NVC, with the remaining nine identified as proposed vegetation types.

It should be again noted that 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 newer Vegetation Classification Standard (FGDC 2008). The bulk of our mapping and classification effort was completed under the old system of classification (see Section 1.4) and, as such, the report reflects both the nomenclature in use at that time and, where appropriate and possible, the newly accepted NVC codes and hierarchy placements. It is our intent that by including the newest information available at the time of writing, this report will better reflect the current, yet still evolving, NVC. Revisions to the hierarchy can be viewed at www.usnvc.org.

One-page text and spatial summaries of each community type are presented at the end of this section; full descriptions of all map classes can be found in Appendix B. Readers may refer to the digital maps and databases accompanying this report for more detail.

2.3.2 New species

During the field data collection process, nine new species were identified and added to the park plant checklist. Of these, five have been added to the species list preliminarily, pending official collection and accession into the University of Arizona herbarium (Table 2-4).

Table 2-4. New species records identified during the vegetation mapping inventory, Fort Bowie National Historic Site.

Scientific name	Common name
Achnatherum eminens	southwestern needlegrass
Aristida divaricata	poverty threeawn
Mirabilis laevis var. *villosa*	wishbone-bush
Panicum bulbosum	bulb panicgrass
*Brickellia lemmonii**	Lemmon's brickellbush
*Chloracantha spinosa**	spiny chloracantha
*Gomphrena nitida**	pearly globe amaranth
*Muhlenbergia minutissima**	annual muhly
*Muhlenbergia polycaulis**	cliff muhly

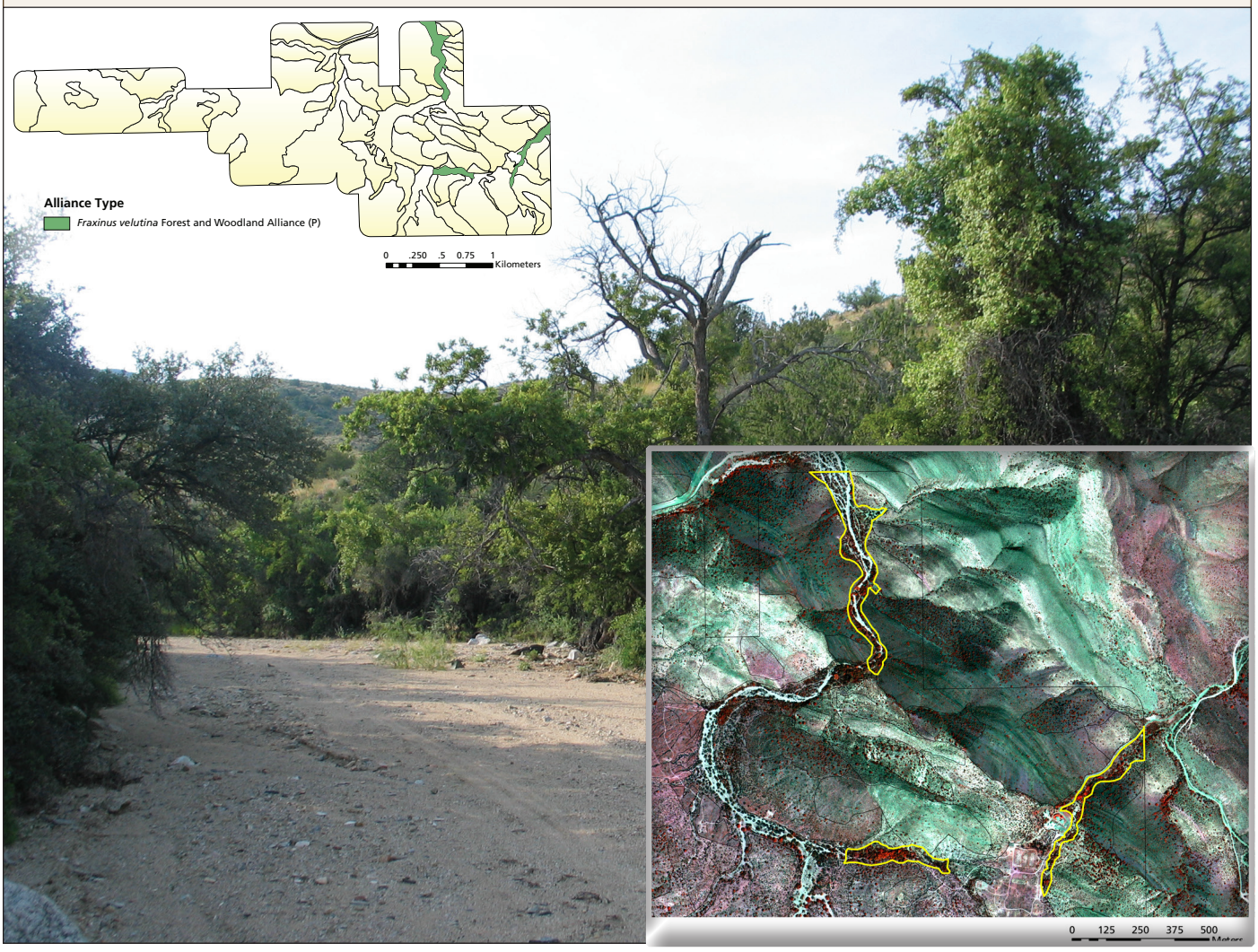
*Species has been preliminarily added to the species list, but formal voucher specimens still need to be collected.

Fraxinus velutina Forest and Woodland Alliance (P)
Velvet ash Forest and Woodland Alliance

Common species
Fraxinus velutina
Salix gooddingii
Juglans major
Quercus turbinella
Bouteloua spp.

This mostly deciduous riparian proposed alliance is dominated by *Fraxinus velutina*, with less cover of such associated tree species as *Salix gooddingii*, *Juglans major*, *Sideroxylon lanuginosum* (gum bumelia or gum bully), *Juniperus coahuilensis*, *Celtis laevigata* var. *reticulata*, and *Quercus arizonica*. The tree canopy is generally 5–6 meters tall and comprises 50–70% cover. Beneath the tree canopy is a diverse layer of 2–4-m tall shrubs and small trees, with no species consistently dominant. *Quercus turbinella* is commonly found, with such species as *Rhus microphylla*, *Prosopis glandulosa*, *Celtis laevigata* var. *reticulata*, *Sideroxylon lanuginosum*, *Garrya wrightii*, *Vitis arizonica*, *Arctostaphylos pungens*, *Rhus virens*, *Sapindus saponari*, and others. The subcanopy (0.5–2 m) and field (0–0.5 m) layers are also well populated and diverse, but comprise less aggregate cover than the canopy. Species present may include those already mentioned plus shorter shrubs, such as *Ericameria laricifolia*, *Mimosa aculeaticarpa* var. *biuncifera*, *Isocoma tenuisecta*, *Gutierrezia sarothrae*, *Agave palmeri*, *Baccharis sarothroides*, *Parthenium incanum*, *Aloysia wrightii*, and others. Common grasses include *Bouteloua* species, *Eragrostis lehmanniana*, *Bothriochloa barbinodis*, and *Heteropogon contortus*. Other grass species may also be present.

This community occurs in intermittently flooded drainages with relatively high soil moisture. Slopes may be gentle or steep, and aspect is variable. The predominant surface cover in the mostly narrow channels is gravel, rock, and bedrock outcrop, with high litter cover on the wooded banks.

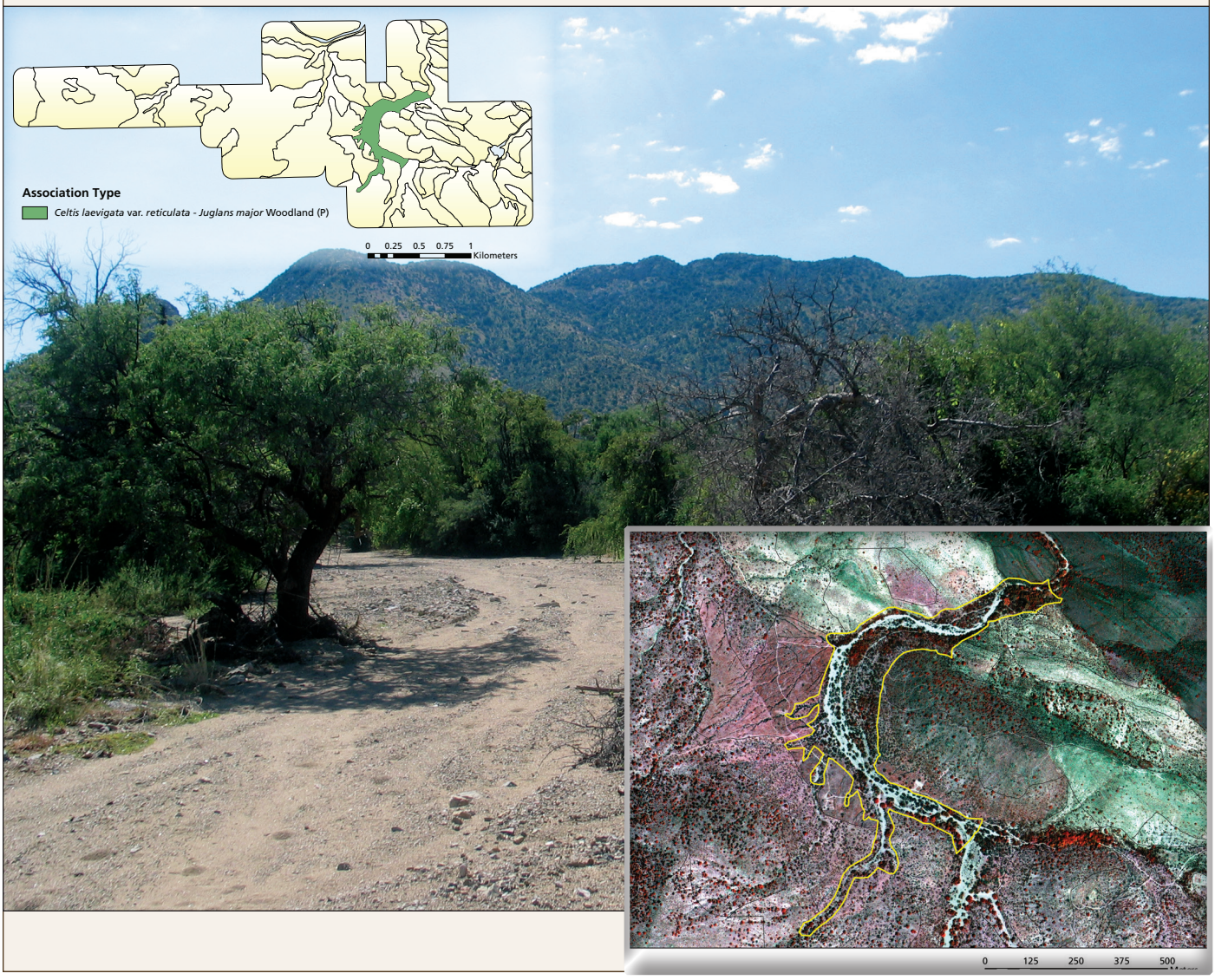


Celtis laevigata var. *reticulata - Juglans major* Woodland (P)
Netleaf hackberry - Arizona walnut Woodland

This proposed association is dominated by tall (9–10 m) *Celtis laevigata* var. *reticulata* and *Juglans major*, with shorter (5-m) *Salix gooddingii*. A number of other tree species may also occur, roughly 4–5 m in height, including *Prosopis glandulosa*, *Quercus emoryi*, *Sideroxylon lanuginosum*, and *Juniperus monosperma*. The canopy and subcanopy layers are occupied by saplings of the tree species mentioned, with such shrubs as *Rhus microphylla, Mimosa aculeaticarpa* var. *biuncifera, Sapindus saponaria, Ziziphus obtusifolia, and Arctostaphylos pungens*. The field layer commonly contains a mix of grasses and short shrubs. These may include *Bouteloua* species, *Setaria leucopila, S. grisebachii, Panicum hirsutum, Eragrostis lehmanniana, Muhlenbergia arenicola, M. emersleyi, Bothriochloa barbinodis, Sporobolus wrightii,* and others.

Common species
Celtis laevigata var. *reticulata*
Juglans major
Salix gooddingii
Prosopis glandulosa
Quercus emoryi
Rhus microphylla
Bouteloua spp.

This woodland occurs in the upper and middle reaches of Siphon Canyon, a relatively wide, undulating wash, and on the adjacent low hills. Slope is near level to 15%, and aspect is variable. Substrate is sand, rock, and gravel in the wash and sandy loam soil on the hills.

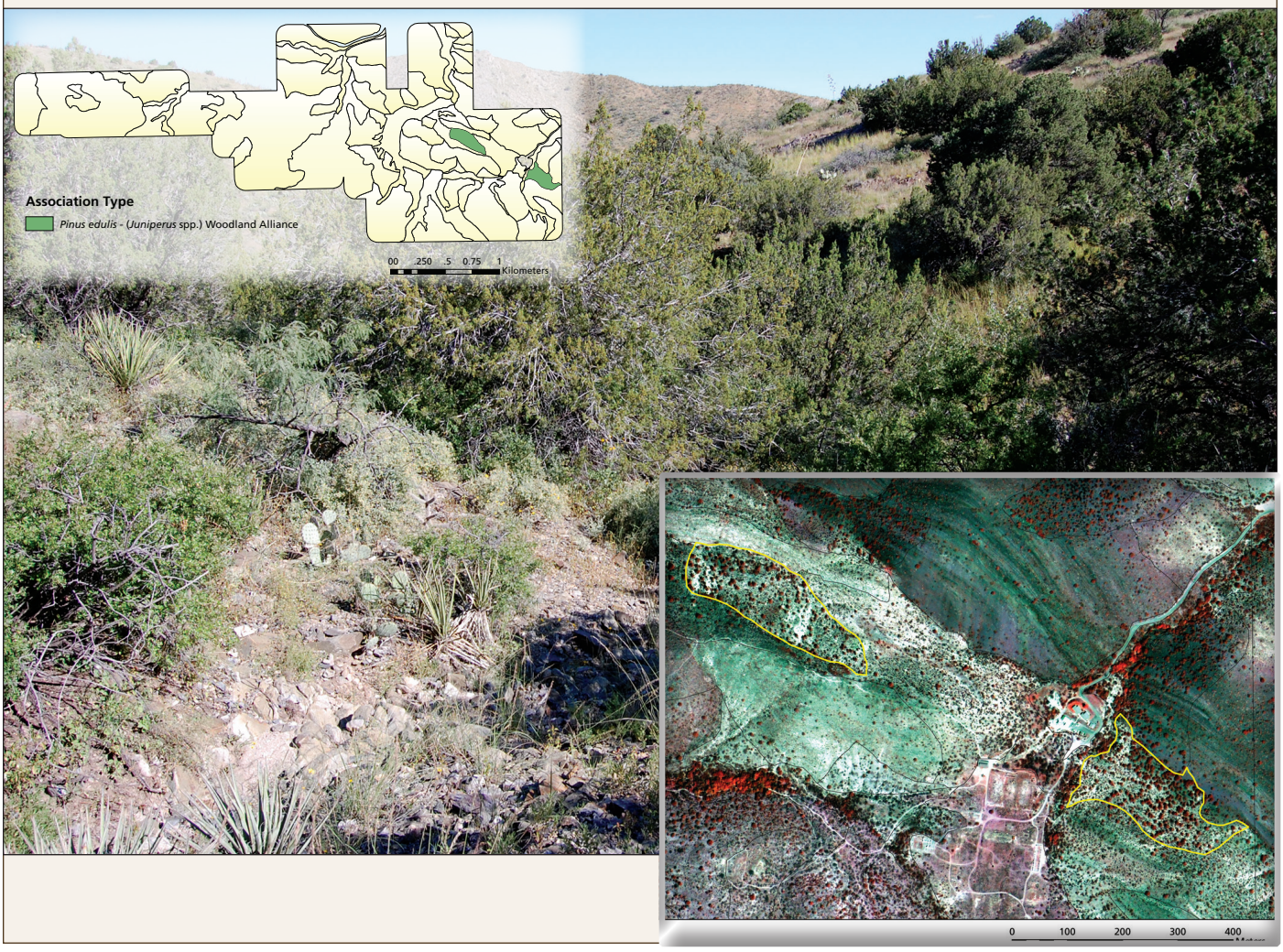


Pinus edulis - (*Juniperus* spp.) Woodland Alliance
Two-needle Pinyon - (Juniper species) Woodland Alliance

Common species
Pinus edulis
Juniperus monosperma
Rhus microphylla
Quercus turbinella
Ceanothus greggii
Cercocarpus montanus
Bouteloua spp.

Woodlands included in this alliance occur on dry sites in the lower montane zone in the southern Rocky Mountains; mountains, mesas, and canyons in the Chihuahuan and Sonoran deserts and the Colorado Plateau; and breaks in the southern Great Plains. *Pinus edulis* and *Juniperus monosperma* are co-dominant species; both are present, and either may be dominant in a given stand. *Juniperus coahuilensis* may be present with very low cover. Other tree species are generally absent. Total tree cover is 25–30%, and greater than shrub cover. Tree height is 3–3.5 meters. A diversity of shrub species is present, and shrub cover is generally 20–25% or slightly greater. Common shrubs are *Rhus microphylla, Quercus turbinella, Ceanothus greggii, Cercocarpus montanus, Parthenium incanum*, and *Aloysia wrightii*, with perhaps a dozen associates. The field layer, with 20–30% cover, is composed of small individual shrubs of these species, and grasses, such as *Bouteloua* species, *Aristida purpurea, Tridens muticus, Setaria leucopila, S. grisebachii, Muhlenbergia arenicola, Heteropogon contortus*, or others.

Both stands of this woodland at Fort Bowie NHS (FOBO) occur on moderate (15–35%) to steep (35–50%) north-facing hillslopes. Surface cover is mostly gravel, loose rock, and bedrock outcrops, with litter present under tree canopies. Large rills may be present, containing sand, gravel, and rock. Parent material is calcareous and non-calcareous sedimentary rock and colluvium.

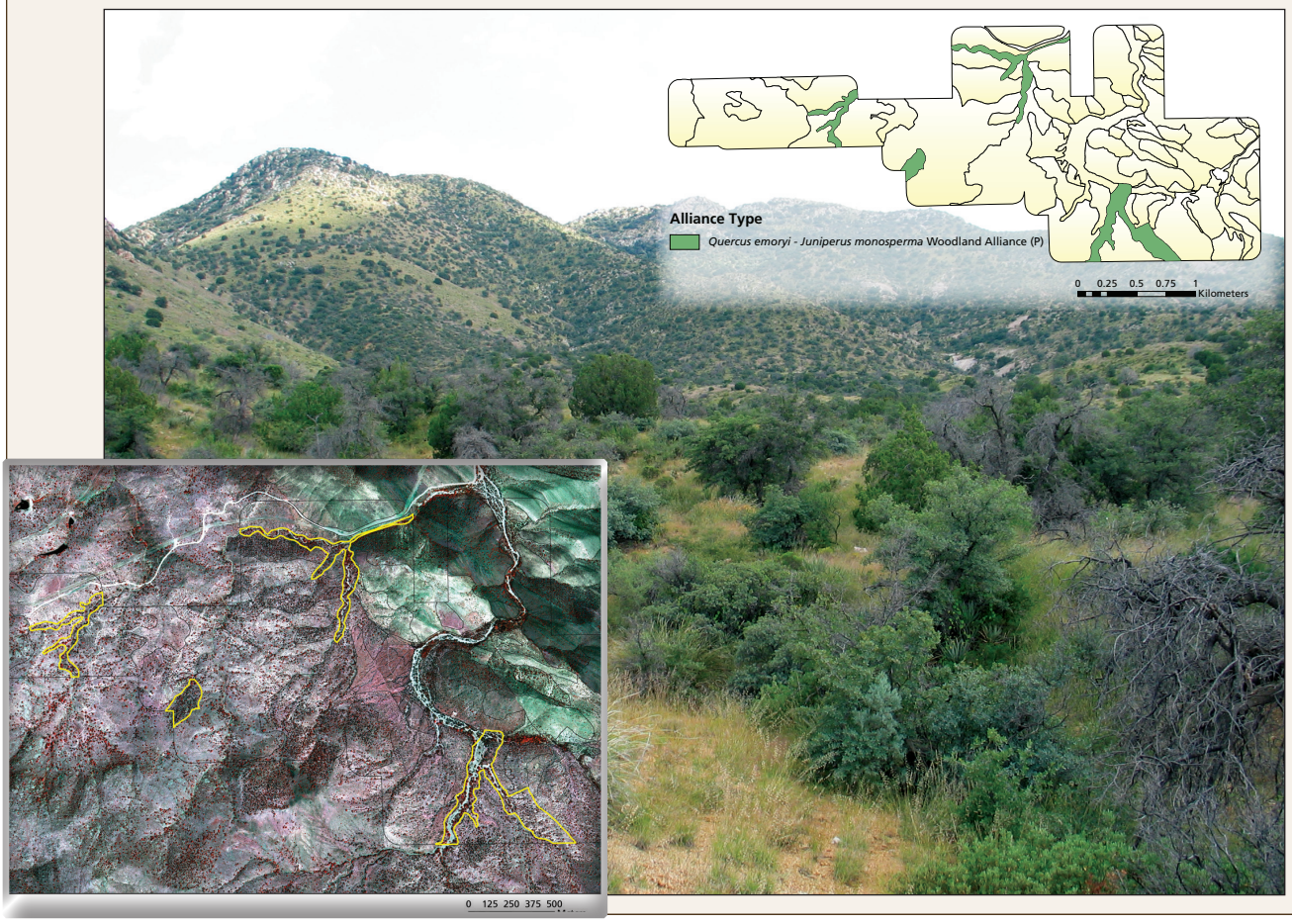


Quercus emoryi - Juniperus monosperma Woodland Alliance (P)
Emory oak - One-seed juniper Woodland Alliance

Common species
Quercus spp.
Juniperus spp.
Prosopis glandulosa
Rhus microphylla
Bouteloua spp.

This is a highly variable proposed alliance, difficult to categorize into consistent associations at FOBO. It is generally dominated by *Quercus emoryi*, *Q. grisea*, or *Q. arizonica* with *Juniperus monosperma* or *J. coahuilensis*. *Prosopis glandulosa* is a common associate (though often as a shrub); others may include *Sideroxylon lanuginosum, Quercus toumeyi, Juniperus deppeana, Quercus turbinella,* and *Pinus edulis*. In stands occurring in intermittently flooded canyon bottoms, riparian associates, such as *Celtis laevigata* var. *reticulata* and *Juglans major*, are often present, while upland stands lack these species. Tree canopy height is generally 5–8 meters, but in a few stands it may be slightly less than 5 m. Tree canopy cover is generally between 20 and 60%. Shrub species diversity is usually high (around 10 species are usually present) and shrub cover may be significant (20–30%), but is less than tree cover. Common shrubs in addition to the ubiquitous *Prosopis glandulosa* are *Rhus microphylla, Arctostaphylos pungens, Garrya wrightii, Ericameria laricifolia*, *Mimosa aculeaticarpa* var. *biuncifera, Nolina microcarpa*, *Agave palmeri, Yucca baccata*, and *Dasylirion wheeleri.* The field layer contains subshrubs, such as *Isocoma tenuisecta*, but is dominated by grasses, including *Bouteloua* species (notably *B. curtipendula*), *Eragrostis lehmanniana, Muhlenbergia emersleyi, Bothriochloa barbinodis*, and other species.

This woodland is often, but not always, associated with small to medium-sized washes at FOBO, occurring along drainages and on the low hills adjacent to them. While these drainages are (very) intermittently flooded by storms, soil development and soil moisture are apparently insufficient to support the *Fraxinus, Celtis,* and *Juglans* woodlands found in the largest washes at FOBO. Slopes along drainage axes are mostly gentle (1–6% or 6–15%), while the slopes up drainage banks are commonly steep (15–35% or greater). Aspect is variable with wash orientation, and this community occurs on both sides of the drainages it occupies. Substrate in the channels is sand, gravel, and rock of all sizes, including bedrock outcrops; banks are generally rocky, with sandy loam soil on the hills above them.



Prosopis (glandulosa, velutina) Wooded Shrubland Alliance (P)
(Honey mesquite, Velvet mesquite) Wooded Shrubland Alliance

Common species
Prosopis glandulosa
Prosopis velutina
Rhus microphylla
Ziziphus obtusifolia
Condalia warnockii

The uppermost stratum of this proposed alliance is dominated by short (<5-m) *Prosopis* trees comprising 30–35% cover, and it has significant shrub and herbaceous layers. Differentiation of *Prosopis glandulosa* var. *torreyana* from *Prosopis velutina* in the field is difficult in the FOBO area because of their morphological similarity and likely hybridization. Thus, consistent distinction was not attempted for mapping, and this type may contain one species or the other, or both, or hybrids. The shrub stratum is co-dominated by *Prosopis* spp. and *Rhus microphylla*, generally followed by *Ziziphus obtusifolia* and *Condalia warnockii*. Other associates are *Sideroxylon lanuginosum*, *Lycium* sp., *Baccharis sarothroides*, and *Isocoma tenuisecta*. The field stratum may have a significant forb component (e.g., *Verbesina encelioides*), but is dominated collectively by a variety of grass species, including *Setaria leucopila, Leptochloa dubia, Sporobolus wrightii, Setaria grisebachii, Muhlenbergia arenicola*, and *Eragrostis cilianensis*.

The single stand of this type at FOBO occurs on the flattish toeslope of a hill, which also includes a section of drainage. Vegetation cover is high and surface litter cover is 15–35%, so little substrate is exposed. Soil is silty loam with sparse gravel.



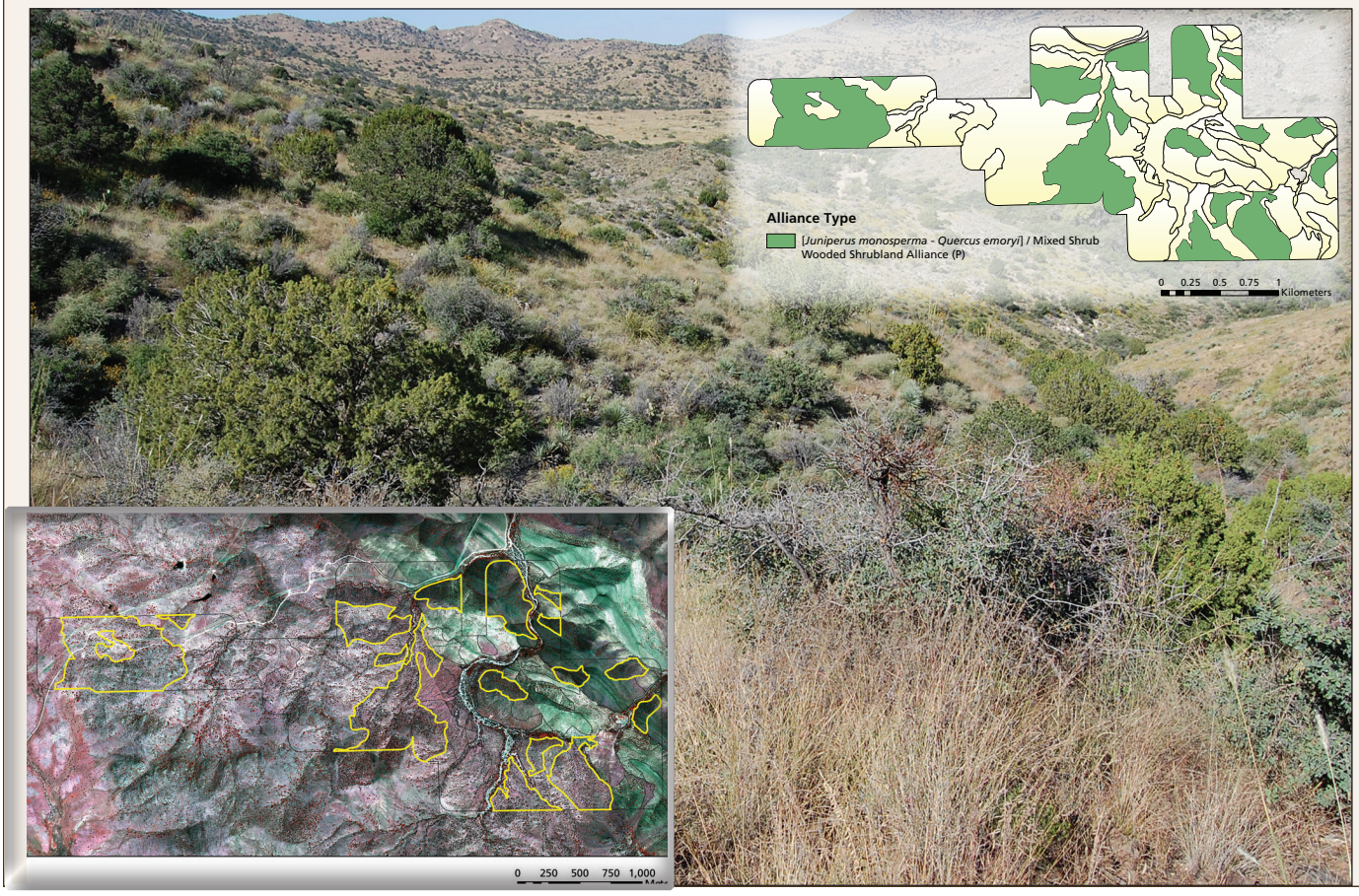
[*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance (P)

[One-seed juniper - Emory oak] / Mixed Shrub Wooded Shrubland Alliance

Common species
Juniperus monosperma
Quercus emoryi
Pinus edulis
Quercus turbinella
Prosopis spp.
Bouteloua spp.

This proposed alliance is widespread at FOBO and somewhat variable in its expression, though the variability is primarily in the relative cover of particular species within a fairly constant floristic composition. *Juniperus monosperma* and *Quercus emoryi* are almost always the dominant tree species; rarely, *Pinus edulis* may slightly dominate the tree stratum, and it is usually present as an associate. Less common tree associates are *Prosopis (velutina, glandulosa*), *Quercus arizonica*, and large *Quercus turbinella* individuals. However, tree canopy cover ranges from about 10 to 30%, and is always less than shrub cover, which ranges from 20 to 40%. Tree canopy height is usually short, at 3–5 meters, but sometimes reaches 6–8 meters. Shrub species richness is relatively high, with 10–15 species usually present. No one species is consistently dominant in this type. The dominant may be *Quercus turbinella*, *Prosopis (velutina, glandulosa)*, *Rhus microphylla*, *Nolina microcarpa*, *Mimosa aculeaticarpa* var. *biuncifera*, *Ericameria laricifolia, Arctostaphylos pungens*, or another species. Associate shrubs include *Aloysia wrightii, Dasylirion wheeleri, Yucca baccata, Agave palmeri, Calliandra eriophylla, Garrya wrightii, Cylindropuntia spinosior*, and others. The field layer is dominated collectively by a mix of grasses, commonly with a total cover of 25–40%. A complex of *Bouteloua* species, led by *B. curtipendula*, with some *Eragrostis lehmanniana*, is usually dominant, and *Muhlenbergia emersleyi* is frequently prominent. Possible associate grass species are numerous, and grass species richness is high in most stands, with 10 or more species found.

This is the most widespread community type at FOBO, and many stands are large, so it occurs in a variety of environmental settings. It is most often found on gravelly, dissected hillslopes, from crests down through toeslopes. Slope gradient is generally 15–35%, but ranges from 1–6% to over 50%. This wooded shrubland occurs on all aspects, but predominantly on north, northeast and northwest aspects. Surface cover in all stands is dominated by gravel and rock, followed in most cases by bedrock and then bare soil. Soils generally consist of shallow sandy loams.

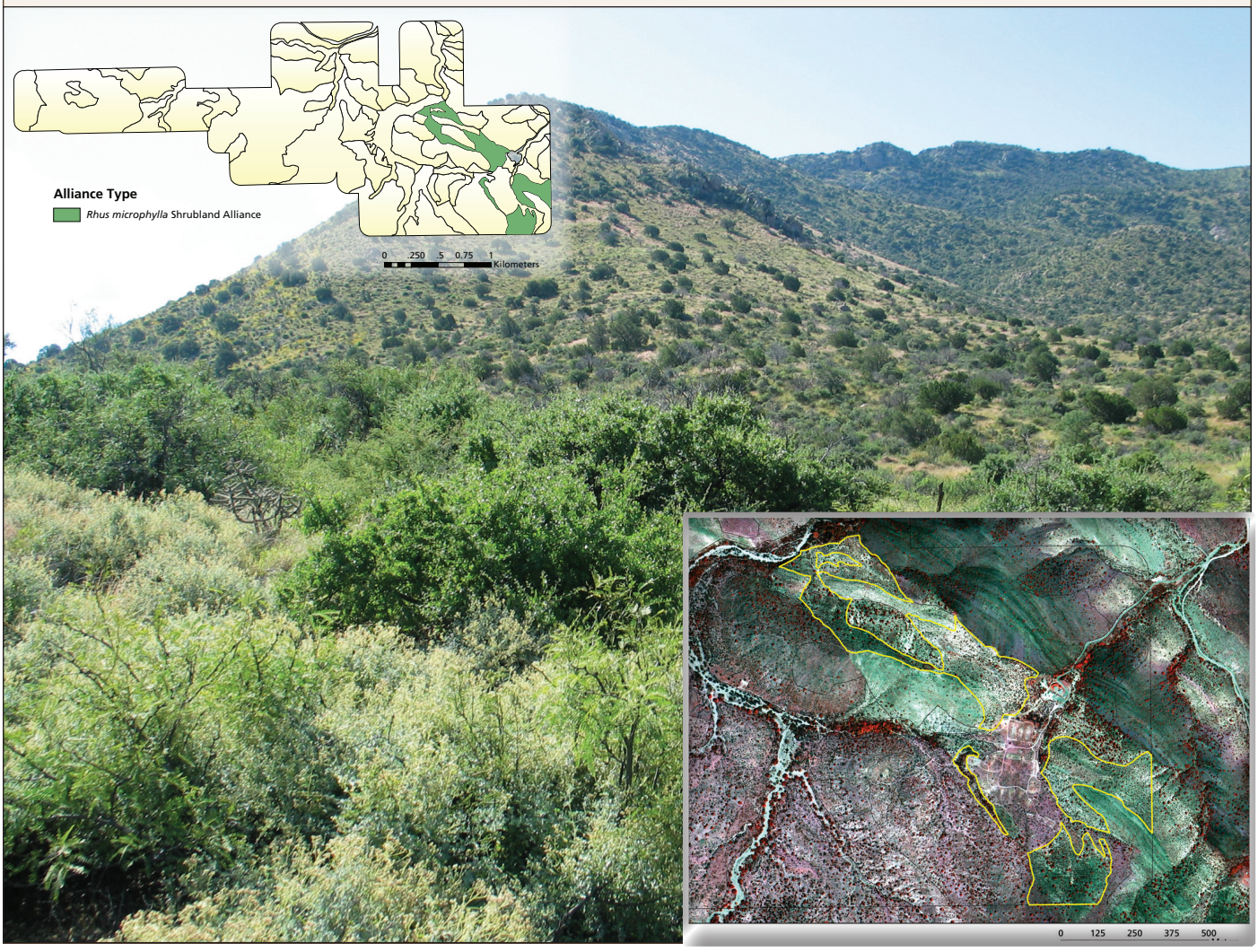


Rhus microphylla Shrubland Alliance
Littleleaf sumac Shrubland Alliance

Common species
Rhus microphylla
Aloysia wrightii
Prosopis spp.
Condalia warnockii
Cercocarpus montanus
Bouteloua spp.

Shrublands in this Chihuahuan Desert alliance occur on upland and basin sites in southern New Mexico. Elevation ranges from 1,250 to 1,500 m. The climate is semi-arid, with approximately two-thirds of the highly variable annual precipitation falling in July through October. These shrublands are found on several landforms and substrates, including gullied ancient river terraces. *Rhus microphylla* is usually the dominant woody species in this alliance, though many stands may be closely co-dominated by other shrub species, such as *Aloysia wrightii, Prosopis (glandulosa, velutina)*, *Condalia warnockii,*or *Cercocarpus montanus*. A variety of associate shrubs may be present, including the four just mentioned and *Fouquieria splendens, Cylindropuntia spinosior, Yucca baccata, Agave palmeri, Parthenium incanum, Krascheninnikovia lanata, Dasylirion wheeleri, Rhus trilobata, Ceanothus greggii, Dalea formosa, Gutierrezia sarothrae, Ericameria laricifolia, Nolina microcarpa*, and others. A few trees may be present, most commonly *Pinus edulis* and *Juniperus monosperma*. The herbaceous layer is usually somewhat sparse (<30% cover), and usually dominated by a mix of *Bouteloua* species and other grasses, notably *Eragrostis lehmanniana*.

This shrubland is most often found on gravelly, rocky hillslopes, from crests down through footslopes, usually on north, northwest, or northeast aspects. Slope gradient is 6–15% or 15–35%. Surface cover in all stands is dominated by gravel and rock, followed in most cases by bedrock and then bare soil. Soils are generally shallow and consist of sandy loams to loams.

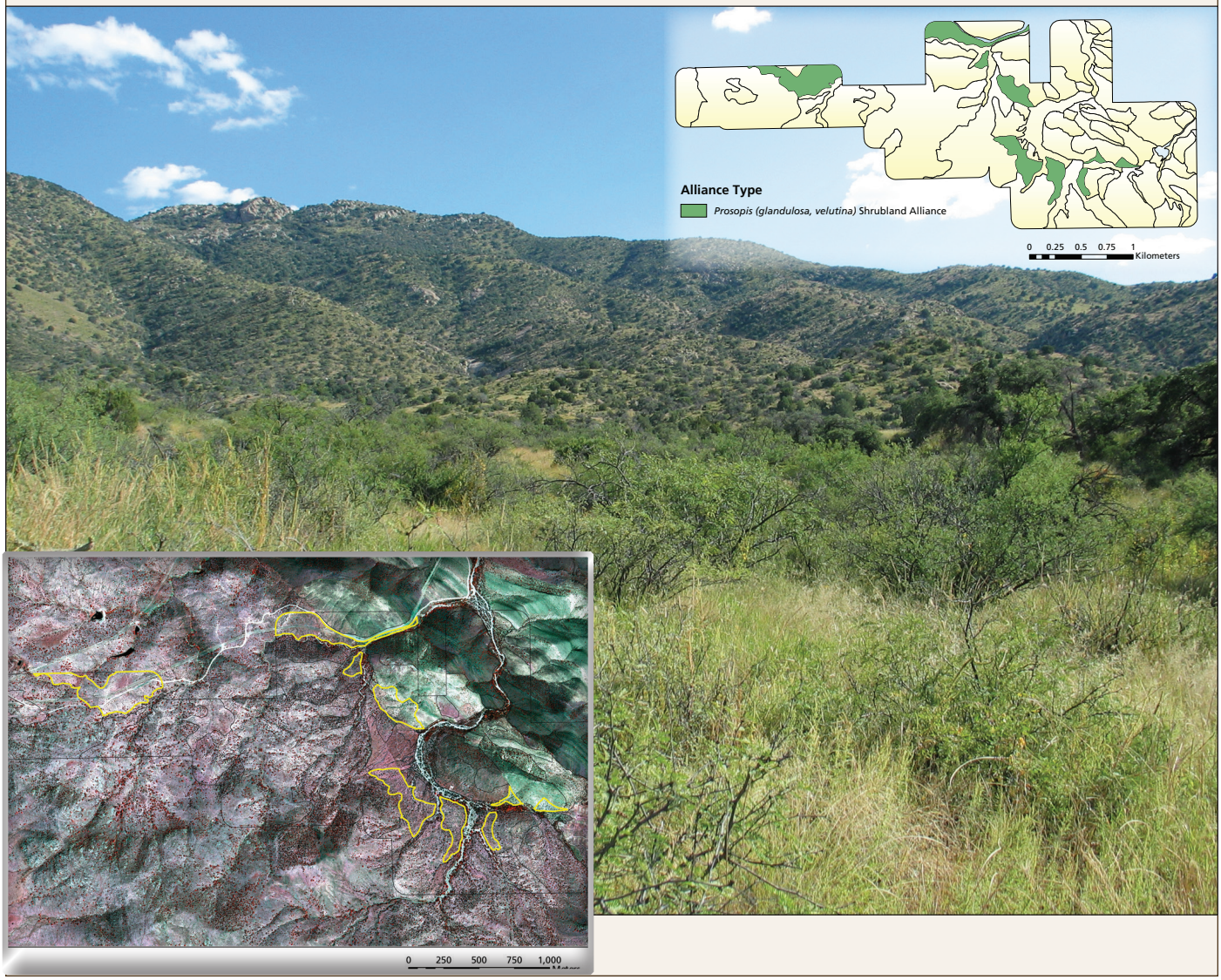


***Prosopis (glandulosa, velutina)* Shrubland Alliance**
(Honey mesquite, velvet mesquite) Shrubland Alliance

Common species
Prosopis glandulosa
Prosopis velutina
Bouteloua spp.

Prosopis glandulosa is the most common dominant species, but *P. velutina* or hybrids may dominate some stands. For any of these species, the shrub lifeform, with heights generally less than 2 meters, is prevalent, but some individuals with a tree lifeform and reaching 4–5 meters may be present. Scattered individuals of other tree species may be present in this shrubland, including *Juniperus monosperma, Juniperus coahuilensis, Celtis laevigata* var. *reticulata, Quercus emoryi*, and *Q. turbinella*. Common associate shrubs, such as *Ericameria laricifolia, Rhus microphylla, Krascheninnikovia lanata, Parthenium incanum*, and *Mimosa aculeaticarpa* var. *biuncifera*, may collectively contribute significant cover, approaching that of the dominant *Prosopis*. Numerous shrub species may be present, of which the diversity is generally high. The herbaceous layer is generally dominated by a mix of *Bouteloua* species, commonly with *Eragrostis lehmanniana*, which may be the clear dominant in some stands. A variety of other grass species may be present, as well. The herbaceous layer generally ranges from 20 to 50% cover.

This shrubland is found on gravel-covered, dissected hillslopes, from crests to toeslopes, on any aspect. Gradients may be gentle, at 1–6%, but more commonly 6–15% or 15–35%. Surface cover in almost all stands is predominantly gravel, with some loose rock but little bedrock outcrop. Soils are generally sandy loams.

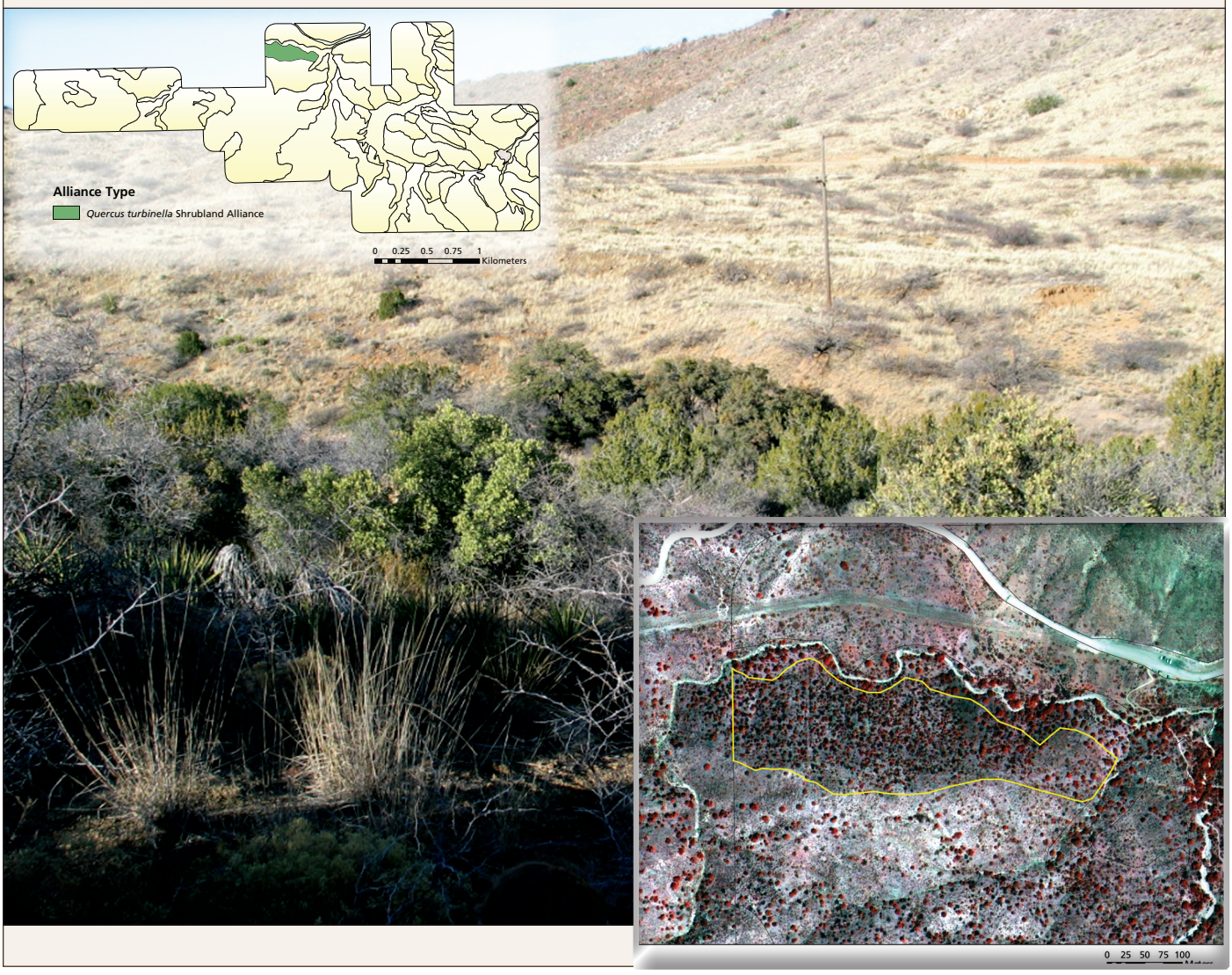


Quercus turbinella Shrubland Alliance
Turbinella live oak Shrubland Alliance

Common species
Quercus turbinella
Garrya wrightii
Cercocarpus montanus
Bouteloua spp.

This shrubland alliance is dominated by *Quercus turbinella*, with *Garrya wrightii* co-dominant. Maximum canopy height of these species is about 3.5 meters, but most cover occurs in the subcanopy of 0.5–2 meters. Total shrub cover is relatively high, at about 70%.This alliance includes evergreen shrublands where *Quercus turbinella* forms thickets with other desert shrubs. Important shrub associates can include *Arctostaphylos* spp., *Cercocarpus montanus, Coleogyne ramosissima, Ephedra viridis, Juniperus osteosperma, Rhus virens, Rhus trilobata, Rhus microphylla, Fraxinus greggii, Ceanothus greggii, Quercus mohriana, Quercus pungens*, and *Garrya wrightii*. Ground cover is typically sparse, with scattered grasses, forbs, and ferns. Some typical herbaceous components include *Bouteloua curtipendula, Bouteloua eriopoda, Aristida* spp., and *Notholaena standleyi*. Shrublands in this alliance are small in extent and occur in a matrix of succulent desert scrub and semi-desert grassland. *Quercus turbinella* shrublands are typically found on steep, rocky slopes and often on sheltered slopes in limestone canyons in the mountains of Nevada, Arizona, New Mexico, and western Texas.

The single stand of this shrubland at FOBO occurs on a dissected north-facing hillslope, from near the crest to the toeslope. Gradients range from 15 to 50%, with most of the slope about 35%. Gravel is the predominant surface cover, at 35–60%.

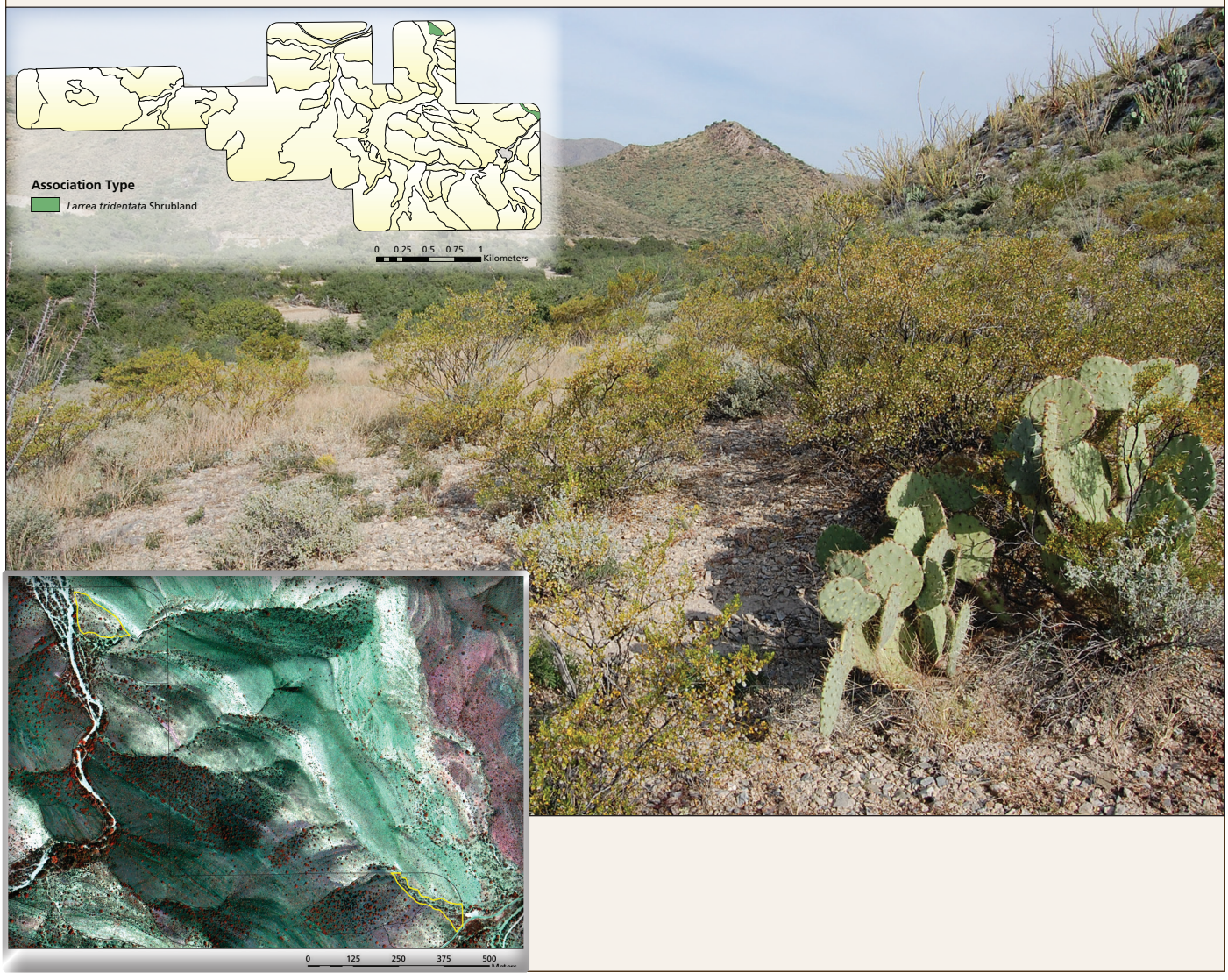


Larrea tridentata Shrubland
Creosotebush Shrubland

Common species
Larrea tridentata
Rhus microphylla
Prosopis spp.
Parthenium incanum
Bouteloua spp.

This creosotebush shrubland association is currently described from Grand Canyon National Park and Grand Canyon-Parashant National Monument in Arizona. More survey and classification work are needed to fully characterize this type. It is dominated by *Larrea tridentata*, with several associated shrub species present. The most frequent associates, and most abundant in a given stand, are *Rhus microphylla, Prosopis (glandulosa, velutina)* and *Parthenium incanum*. Less common associates, which may be present but contributing relatively little cover (generally <1% each), include *Aloysia wrightii, Yucca baccata, Nolina microcarpa, Ziziphus obtusifolia, Calliandra eriophylla, Opuntia phaeacantha, Fouquieria splendens*, and *Dalea formosa*. Total shrub cover ranges from about 20 to 50%. Trees are absent except for an occasional *Juniperus monosperma* individual. The field stratum is dominated by a mix of grasses that may include *Bouteloua curtipendula, B. eriopoda, Eragrostis lehmanniana, Tridens muticus, Muhlenbergia porteri, Setaria leucopila*, and others.

This shrubland is found on the lower footslopes and toeslopes of limestone hills at FOBO. Gradients are gentle, at 1–6%, and aspect is variable. The predominant surface cover is gravel and rock, and soils are fine sandy loams.

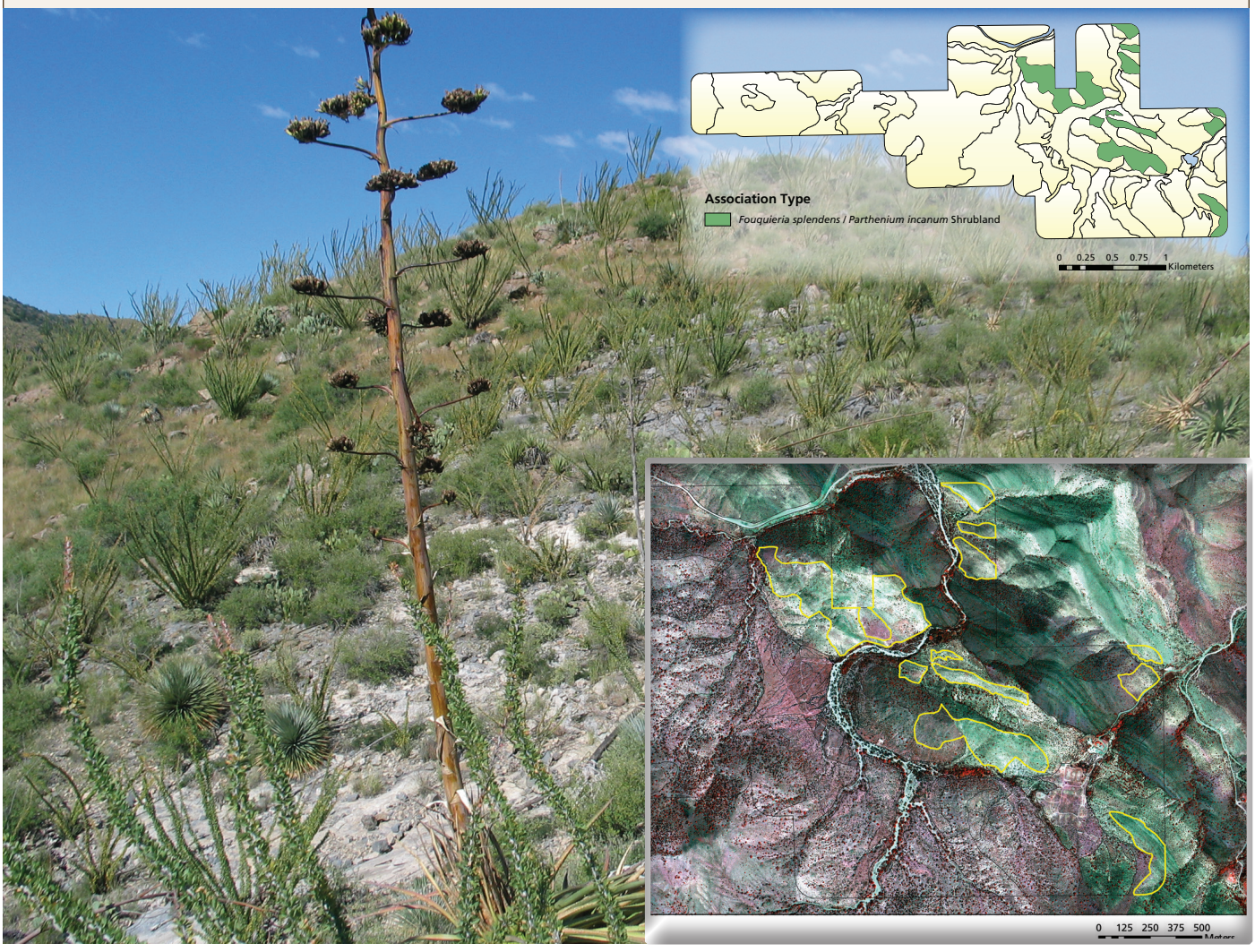


Fouquieria splendens / Parthenium incanum Shrubland
Ocotillo / Mariola Shrubland

Common species
Fouquieria splendens
Parthenium incanum
Rhus microphylla
Aloysia wrightii
Bouteloua spp.
Tridens muticus
Heteropogon contortus

Fouquieria splendens is a characteristic species of this association. It is by far the tallest shrub present, at 2–3 meters, but may not be dominant by density or canopy cover, depending on how this is measured because of its unusual morphology. *Parthenium incanum* is generally the dominant shrub by cover, but may be co-dominant with *Rhus microphylla*, *Aloysia wrightii*, or another species. A number of other shrub species are generally present. These may include *Prosopis (glandulosa, velutina), Dasylirion wheeleri, Yucca baccata, Agave palmeri, Nolina microcarpa, Cylindropuntia* spp., *Larrea tridentata*, and others. Trees are often absent, though occasional *Juniperus monosperma* individuals may be found in this type. Grass cover is sparse. Dominant species are generally a mix of *Bouteloua eriopoda, B. curtipendula, Tridens muticus, Heteropogon contortus*, and several other species, with *Eragrostis lehmanniana* prevalent in some stands. The field stratum (0–0.5 m) is often dominated by *Parthenium incanum, Calliandra eriophylla*, and other short shrubs.

This is a common shrubland association at FOBO, but its distribution is limited to the calcareous hillslopes of a wide band of limestone running through the eastern half of the park. It occurs on hillcrests through toeslopes, generally with gradients of 6–15% or 15–35% and on all aspects, though most frequently on south- or west-facing slopes. The predominant surface cover is gravel, with rock and bedrock, and soils are shallow.

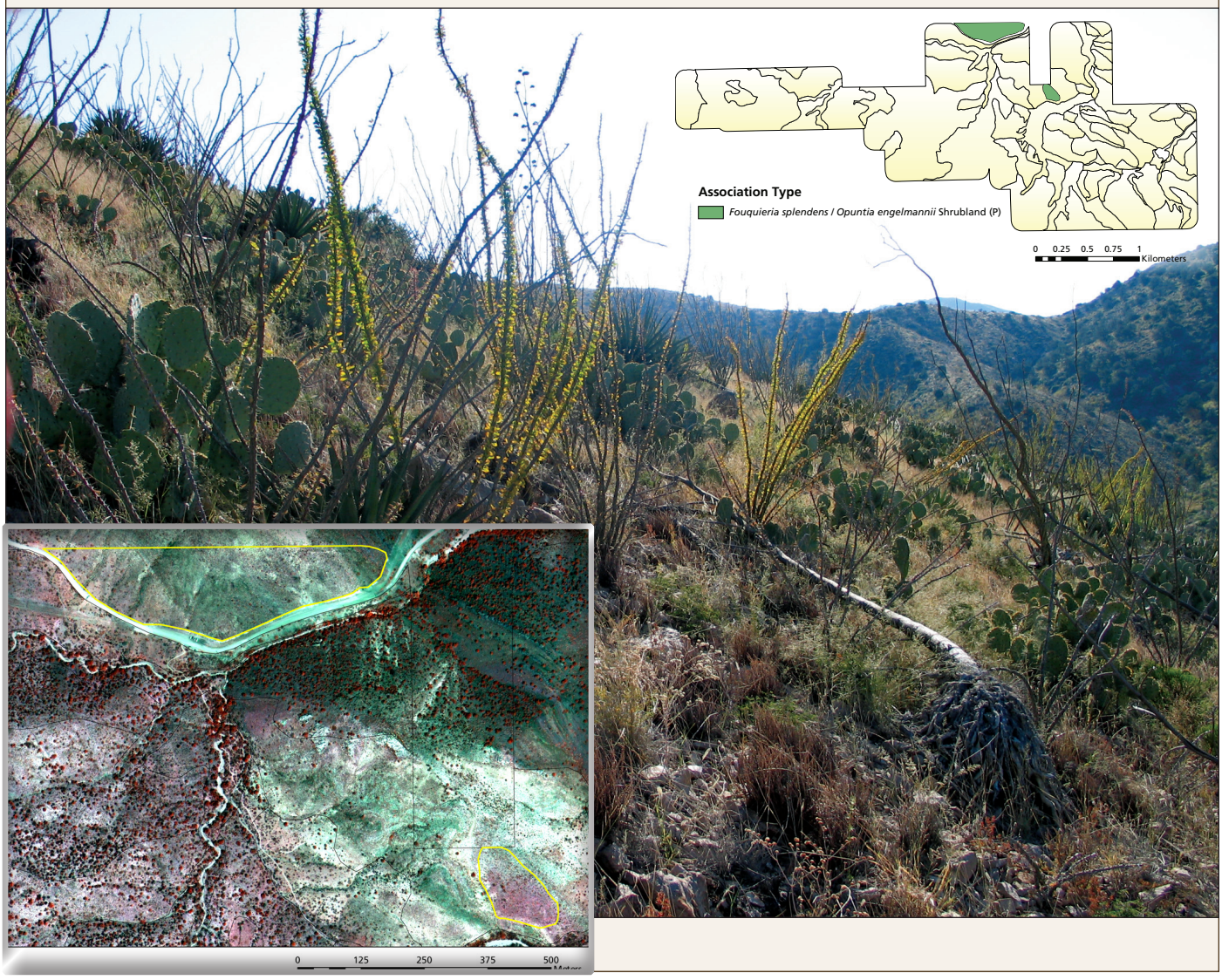


Fouquieria splendens / Opuntia engelmannii Shrubland (P)
Ocotillo / Engelmann pricklypear Shrubland

Common species
Fouquieria splendens
Opuntia engelmannii
Acacia greggii
Prosopis spp.
Eragrostis lehmanniana

Fouquieria splendens is the characteristic species of this proposed association, but may not appear dominant by density or canopy cover. Beneath the 2–3 m "canopy" of *F. splendens*, *Opuntia engelmannii* is generally the dominant shrub. Some stands may have significant cover of *Acacia greggii, Prosopis* (*glandulosa*, *velutina*), *Calliandra eriophylla*, or another species, with *O. engelmannii* sub-dominant. A number of other shrub species are generally present. These may include *Aloysia wrightii, Yucca baccata, Agave palmeri, Dasylirion wheeleri, Parthenium incanum, Mimosa aculeaticarpa* var. *biuncifera*, *Ferocactus wislizenii, Ericameria laricifolia*, *Cylindropuntia* spp., and other species. Trees are often absent, though occasional *Juniperus monosperma* individuals may be found in this type. Grass cover is typically sparse (<20%), except where the often-dominant *Eragrostis lehmanniana* is present.

This shrubland occurs at FOBO on some of the calcareous hillslopes of a wide band of limestone running through the eastern half of the park, generally on backslopes to footslopes with 15–35% or 35–50% gradients and south-to-southwest aspects. Rock and gravel make up the predominant surface cover, with some bedrock outcrop, and soils are shallow.

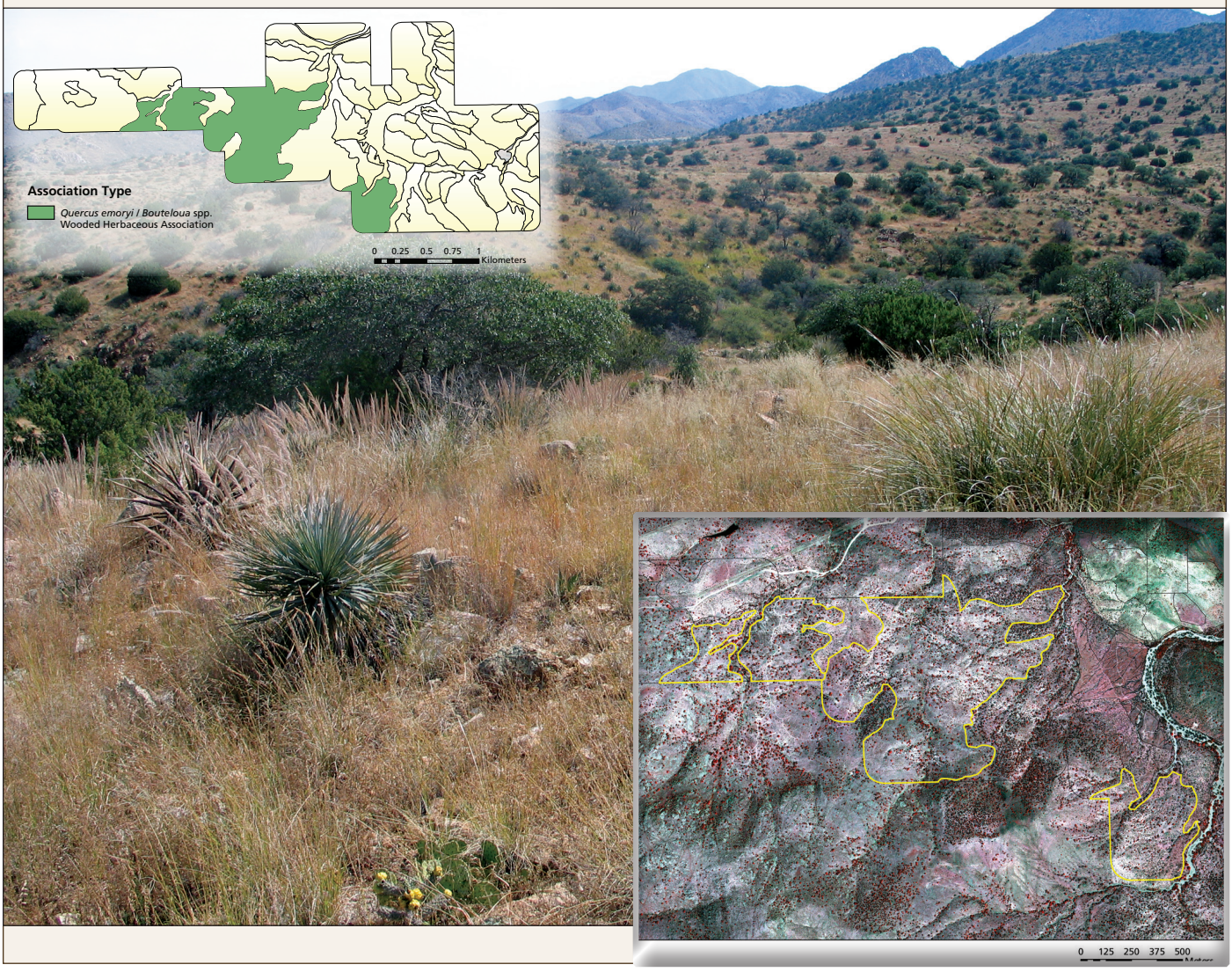


Quercus emoryi / Bouteloua spp. Wooded Herbaceous
Emory oak / Mixed grama species Wooded Herbaceous

Common species
Quercus emoryi
Juniperus monosperma
Prosopis spp.
Bouteloua spp.

Quercus emoryi dominates the tree stratum (2–5 meters tall) with 5–15% canopy cover, and *Juniperus monosperma* is usually present as a sub-dominant. Other tree species may be present with very low cover, including *Juniperus coahuilensis*, *Juniperus deppeana*, *Quercus arizonica*, *Pinus edulis*, or *Prosopis glandulosa*. A diverse shrub stratum is present, comprising 10–25% cover, without a consistent dominant species. The most common shrub species are *Prosopis (glandulosa, velutina)*, *Ericamerica laricifolia*, *Mimosa aculeaticarpa* var. *biuncifera*, *Arctostaphylos pungens*, *Nolina microcarpa*, *Yucca baccata*, *Dasylirion wheeleri*, *Agave palmeri*, and *Calliandra eriophylla*. The herbaceous layer comprises 40–70% cover and contains a variety of grasses, with a complex of *Bouteloua* species collectively dominant. These include *Bouteloua curtipendula*, *B. gracilis*, *B. aristidoides*, *B. eriopoda*, *B. repens*, and *B. hirsuta*. *Muhlenbergia emersleyi* and the introduced *Eragrostis lehmanniana* may also be prevalent. Associated grass species include *Bothriochloa barbinodis*, *Aristida ternipes*, *Eragrostis cilianensis*, *Heteropogon contortus*, *Aristida purpurea*, *Panicum hirticaule*, *Chloris virgata*, and others.

This association occurs at FOBO in relatively large stands covering the undulating granodiorite hills typical of the area. It is found from hillcrests to toeslopes, on gradients up to about 35%, and on all aspects. Surface cover is predominantly gravel, with rock and bedrock outcrops, and soils are sandy loams.

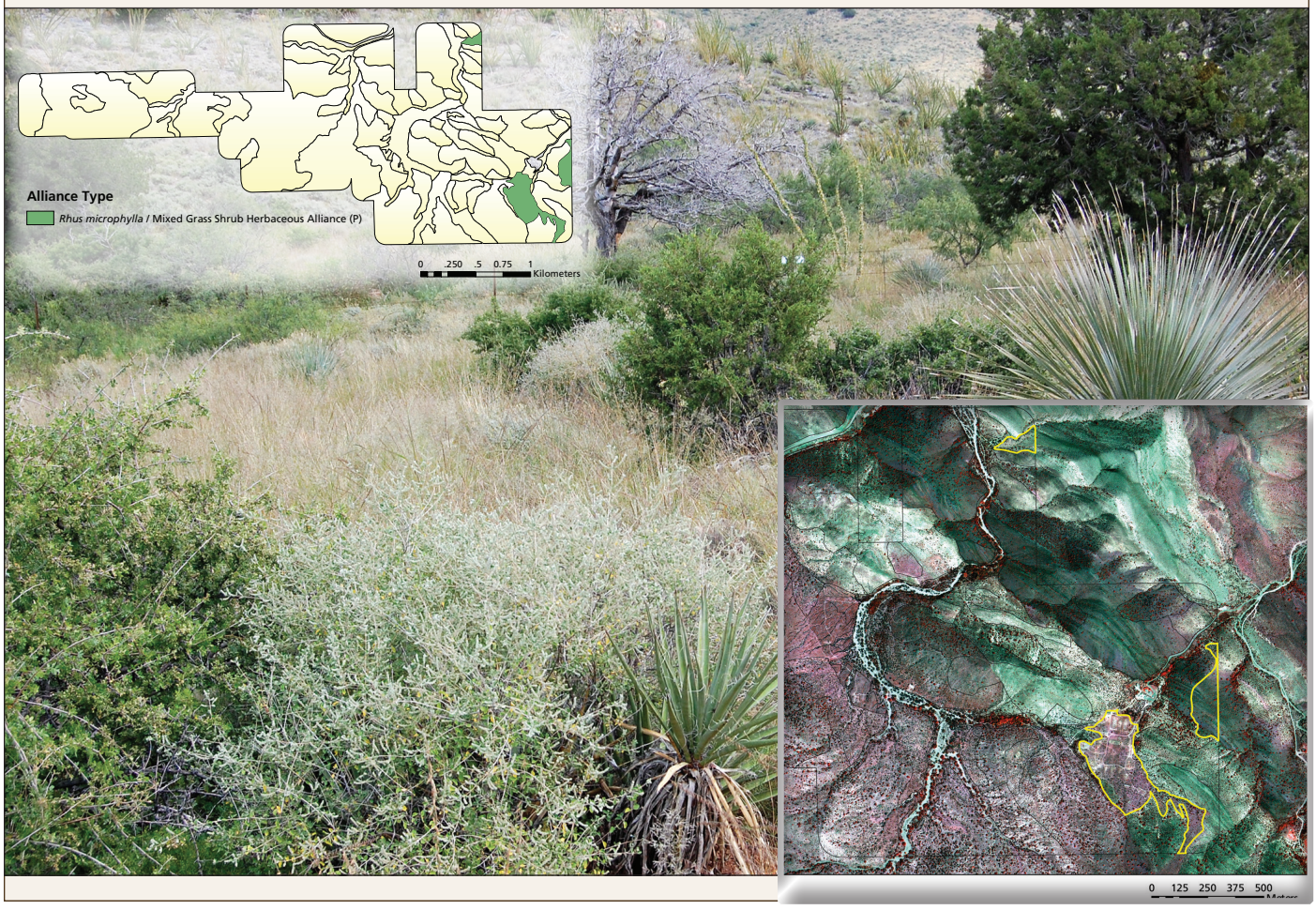


Rhus microphylla / Bouteloua spp. Shrub Herbaceous Alliance (P)
Littleleaf sumac / Mixed grass Shrub Herbaceous Alliance

Common species
Rhus microphylla
Prosopis spp.
Aloysia wrightii
Eragrostis lehmanniana
Bouteloua spp.

This proposed shrub herbaceous alliance is floristically similar to the *Rhus microphylla* Shrubland Alliance, also found at FOBO, but has considerably higher herbaceous cover (30–85%) and a higher ratio of herbaceous cover to shrub cover (2:1 or greater). *Rhus microphylla* is the dominant woody species in this alliance, though some stands may be closely co-dominated by other shrub species, such as *Prosopis (glandulosa, velutina)* or *Aloysia wrightii.* A variety of associate shrubs may be present, including *Fouquieria splendens, Mimosa aculeaticarpa* var. *biuncifera, Yucca baccata, Agave palmeri, Calliandra eriophylla, Dasylirion wheeleri, Gutierrezia sarothrae, Opuntia engelmannii, Cylindropuntia spinosior, Larrea tridentata, Ericameria laricifolia, Parthenium incanum*, and others. A few trees may be present, most commonly *Juniperus monosperma*. The herbaceous layer is difficult to characterize because there is no consistently dominant species or group of species, grass species diversity is fairly high, usually with 8–10 or more species present, and the mix of species is variable among stands. *Eragrostis lehmanniana* is frequently but not always found in this type. Other species may include *Bouteloua eriopoda, B. curtipendula, B. hirsuta, B. chondrosioides, B. gracilis, Bothriochloa barbinodis, Tridens muticus, Muhlenbergia porteri, M. arenicola, Setaria leucopila, S. grisebachii, Heteropogon contortus, Aristida purpurea, Sporobolus wrightii, Eragrostis cilianensis, Chloris virgata, Leptochloa dubia, Digitaria californica, Panicum obtusum*, and others.

This community occurs at FOBO on hillslopes of any aspect, usually footslopes and toeslopes, but can range up to crests. Gradients are 1–6% or 6–15%. The predominant surface cover, apart from the grass and grass litter, which may be dense, is generally gravel and rock. Soils are sandy loams to silty loams.



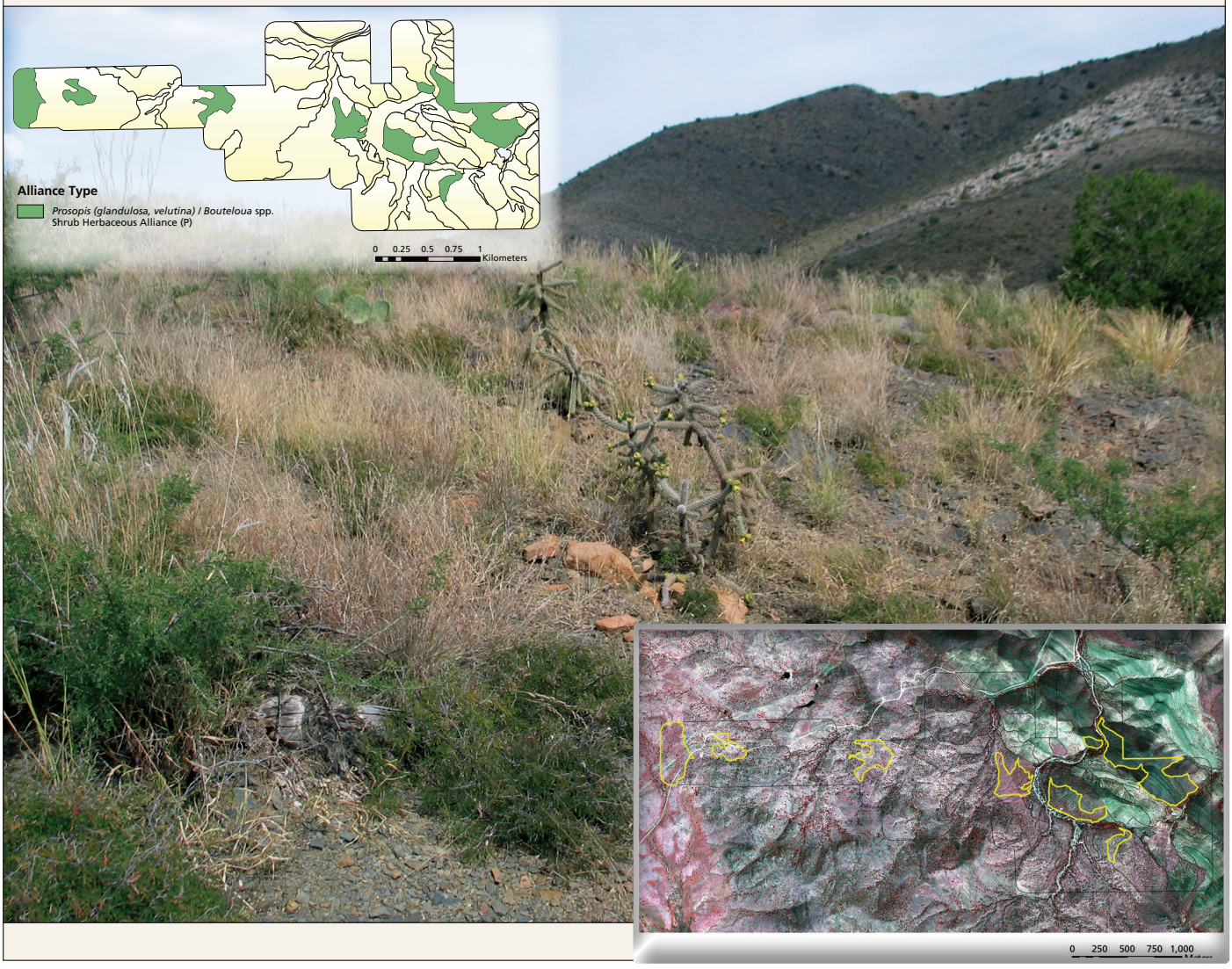
Prosopis (glandulosa, velutina) / Bouteloua spp. Shrub Herbaceous Alliance (P)

(Honey mesquite, Velvet mesquite) / Mixed grama species Shrub Herbaceous Alliance

Common species
Prosopis spp.
Rhus microphylla
Aloysia wrightii
Ericameria laricifolia
Fouquieria splendens
Bouteloua spp.

Prosopis (glandulosa, velutina) is most commonly the dominant woody species in this proposed alliance, growing as a shrub generally under 2 meters tall. *Rhus microphylla*, *Aloysia wrightii*, and *Ericameria laricifolia* are common shrub associates, and one of these species may actually dominate *Prosopis* in canopy cover. *Fouquieria splendens* is also a common associate. A number of other shrubs may be present with little cover, including *Mimosa aculeaticarpa* var. *biuncifera*, *Acacia greggii*, *Dasylirion wheeleri*, *Agave palmeri*, *Yucca baccata*, *Opuntia engelmannii*, *Ferocactus wislizenii*, *Cylindropuntia spinosior*, *Gutierrezia sarothrae*, *Calliandra eriophylla*, and others. A few trees may be present: *Juniperus monosperma*, *J. deppeana*, *J. coahuilensis*, *Pinus edulis*, *Quercus emoryi*, or other species. *Bouteloua* species and other grasses comprise more cover than the woody species. A complex of *Bouteloua curtipendula*, *B. gracilis*, *B. aristidoides*, *B. eriopoda*, *B. repens*, and *B. hirsuta* and other grasses usually makes up most of the herbaceous cover, but *Eragrostis lehmanniana* may be dominant in some stands.

This community is widespread at FOBO and occurs on the dissected hills, from crests to toeslopes, on all aspects. Gradients are usually gentle to 35%, but may be 35–50%. The predominant surface cover is most often gravel, sometimes rock. Soils are sandy loams, generally shallow and gravelly.

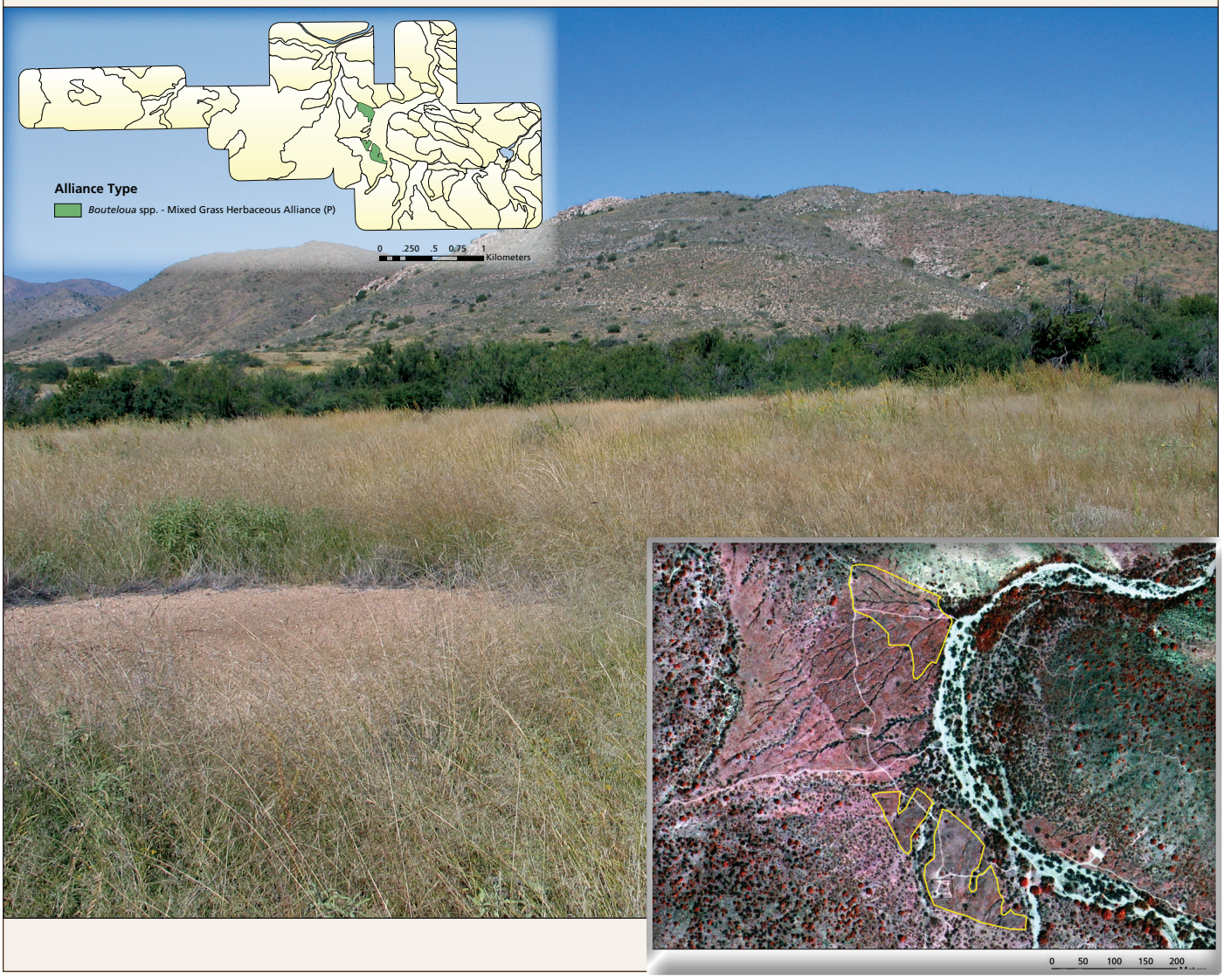


Bouteloua spp. - Mixed Grass Herbaceous Alliance (P)
Grama - Mixed Grass Herbaceous Alliance

This proposed alliance is dominated by grasses, generally with <10% cover of trees and shrubs, though some stands may have higher cover of weedy subshrubs, such as *Isocoma tenuisecta*, *Gutierrezia sarothrae*, *Salsola kali*, or *Amaranthus palmeri*. Total herbaceous canopy cover (not foliar cover), including subshrubs and forbs, is high, sometimes 90% or greater. A mix of *Bouteloua* species, possibly including *B. curtipendula, B. eriopoda, B. gracilis, B. hirsuta, B. repens*, or *B. chondrosioides*, is present, and is often collectively dominant. However, dominance is never clear and species composition varies among stands, and even among patches within stands. *Eragrostis lehmanniana* is present in most stands, and may be dominant or co-dominant with one or several other species.

Common species
Bouteloua spp.
Isocoma tenuisecta
Gutierrezia sarothrae
Salsola kali
Amaranthus palmeri

This grassland is found at FOBO on the toe of a broad, dissected fan, just above Siphon Canyon, in the area of the historical Butterfield stage route, the cemetery, and the current hiking trail from the parking lot to the fort ruins. In this area, some mesquite shrub clearing has been done in recent years. Slope gradients are gentle, at 0–6%, and the overall aspect is northeast. The predominant surface cover, apart from grass and grass litter, is gravel, with some bare soil and loose rock. Soils are sandy loams to silty loams, and relatively deep for this area.



3 Accuracy Assessment

3.1 Methods

Following NPS Vegetation Mapping Program guidelines for small parks under 300 ha, we conducted a census-based accuracy assessment (AA), rather than a sample-based one. Fort Bowie NHS Chief of Resources D. Foster and biological science technician T. Thompson carried out most of the accuracy assessment, with some done by SODN ecologist S. Studd and OALS researcher S. Drake.

These assessors were thoroughly briefed on the methods used for classification and mapping, and on the map classes. This was to ensure that the methods and thought processes used to evaluate each polygon for accuracy assessment were essentially the same as those used for classification and mapping, and that the assessment would be completed by objective, knowledgeable observers who were not part of the original mapping team. The briefing included discussion of plant lifeforms; familiarization with the NVC hierarchy and criteria for identifying formations, alliances and associations; techniques for estimating species cover classes by stratum; subtleties of visual interpretation of satellite imagery for evaluation of vegetation; use of the RECON GPS-linked handheld computer; and other necessary methods.

The assessors were provided with tools similar to those used by the mappers: a RECON unit loaded with draft map polygon boundaries, and printed map sections with each polygon labeled with a simple ID number. Also provided were a vegetation formation key (Appendix C), a set of map class descriptions (abbreviated versions of those in Appendix B), and datasheets (Appendix D) for recording AA data. These datasheets contained a checklist of the map classes at Fort Bowie NHS, and requested some additional descriptive data to guard against erroneously checking the wrong box.

The task of the assessors was to walk through each polygon and (1) evaluate the lifeform and canopy cover of the dominant species in each stratum, (2) consider the text descriptions of relevant vegetation types, and (3) assign the best-fitting map class name for the polygon on the datasheet. A rating of the goodness-of-fit (poor, good, or excellent) was also requested, as well as any notes or observations that might help interpretation of the assessment data. (These notes could include notes on the polygon boundary, but the assessor was asked to choose a class name for the polygon as mapped, considering the whole area of the polygon.) The AA was carried out intermittently between January and April 2010.

3.2 Results

Table 3-1 is an error matrix showing the results of the AA, including user's and producer's accuracy per class, overall accuracy for all classes (85.7%), and Kappa (83.7%), which is a measure of overall accuracy minus chance agreement. Of the 16 map classes, three had user's accuracy of less than 80%. However, the data used to create this matrix are somewhat misleading due to the small census size (i.e., the small number of polygons census for most types). A small census size often results in a high proportion of classes with measured accuracy of 100%. If those classes consist of only one polygon (which occurred three times in this case), overall accuracy is artificially inflated. Conversely, many classes drop below 80% accuracy if just one of the 2–4 polygons is misclassified. It should also be noted that each of the two "new" types, described as a result of new information gathered during accuracy assessment work, has a user's and producer's accuracy of 0%, because they did not exist prior to this work. They were included for the purpose of providing comprehensive results, but their inclusion reduced the accuracy from 91% to 85.7%.

In all, there were 13 discrepancies or mismatches between map class and AA field class (Table 3-2). Many of these resulted from the accuracy assessor's acknowledged difficulty in estimating species cover or relative cover of different lifeforms (e.g., trees vs. shrubs), rather than from errors of species identification or dominance. While the flora of Fort Bowie NHS is extremely diverse, the vegetation communities are less so, because

Table 3-1. Thematic accuracy assessment error matrix.

Map class	FRAVEL Forest and Woodland (P) 1	CELLAE-JUGMAJ Woodland (P) 2	PINEDU-JUN Woodland 3	QUEEMO-JUNMON Woodland (P) 4	Prosopis Wooded Shrubland (P) 5	JUNMON-QUEEMO Wooded Shrubland (P) 6	RHUMIC Shrubland 7	Prosopis Shrubland 8	QUETUR Shrubland 9	LARTRI Shrubland* 10	FOUSPL/PARINC Shrubland 11	FOUSPL/OPUENG Shrubland (P) 12	QUEEMO/Bouteloua Wooded Herbaceous 13	RHUMIC/Bouteloua ssp. Shrub Herbaceous* (P) 14	Prosopis/Bouteloua Shrub Herbaceous (P) 15	Bouteloua-Mixed Grass Herbaceous (P) 16	Total	User's accuracy
1	3																3	100%
2		1															1	100%
3			2														2	100%
4				6													6	100%
5					1												1	100%
6				1		21	1						1				24	88%
7							6			2	1						9	67%
8							1	10									11	91%
9									1								1	100%
10										0							0	0%
11											10						10	100%
12												2			1		3	67%
13													3				3	100%
14														0			0	0%
15											1			4	8		13	62%
16																4	4	100%
Producer's accuracy	100%	100%	100%	86%	100%	100%	75%	100%	100%	0%	83%	100%	75%	0%	89%	100%	78	1,015
																Overall accuracy		**0.857**
																Khat		**0.837**

*Rose-shaded rows represent types added following the accuracy assessment.

See Table 2-3 for map class abbreviations.

many species have wide ranges across the entire park. However, while the park is relatively small, the complex topography, land-use history, and varied geoedaphic properties lead to many potential variations in vegetation communities, based mostly on variation in abundances or relative dominance of species, rather than large differences in species composition, which is the main driver of vegetation classification and mapping.

It became apparent during validation work prior to accuracy assessment that some of our preliminary vegetation formations and alliances shared many of the same species, and separating them in the field was sometimes difficult. Because the mapping and accuracy assessment at Fort Bowie NHS were both census-based, we decided that the best course of action would be to examine and resolve all of the mismatches and correct the map to achieve essentially 100% accuracy for each class. The adjustments are described in Appendix E.

3.3 Resolution of accuracy assessment discrepancies

The discrepancies between the map data and AA reference data shown in Table 3-2 were all investigated and resolved. The original datasheets from both polygon surveys and classification plots were reviewed again, along with other field notes and photographs. In most cases, the AA data were demonstrated to be correct and the map was changed accordingly. In other cases, the map data were found to correctly describe the structural formation but the AA data correctly identified the most dominant shrub species (Polygons SS02, 03, 11 and 15). In those cases, the map classes were changed to reflect the corrected information.

Two new types were described after the accuracy assessment was complete. Although this is an unusual procedure, the mapping team determined it to be the best solution after data review and a subsequent field visit by the map producers. The first new type described was a *Larrea tridentata* Shrubland association that was clearly identified on the ground in two small areas (2 and 3 acres) during AA but for which no plot data were collected due to the random location of plots. Instead, this type had been included into other polygons during field mapping. Both sites occurred just beyond the park's eastern boundary—beyond which this vegetation type increases, becoming dominant where the topography flattens into alluvial surfaces. Both polygons are outside the park boundary but within the project bounds. For this reason, and because the type is locally abundant, the polygons were modified and attributed with this new type.

In the second type modification, a *Rhus microphylla* / *Bouteloua* spp. Shrub Herbaceous Alliance was described and applied to four polygons previously mapped as *Prosopis velutina* / *Bouteloua* spp. Shrub Herbaceous. The need for this clarification was unsurprising, as both shrub species (*P. velutina* and *R. microphylla*) were present in all polygons to varying degrees of cover and dominance. In these cases, it was determined, upon further review of all data sources, that these stands would be more properly classified as a *Rhus* shrub herbaceous type. Appendix E explains each case in turn, with reference to polygons by the ID numbers provided in Table 3-2.

Finally, as a result of the AA final decisions, some adjacent polygons were attributed with the same vegetation and structural types. These adjacent polygons were subsequently merged, with the attributes and polygon ID taken (by default) from the largest polygon of those being merged.

These post-AA modifications resulted in a revised total of 74 polygons. All changes made were documented (Appendix E) and a copy of the pre-merge polygons was archived with all other data.

3.4 Spatial accuracy assessment

The U.S. National Map Accuracy Standards (NMAS) for spatial or positional accuracy stipulate that no more than 10% of tested points on a 1:24,000-scale map can be in error by more than 0.51 mm (0.02 inch), or 12.2 m (40 feet) ground distance. The revised National Cartographic Standards for Spatial Accuracy (NCSSA) state accuracy as a root mean square error (RMSE) in the x- and y-coordinate directions, rather than as a circular error with a 90% confidence level (as is indirectly implied by the NMAS of 1947). For a Class 1 product of 1:24,000 scale, the maximum allowable RMSE is 6.0 meters (20

Table 3-2. Cases of mismatch between map class and accuracy assessment field class.

Polygon ID	AA ID	Original map class	AA field class	Final type name
WS02	63	[*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance	*Quercus emoryi* / *Bouteloua* spp. Wooded Herbaceous	*Quercus emoryi* / *Bouteloua* spp. Wooded Herbaceous
WS11	68	[*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance	*Rhus microphylla* Shrubland Alliance	*Rhus microphylla* Shrubland Alliance
WS117	98	[*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance	*Quercus emoryi - Juniperus monosperma* Woodland Alliance	*Quercus emoryi - Juniperus monosperma* Woodland Alliance
S22	32	*Rhus microphylla* Shrubland Alliance	no box checked (*Larrea tridentata* shrubland:new type)	*Larrea tridentata* Shrubland
S25	34	*Rhus microphylla* Shrubland Alliance	no box checked (*Larrea tridentata* shrubland:new type)	*Larrea tridentata* Shrubland
S51	283	*Rhus microphylla* Shrubland Alliance	*Fouquieria splendens* / *Parthenium incanum* Shrubland	*Fouquieria splendens* / *Parthenium incanum* Shrubland
S41*	40	*Prosopis* (*glandulosa, velutina*) Shrubland Alliance	[*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance	[*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance
SS09*	52	*Prosopis* (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance	*Fouquieria splendens* / *Parthenium incanum* Shrubland	*Fouquieria splendens* / *Parthenium incanum* Shrubland
SS02	11	*Prosopis* (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance	*Bouteloua* - Mixed Grass Herbaceous Alliance	*Rhus microphylla* / *Bouteloua* spp. Shrub Herbaceous Alliance
SS03*	12	*Prosopis* (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance	*Rhus microphylla* Shrubland Alliance	*Rhus microphylla* / *Bouteloua* spp. Shrub Herbaceous Alliance
SS11	35	*Prosopis* (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance	*Fouquieria splendens* / *Opuntia engelmannii* Shrubland	*Rhus microphylla* / *Bouteloua* spp. Shrub Herbaceous Alliance
SS15	285	*Prosopis* (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance	*Rhus microphylla* Shrubland Alliance	*Rhus microphylla* / *Bouteloua* spp. Shrub Herbaceous Alliance
S10	25	*Fouquieria splendens* / *Opuntia engelmannii* Shrubland	*Prosopis* (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance	*Prosopis* (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance

*Area was merged into an adjacent area sharing the same type name. These polygons do not appear in the final map.
AA ID numbers listed here are arbitrarily assigned for reference during the accuracy assessment.

ft) ground distance; for a Class 2 product, the RMSE must be no more than 12.0 meters (39 ft). For digital products with no set scale, the reference to a 1:24,000 standard scale loses direct relevance, but the implied ground distances can still be used as benchmarks.

The positional accuracy measured is that of "well-defined points" on the map; that is, discrete features that can be clearly identified and located in the map product as well as the source of higher accuracy used for comparison (the reference data). Boundaries subject to interpretive judgment or certain natural boundaries subject to environmental fluctuations (e.g., river banks) generally do not qualify as well-defined points, even if they form intersections. Because vegetation boundaries are nearly always interpretive, positional accuracy statements for the Fort Bowie NHS vegetation map do not directly apply to the primary mapped features in the product, but instead should be understood to indicate how well the map product is registered (geocoded) to its control, and not to indicate how well the vegetation polygon boundaries reflect their true positions on the ground (ESRI et al. 1994).

For this project, the highest-accuracy spatial reference data available were a set of DOQQs from 1992; our spatial accuracy measurements were performed in comparison with these. Across the park, 20 test points were selected that were small, discrete, and could be definitively located in both the base satellite imagery used for mapping and in the DOQQs. Most of these were individual shrub canopies against a contrasting background. The georeferencing tool in ArcGIS was used to visually select point pairs (one in the imagery and a corresponding one in the DOQQ), record coordinates, and calculate an overall RMSE. MS Excel was used to calculate additional error values (Table 3-3) from the point coordinates.

Table 3-3. Spatial accuracy assessment summary, Fort Bowie NHS.

Highest error values*		RMS error**		
Max-X	Max-Y	RMS-X	RMS-Y	RMS-Total
-3.2762 m	1.6757 m	1.8797 m	1.1482 m	0.9887 m

Values are meters, ground distance. Twenty test points were used.
*Standard = 12.2 m
**Standard for Class 1 products = 6 m

As shown in Table 3-3, the Fort Bowie NHS vegetation map easily met the spatial accuracy standards for a Class 1 product. Features were estimated to lie within two meters of their "true" position on the DOQQ reference imagery, with an average RMSE of 1.88 m and 1.14 m for X and Y ground coordinates, respectively. None of the test points approached the 12-m error allowable (for 10% of tested points) under the NMAS, and the average measured RMSE of 1.88 meters was well below the 6-m limit imposed by the NCSSA.

4 Discussion

4.1 Vegetation characterization

Situated as it is on a mountain pass, the vegetation of Fort Bowie NHS represents an intermingling of the Sky Island flora of the nearby Chiricahua Mountains, above, and the lower desert, grassland, and semi-desert grassland areas, below. As such, the park's vegetation communities possess ecotonal qualities of each of these different physiological and floristic regions. This intermingling made this project challenging, because the several dominant species (Emory oak, mesquite, and one-seed juniper; *Quercus emoryi*, *Prosopis* spp., and *Juniperus monosperma*) were widespread and their ranges intergraded across and between different physiognomic (structural) expressions of the types, making identification, separation, classification, and mapping of similar vegetation units difficult. The inventory team attempted to ensure that these differences were reflected in the structural characteristics identified in the map by inclusively naming formation types (e.g., wooded shrubland versus shrubland or woodland). In these instances, we tried to identify additional diagnostic key species to aid in differentiating the formations.

The accuracy assessment team faced similar challenges—specifically, (1) the difficulty of assessing the relative dominance/cover of Emory oak, mesquite, and one-seed juniper from the understory mixture of many mixed shrubs, and (2) determining the lifeform abundances of species that can grow in both tree and shrub form (e.g., mesquite as both shrub and short tree). Still, the final overall accuracy was very good, at 85.7%, and reflected the benefits of being able to census (rather than sample) the study area.

4.2 Mixed semi-desert grassland communities

Desert grasslands, or "semi-desert grasslands," are one of the most interesting and widespread communities at Fort Bowie NHS, with a characteristic mix of growth forms comprising perennial grasses, succulents, subshrubs, shrubs, and, often, trees (Burgess 1995). The overarching classification of semi-desert grassland fits the Fort Bowie NHS landscape well, yet presents difficulties when we attempt to classify vegetation according to both floristic and structural characteristics. In this case, one-third of the total study area was mapped as herbaceous-dominated communities, with either scattered trees or shrubs (wooded or shrub herbaceous types). These systems are inherently variable, supporting an arguably unstable mix of growth forms that can shift in dominance over climatic wet and dry periods, favoring grasses during wet periods and deeper-rooted shrubs during prolonged drought (Burgess 1995). The grassland systems of Fort Bowie NHS have also been degraded by prolonged historical uses (primarily grazing) during the fort's heyday (Warren 1992) and invaded by the non-native African perennial, Lehmann lovegrass (*Eragrostis lehmanniana*). However, the grasslands still boast a rich diversity and are dominated, parkwide, by the grama complex (*Bouteloua* spp.) that extends eastward to the grasslands of New Mexico and Texas. Hubbard and others (2010) found that while Lehmann lovegrass is widely distributed at low abundance, native perennials are far more abundant than this exotic.

Semi-desert grassland formation types are commonly considered to be endangered, degraded, or at risk from shrub encroachment (Brown and Archer 1999; Burgess 1995; Harris 1966), particularly by mesquite. Mesquite-dominated communities covered 19% of the study area, split more or less equally between shrubland and shrub herbaceous (shrub savanna) formation types. The park has a history of mesquite eradication efforts, including cutting trees and spraying herbicide, mostly in the central grasslands (Hubbard et al. 2010). However, the mesquite shrublands of Fort Bowie NHS are of mixed-shrub composition. While mesquite typically has the greatest cover, other shrubs and trees, collectively, often approach equal ranking (Figure 4-1, next page). These include juniper (*Juniperus monosperma and Juniperus coahuilensis),* hackberry (*Celtis laevigata* var. *reticulata*), oaks (*Quercus emoryi* and *Q. turbinella*), and shorter-statured shrubs, such as turpentine bush (*Ericameria laricifolia*), little-leaf sumac (*Rhus microphylla*), winterfat (*Krascheninnikovia lanata*), mariola (*Parthenium incanum*), and catclaw mimosa (*Mimosa aculeaticarpa* var. *biuncifera*). This mixed community is more indicative of typical desert scrub than an invaded grassland system.

Conversely, the areas mapped as *Prosopis* (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance had a much lower tall-shrub component overall, with a higher percentage



Figure 4-1. Mesquite-dominated shrubland at Fort Bowie National Historic Site.



Figure 4-2. Semi-desert grassland community with mesquite.



Figure 4-3. Ocotillo / Mariola Shrubland community.

contributed by succulents, subshrubs, and perennial bunchgrasses. These areas have consistent distribution of mesquite, but the trees are usually less than two meters tall and are often obscured by dense grasses, sotol (*Dasylirion wheeleri*), pricklypear (*Opunita engelmannii*), and banana yuccas (*Yucca baccata*) (Figure 4-2).

4.3 Woody communities

At Fort Bowie NHS, oak and juniper dot the entire landscape and are present in all but a few areas of the park. Approximately 32% of the park area was mapped as [*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance. An additional 19% was mapped as *Quercus emoryi* / *Bouteloua* spp. Wooded Herbaceous and 5% as *Quercus emoryi - Juniperus monosperma* Woodland Alliance. These three types are essentially different expressions of the same dominant woody species whose understory composition changes with landform, aspect, and soil parent material. These species have affinities to the Madrean floristic province. As one moves into the higher elevations of the nearby Chiricahua Mountains, oak woodlands dominate the landscape.

The small strips of riparian woodland and forest lining the banks of Siphon Canyon and Willow Gulch contribute to a species-rich, complex environment that includes walnut (*Juglans major*), willow (*Salix gooddingii*), and hackberry. Individual trees reaching up to 10 meters tall line the banks of the wide, open, ephemeral wash. In the smaller, neighboring drainages, ash (*Fraxinus velutina*) and gum bumelia (*Sideroxlon lanuginosum*) mix with Arizona white oak (*Quercus arizonica*) and hackberry to form dense canopies and rich understory vegetation. While only 5% of the total site area, these are critically important areas for supporting the more mesic species, such as canyon grape (*Vitus arizonica*), graythorn (*Ziziphus obtusifolia*), and other herbaceous species. They also provide critical habitat for birds and mammals.

The fault lines of the park contribute to a generally NW–SE-trending ridgeline that extends from

the visitor center across Siphon Canyon and to the northern edge of the park. Along this ridge, limestone-dominated slopes support distinct ocotillo (*Fouquieria splendens*) stands that visually dominate the subcanopy layers and tower over mariola, winterfat, and pricklypear patches (Figure 4-3). These Ocotillo / Mariola Shrublands are found on specific soil types, preferring the more calcareous rocky slopes above the fort.

4.4 National Vegetation Classification System placement

Seven of the 16 community types had accepted corollaries within the NVCS at time of writing. This number is expected to increase in future years as the NVCS is refined and the inclusion of more data leads to new type descriptions. Of the seven types, four are actually "old" alliance codes that represent recognized and described alliances under the first iteration of the NVC hierarchy; these do not have more recent association counterparts under the revised hierarchy and have been left as alliances (rather than SODN-specific alliance codes) in order to provide the former regional description rather than having no broader description at all. The other three are current, accepted associations that fall under the group listings in the revised hierarchy.

The NVC "Elcodes" or SODN placeholder codes (for those currently unaccepted types) are shown in Table 4-1 and are included in the full community descriptions in Appendix B.

4.5 The flora

As was noted by Warren (1992) and McLaughlin (1994), the flora of Fort Bowie NHS has diverse affinities driven by its geographic location, various geologic substrates, the presence of permanent water at Apache Spring, and the ephemeral riparian corridor. As a result of the data collection undertaken during this project and subsequent research, the species occurrence list has been revised to include 78 families and 598 species (including 72 subspecies and varieties) (SODN unpublished data). During this effort, a total of 197 species were observed during plot and polygon sampling. A full list of species recorded during this project is provided in Appendix F.

A Fort Bowie NHS plant field guide has been developed as a companion product to the vegetation map and report. The plant guide lists the vegetation community types in an abbreviated format, at the front of the guide. Detailed descriptions and photographs of each species known to the park follow, arranged by lifeform and then by family. The species list that serves as the basis for the field guide, developed in part through the effort described in this report, is available at http://swbiodiversity.org/seinet/checklists/checklist.php?cl=2528&proj=5, through the Southwest Environmental Information Network. Final PDF versions of the plant guide will be available through the SODN website at http://science.nature.nps.gov/im/units/sodn/inventory/floraproject.cfm.

4.6 Final products and geodatabase delivery

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

All final products, including this report and the geodatabase, are available for download and viewing from the NPS Data Store and from the USGS-NPS Vegetation Characterization Program website at http://www.usgs.gov/core_science_systems/csas/vip/index.html. Spatial map data products can be viewed without downloading via the NPS vegetation inventory map viewer http://science.nature.nps.gov/im/inventory/veg/mapviewer/mapviewer.html or by searching by park or geographic area. Data can also be requested direct from the SODN offices or accessed via the SODN website under the inventory reports tab http://science.nature.nps.gov/im/units/sodn/digital_library.cfm.

Table 4-1. Final vegetation community types listed with their accepted NVC association codes or SODN placeholder codes.

Map class/Community name	Common name	NVC Version 1 code	NVC Version 2 code
Woodland			
Fraxinus velutina Forest and Woodland Alliance (P)	Velvet ash Forest and Woodland Alliance	NPSSODN019	---
Celtis laevigata var. *reticulata* - *Juglans major* Woodland (P)	Netleaf hackberry - Arizona walnut Woodland	NPSSODN020	---
Pinus edulis - *Juniperus* spp. Woodland Alliance	Two-needle pinyon - Juniper spp. Woodland Alliance	A.516	---
Quercus emoryi - *Juniperus monosperma* Woodland Alliance (P)	Emory oak - One-seed juniper Woodland Alliance	NPSSODN023	---
Wooded Shrubland			
Prosopis (*glandulosa, velutina*) Wooded Shrubland Alliance (P)	Mesquite (honey/velvet) Wooded Shrubland Alliance	NPSSODN022	---
[*Juniperus monosperma* - *Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance (P)	[One-seed juniper - Emory oak] / Mixed Shrub Wooded Shrubland Alliance	NPSSODN024	---
Shrubland			
Rhus microphylla Shrubland Alliance	Littleleaf sumac Shrubland Alliance	A.1040	---
Prosopis (*glandulosa, velutina*) Shrubland Alliance	Mesquite (honey/velvet) Shrubland Alliance	A.1043	---
Quercus turbinella Shrubland Alliance	Sonoran scrub oak Shrubland Alliance	A.793	---
Larrea tridentata Shrubland	Creosote bush Shrubland		CEGL005145
Fouquieria splendens / *Parthenium incanum* Shrubland	Ocotillo / Mariola Shrubland		CEGL001378
Fouquieria splendens / *Opuntia engelmannii* Shrubland (P)	Ocotillo / Engelmann's pricklypear Shrubland	NPSSODN016	
Herbaceous			
Quercus emoryi / *Bouteloua* spp. Wooded Herbaceous	Emory oak / Mixed grama Wooded Herbaceous		CEGL000683
Rhus microphylla / *Bouteloua* spp. Shrub Herbaceous Alliance (P)	Littleleaf sumac / Mixed grama Shrub Herbaceous Alliance	NPSSODN018	
Prosopis (*glandulosa, velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance (P)	Mesquite (honey/velvet) / Mixed grama Shrub Herbaceous Alliance	NPSSODN017	
Bouteloua spp. - Mixed Grass Herbaceous Alliance (P)	Grama spp. Mixed grass Herbaceous Alliance	NPSSODN021	

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Appendix A. Dichotomous Key to Mapped Vegetation Types

1a	Forest or Woodland dominated by *Fraxinus velutina*, with such associated tree species as *Salix gooddingii*, *Juglans major*, *Sideroxylon lanuginosum* (gum bumelia or gum bully), *Juniperus coahuilensis*, *Celtis laevigata* var. *reticulata* and *Quercus arizonica*. ***Fraxinus velutina* Forest and Woodland Alliance**
1b	Vegetation not as above. **(2)**
2a	Woodland vegetation, with trees the dominant lifeform and having 10–60% canopy cover **(3)**
2b	Not a woodland; community is dominated by shrubs or herbaceous vegetation **(6)**
3a	Woodland dominated by *Celtis laevigata* var. *reticulata* and *Juglans major*, with shorter *Salix gooddingii* generally present. A number of other tree species may also occur, including *Prosopis glandulosa*, *Quercus emoryi*, *Sideroxylon lanuginosum*, and *Juniperus monosperma*. ***Celtis laevigata* var. *reticulata* - *Juglans major* Woodland**
3b	Vegetation not as above. **(4)**
4a	Woodland dominated by *Pinus edulis* and *Juniperus monosperma*, with other tree species generally absent. A diversity of shrub species may be present, but tree cover exceeds shrub cover. ***Pinus edulis* - *Juniperus* spp. Woodland Alliance**
4b	Vegetation not as above. **(5)**
5a	Woodland generally dominated by *Quercus emoryi*, *Q. grisea,* or *Q. arizonica* with *Juniperus monosperma* or *J. coahuilensis*. *Prosopis glandulosa* is a common associate, and others may include *Sideroxylon lanuginosum, Quercus toumeyi, Juniperus deppeana, Quercus turbinella,* and *Pinus discolor*. In stands occurring in intermittently flooded canyon bottoms, riparian associates, such as *Celtis laevigata* var. *reticulata* and *Juglans major*, are often present, while upland stands lack these species. Shrub species diversity is usually high and total shrub cover may be significant, but is less than tree cover and no one shrub species contributes more than 5% cover. ***Quercus emoryi* - *Juniperus monosperma* Woodland Alliance**
5b	Vegetation not as above. **(6)**
6a	Community dominated by shrubs, with or without significant tree or herbaceous cover **(7)**
6b	Community dominated by herbaceous vegetation, with or without significant tree or shrub cover. **(12)**
7a	Shrubs dominant, but with tree cover (generally *Juniperus monosperma* and *Quercus emoryi*) >10%. Shrub species composition is diverse and highly variable. The dominant may be *Quercus turbinella*, *Prosopis glandulosa*, *Rhus microphylla*, *Nolina microcarpa*, *Mimosa aculeaticarpa* var. *biuncifera*, *Ericameria laricifolia*, *Arctostaphylos pungens*, or another species. Note: This type is similar in species composition to the *Quercus emoryi* - *Juniperus monosperma* Woodland Alliance and is distinguished by having much lower tree cover (usually between 10% and 20%) and greatly increased shrub cover (usually 30–60%). Native perennial bunchgrasses can also provide substantial cover. **[*Juniperus monosperma* - *Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance**
7b	Vegetation not as above. **(8)**
8a	Shrubs dominant but with *Prosopis glandulosa* and/or *Prosopis velutina* trees comprising ~30–35% canopy and sub-canopy cover. The shrub layer is co-dominated by *Rhus microphylla* and occasional individuals of *Condalia warnockii*, *Lycium pallidum*, and *Zizphus obtusifolia*. Grasses have low diversity and low cover, with *Setaria leucopila* the dominant species; grama grasses (*Bouteloua* sp.) are notably absent or nearly so. This type has a "weedy" herbaceous component with non-natives Lehmann lovegrass and horehound both present. ***Prosopis (glandulosa/velutina)* Wooded Shrubland Alliance**
8b	Vegetation not as above. **(9)**

9a	Shrubland dominated by *Rhus microphylla*, possibly closely co-dominated by other shrub species such as *Parthenium incanum, Aloysia wrightii, Prosopis glandulosa*, *Larrea tridentata, Cercocarpus montanus,* or *Condalia warnockii*. A variety of associate shrubs may be present, including *Fouquieria splendens, Krascheninnikovia lanata, Ceanothus greggii, Yucca baccata, Ziziphus obtusifolia, Agave palmeri, Dasylirion wheeleri, Rhus trilobata, Dalea formosa*, *Gutierrezia sarothrae, Ericameria laricifolia, Nolina microcarpa*, *Cylindropuntia spinosior,* and others. *Bouteloua curtipendula*, *Tridens muticus*, and *Aristida purpurea* are common grasses in this type often providing >10% cover. *Pinus edulis* and *Juniperus monosperma* are occasional trees. ***Rhus microphylla* Shrubland Alliance**
9b	Vegetation not as above. **(10)**
10a	Shrubland dominated by *Prosopis glandulosa* or *P. velutina* having a shrubby lifeform and heights generally less than 2 m. Some individuals may have a tree lifeform and height to about 5 m, and scattered individuals of other tree species may be present. Common associate shrubs, such as *Rhus microphylla, Krascheninnikovia lanata, Parthenium incanum, Ericameria laricifolia*, and *Mimosa aculeaticarpa* var. *biuncifera*, may contribute significant cover, approaching that of the dominant and consistently distributed *Prosopis spp*. ***Prosopis (glandulosa, velutina)* Shrubland Alliance**
10b	Vegetation not as above. **(11)**
11a	Shrubland dominated by *Quercus turbinella*, possibly with *Garrya wrightii* co-dominant. Trees such as *Juniperus monosperma* or *Quercus emoryi* may be present with <5% cover. Associated shrub species may include *Mimosa aculeaticarpa* var. *biuncifera, Prosopis glandulosa, Yucca baccata, Agave palmeri, Cylindropuntia spinosior, Opuntia engelmannii, Nolina microcarpa, Ericameria laricifolia, Arctostaphylos pungens, Dasylirion wheeleri, Ferocactus wislizenii, Fouquieria splendens*, and others. ***Quercus turbinella* Shrubland Alliance**
11b	Vegetation not as above. **(12)**
12a	Shrubland with *Larrea tridentata* as the dominant sub-canopy height species with between 10% and 35% cover. Other shrubs, such as *Parthenium incanum*, *Prosopis* sp., *Aloysia wrightii*, and *Calliandra eriophylla*, can in places have cover up to 10%. *Yucca baccata*, *Dasyliron wheeleri*, and *Opuntia engelmannii*, along with native bunchgrasses, each contribute a few percent cover. ***Larrea tridentata* Shrubland Alliance**
12b	Vegetation not as above **(13)**
13a	Shrubland characterized by a prominent stand of *Fouquieria splendens*, with an "understory" dominated by *Parthenium incanum*, possibly co-dominant with *Rhus microphylla, Aloysia wrightii*, or another species. A number of other shrub species are generally present, but trees are few or absent. ***Fouquieria splendens* / *Parthenium incanum* Shrubland**
13b	Shrubland characterized by a prominent stand of *Fouquieria splendens*, with an "understory" dominated by *Opuntia engelmannii*, possibly co-dominant with *Acacia greggii, Prosopis glandulosa* (or *P. velutina*), *Calliandra eriophylla*, or another species. A number of other shrub and grass species are generally present, but trees are few or absent. ***Fouquieria splendens* / *Opuntia engelmannii* Shrubland**
14a	Community is dominated by diverse herbaceous vegetation, with tree cover greater than 10%, with or without significant shrub cover. *Quercus emoryi* provides on average 18% cover but other tree species are often present in low abundance, such as *Juniperus monosperma, Quercus arizonica*, and *Pinus edulis*. A mixture of *Bouteloua* species dominates the field layer. ***Quercus emoryi* / *Bouteloua* spp. Wooded Herbaceous**
14b	Community is dominated by herbaceous vegetation, with tree cover less than 10%, with or without significant shrub cover. **(15)**

15a	Grassland generally dominated by a complex of *Bouteloua* species and other grasses, or *Eragrostis lehmanniana*. A shrub component is present with greater than 10% cover, generally dominated by shrubby *Prosopis glandulosa* or *P. velutina*, possibly co-dominant with *Rhus microphylla*, *Aloysia wrightii*, or *Ericameria laricifolia*. A number of other shrub associates may be present. ***Prosopis (glandulosa, velutina) / Bouteloua* spp. Shrub Herbaceous Alliance**
15b	Vegetation not as above **(16)**
16a	Grassland generally dominated by a complex of *Bouteloua* species and other grasses, and with *Rhus microphylla* shrubs regularly distributed throughout with on average 8% cover. Other shrubs together are common associates in this type and include *Fouquieria splendens* and *Prosopis* spp. ***Rhus microphylla / Bouteloua* spp. Shrub Herbaceous Alliance**
16b	Grassland generally dominated by a complex of *Bouteloua* species and other grasses, or *Eragrostis lehmanniana*, with tree and shrub cover less than 10%. Some stands may have higher cover of weedy subshrubs, such as *Isocoma tenuisecta*, *Gutierrezia sarothrae*, *Salsola kali*, and *Amaranthus palmeri*. ***Bouteloua* spp. - Mixed Grass Herbaceous Alliance**

Appendix B. Vegetation Type Descriptions

This appendix includes information on the 16 vegetation types that were identified and mapped at Fort Bowie National Historic Site between 2008 and 2010. All information not identified as specific to Fort Bowie NHS was collected from NatureServe Explorer (http://www.natureserve.org/explorer/) or from the U.S. National Vegetation Classification 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

Fraxinus velutina Forest and Woodland Alliance (P)
Celtis laevigata var. *reticulata - Juglans major* Woodland (P)
Pinus edulis - Juniperus spp. Woodland Alliance
Quercus emoryi - Juniperus monosperma Woodland Alliance (P)

Wooded Shrubland

Prosopis (*glandulosa/velutina*) Wooded Shrubland Alliance (P)
[*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance (P)

Shrubland

Rhus microphylla Shrubland Alliance
Prosopis (*glandulosa /velutina*) Shrubland Alliance
Quercus turbinella Shrubland Alliance
Larrea tridentata Shrubland
Fouquieria splendens / *Parthenium incanum* Shrubland
Fouquieria splendens / *Opuntia engelmannii* Shrubland (P)

Herbaceous

Quercus emoryi / *Bouteloua* spp. Wooded Herbaceous
Rhus microphylla / *Bouteloua* spp. Shrub Herbaceous Alliance (P)
Prosopis (*glandulosa /velutina*) / *Bouteloua* spp. Shrub Herbaceous Alliance (P)
Bouteloua spp. Mixed Grass Herbaceous Alliance (P)

Woodland

Fraxinus velutina Forest and Woodland Alliance (P)

Translated Name: Velvet ash Forest and Woodland Alliance
NatureServe Code: Data not available. NPS code is NPSSODN019

NOTE: Similar to CEGL003729 *Salix goodingii - Fraxinus velutina* Temporarily Flooded Woodland. However, this type is currently only described from Texas and New Mexico.

Summary

Globally— Data are not available.

Fort Bowie National Historic Site— This mostly deciduous riparian forest or woodland is dominated by *Fraxinus velutina*, with less cover of such associated tree species as *Salix gooddingii*, *Juglans major*, *Sideroxylon lanuginosum* (gum bumelia or gum bully), *Juniperus coahuilensis, Celtis laevigata* var. *reticulata,* and *Quercus arizonica*. The tree canopy is generally 5–6 meters tall and comprises 50–70% cover. Beneath the tree canopy is a diverse layer of 2–4-m tall shrubs and small trees, with no species consistently dominant. *Quercus turbinella* is commonly found with such species as *Rhus microphylla, Prosopis glandulosa, Celtis laevigata* var. *reticulata*, *Sideroxylon lanuginosum, Garrya wrightii, Vitis arizonica*, *Arctostaphylos pungens, Rhus virens, Sapindus saponaria,* and others. The subcanopy (0.5–2 m) and field (0–0.5 m) layers are also well populated and diverse, but comprise less aggregate cover than the canopy. Species present may include those already mentioned plus shorter shrubs, such as *Ericameria laricifolia, Mimosa aculeaticarpa* var. *biuncifera, Isocoma tenuisecta, Gutierrezia sarothrae, Agave palmeri, Baccharis sarothroides, Parthenium incanum, Anisacanthus thurberi, Aloysia wrightii, Brickellia californica*, and others. Common grasses include *Bouteloua* species, *Eragrostis lehmanniana, Bothriochloa barbinodis*, and *Heteropogon contortus*, and other grass species may be present.

Classification

Classification Comments: Globally— Data are not available.

Fort Bowie National Historic Site— This description is based on 2008 field data (0 classification plots and 3 censused polygons).

Vegetation Hierarchy

Formation Class	II Woodland
Formation Subclass	II.B Deciduous woodland
Formation Group	II.B.2 Cold-deciduous woodland
Formation Subgroup	II.B.2.N Natural/Semi-natural cold-deciduous woodland
Formation Name	II.B.2.N.b Temporarily flooded cold-deciduous woodland
Alliance Name	*Fraxinus velutina* Forest and Woodland Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

Distribution

Globally— Data are not available.

Fort Bowie National Historic Site— This type was found in 3 polygons: FW-FV01, FW-FV02, FW-FV03.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This community occurs in intermittently flooded drainages with relatively high soil moisture. Slopes may be gentle or steep, and aspect is variable. The predominant surface cover in the mostly narrow channels is gravel, rock and bedrock outcrop, with high litter cover on the wooded banks.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	*Fraxinus velutina, Salix gooddingii, Juglans major*
Canopy (2–5 m)	*Sideroxylon lanuginosum, Quercus turbinella, Juniperus coahuilensis*
Subcanopy (0.5–2 m)	*Quercus turbinella, Rhus microphylla, Prosopis glandulosa*
Field (0–0.5m)	*Ericameria laricifolia, Isocoma tenuisecta, Gutierrezia sarothrae*

Other Noteworthy Species

Celtis laevigata var. *reticulata*, *Rhus microphylla*, *Vitis arizonica*

Element Sources

Global Description Authors: Data are not available.

Local Description Authors: B. Fallon, L. Crumbacher, and S. Drake.

References:

Celtis laevigata var. *reticulata - Juglans major* Woodland (P)

Translated Name: Netleaf hackberry - Arizona walnut Woodland
NatureServe Code: Data not available. NPS code NPSSODN020.

NOTE: Similar to CEGL005955 *Juglans major - Celtis laevigata* var. *reticulata*/ *Brickellia californica Forest*. However, this type is currently only described from New Mexico.

Summary

Globally— Data are not available.

Fort Bowie National Historic Site— This proposed association is dominated by tall (9–10-m) *Celtis laevigata* var. *reticulata* and *Juglans major*, with shorter (5-m) *Salix gooddingii*. A number of other tree species may also occur, roughly 4–5 m in height, including *Prosopis glandulosa*, *Quercus emoryi*, *Sideroxylon lanuginosum,* and *Juniperus monosperma*. The canopy and subcanopy layers are occupied by saplings of the tree species mentioned, with such shrubs as *Rhus microphylla, Mimosa aculeaticarpa* var. *biuncifera, Sapindus saponaria, Ziziphus obtusifolia, and Arctostaphylos pungens*. The field layer commonly contains a mix of grasses and short shrubs. These may include *Bouteloua* species, *Setaria leucopila, S. grisebachii, Panicum hirsutum, Eragrostis lehmanniana, Muhlenbergia arenicola, M. emersleyi, Bothriochloa barbinodis, Sporobolus wrightii, Aristida ternipes, Isocoma tenuisecta, Gutierrezia sarothrae, Acourtia wrightii, Opuntia engelmannii*, and others.

Classification

Classification Confidence: Data are not available.
Classification Comments: Globally— A Celtis laevigata var. reticulata Woodland Alliance has been described, A.632, as has a Juglans major - Celtis laevigata var. reticulata / Brickellia californica Forest association (CEGL005955). The latter is similar to the FOBO type but has been written to describe the type as it occurs in New Mexico, and is not strictly applicable here. Specifically, the Forest association has *Brickellia californica* as a diagnostic species, which was not recorded at Fort Bowie NHS.

Fort Bowie National Historic Site— This description is based on 2008 field data (1 classification plot and 1 censused polygon).

Vegetation Hierarchy

Formation Class	II – Woodland
Formation Subclass	II.B - Deciduous woodland
Formation Group	II.B.2 - Cold-deciduous woodland
Formation Subgroup	II.B.2.N - Natural/Semi-natural cold-deciduous woodland
Formation Name	II.B.2.N.a - Cold-deciduous woodland
Alliance Name	*Celtis laevigata* var. *reticulata* Woodland Alliance
Association Name	*Celtis laevigata* var. *reticulata - Juglans major* Woodland

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

NatureServe Conservation Status

Global Status: Data are not available.
Rounded Global Status: Data are not available.

Distribution

Globally— Data are not available.

Fort Bowie National Historic Site— This type is found in 1 polygon: W-CL01.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This woodland occurs in the upper and middle reaches of Siphon Canyon, a relatively wide, undulating wash, and on the adjacent low hills. Slope is near level to 15%, and aspect is variable. Substrate is sand, rock, and gravel in the wash and sandy loam soil on the hills.

Most Abundant Species: Globally— Data are not available.
Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	*Celtis laevigata* var. *reticulata, Juglans major, Salix gooddingii*
Canopy (2–5 m)	*Prosopis glandulosa, Rhus microphylla, Sideroxylon lanuginosa*
Subcanopy (0.5–2 m)	*Prosopis glandulosa, Celtis laevigata* var. *reticulata, S. lanuginosa*
Field (0–0.5 m)	*Bouteloua* species, mixed grasses, *Isocoma tenuisecta*

Other Noteworthy Species

Globally— Data are not available.
Fort Bowie National Historic Site—

Element Sources

Global Description Authors: Data are not available.

Local Description Authors: B. Fallon, L. Crumbacher and S. Drake.

References:

Pinus edulis - (Juniperus monosperma) Woodland Alliance

Translated Name: Two-needle Pinyon - (Juniper species) Woodland Alliance
NatureServe Code: A.516.

NOTE: This alliance description came from the original NVC version 1 hierarchy, but all alliance descriptions have since been withdrawn from the NatureServe website for review. Alliances are essentially being dissolved and replaced by association-level descriptions underneath Groups. At time of writing, no new description or corollary existed for this type, so the original alliance has been kept to provide regional context.

Summary

Globally— Woodlands included in this alliance occur on dry sites in the lower montane zone in the southern Rocky Mountains; mountains, mesas and canyons in the Chihuahuan and Sonoran Deserts, and the Colorado Plateau; and breaks in the southern Great Plains. Stands have a moderately sparse to moderately dense tree canopy, typically 3–12 m tall. Mature individuals range from 2 to 3-m tall "scrub" to large trees up to 21 m tall. Moderately sparse stands have an open canopy with trees distributed in patches, whereas the tree crowns touch in the moderately dense stands. The upper canopy may be solely dominated by the evergreen needle-leaved tree *Pinus edulis*, but more commonly is co-dominated by one of several species of *Juniperus* or *Quercus*, depending on geography. On the Colorado Plateau, *Juniperus osteosperma* may co-dominate, whereas *Juniperus monosperma* co-dominates in the eastern part of the woodland's range. At higher elevations, *Juniperus scopulorum* may be present and, in the far southern extent, Madrean evergreen woodland species co-occur. These species include *Juniperus deppeana, Juniperus coahuilensis (= Juniperus erythrocarpa)* and the encinals, *Quercus arizonica, Quercus grisea, Quercus X pauciloba*.

The understory ranges from a relatively rich mixture of evergreen and/or deciduous shrubs, to a sparse to moderately dense herbaceous layer dominated by perennial grasses (with or without shrubs), to no vegetation at all. Most commonly, the understory is sparse and has a patchy distribution. Characteristic shrubs and dwarf-shrubs include *Artemisia tridentata, Cercocarpus montanus, Cercocarpus ledifolius, Coleogyne ramosissima, Ephedra viridis, Gutierrezia sarothrae, Lycium pallidum, Opuntia* spp., *Purshia mexicana, Purshia tridentata, Rhus trilobata*, and *Quercus gambelii*. Shrubs restricted to warmer southern latitudes include *Agave* spp., *Arctostaphylos pungens, Dasylirion wheeleri, Garrya* spp., *Nolina microcarpa, Quercus turbinella*, and *Yucca baccata*. The herbaceous layer is sparse to moderately dense, ranging from 1 to 30% cover. Perennial graminoids are the most abundant species, particularly *Bouteloua curtipendula, Bouteloua gracilis, Bouteloua hirsuta, Aristida* spp., *Festuca arizonica, Koeleria macrantha, Muhlenbergia* spp., *Achnatherum hymenoides (= Oryzopsis hymenoides), Piptatherum micranthum (= Oryzopsis micrantha), Poa fendleriana, Pseudoroegneria spicata*, and *Hesperostipa* spp. *Andropogon hallii* occurs as an understory species in rare, deep sands habitats. Many forb species occur, but few have much cover. Commonly present forbs include species of *Artemisia, Eriogonum, Heterotheca, Mirabilis, Penstemon, Phlox, Senecio*, and *Zinnia*. Annual grasses and forbs are seasonally present.

Fort Bowie National Historic Site— *Pinus edulis* and *Juniperus monosperma* are co-dominant species; both are present, and either may be dominant in a given stand. *Juniperus coahuilensis* may be present with very low cover. Other tree species are generally absent. Total tree cover is 25–30%, and greater than shrub cover. Tree height is 3–3.5 meters. A diversity of shrub species is present, and shrub cover is generally 20–25% or slightly greater. Common shrubs are *Rhus microphylla, Quercus turbinella, Ceanothus greggii, Cercocarpus montanus, Parthenium incanum,* and *Aloysia wrightii*, with perhaps a dozen associates. The field layer, with 20–30% cover, is comprised of small individual shrubs of these species, and grasses such as *Bouteloua* species, *Aristida purpurea, Tridens muticus, Setaria leucopila, S. grisebachii, Muhlenbergia arenicola, Heteropogon contortus*, or others.

Classification

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

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

Fort Bowie National Historic Site— This description is based on 2008 field data (0 classification plots and 2 censused polygons).

Vegetation Hierarchy

Formation Class	II – Woodland
Formation Subclass	II.A - Evergreen woodland
Formation Group	II.A.4 - Temperate or subpolar needle-leaved evergreen woodland
Formation Subgroup	II.A.4.N - Natural/Semi-natural temperate or subpolar needle-leaved evergreen woodland
Formation Name	II.A.4.N.a - Rounded-crowned temperate or subpolar needle-leaved evergreen woodland
Alliance Name	*Pinus edulis - Juniperus* spp. Woodland Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
9	Utah–Wyoming Rocky Mountains
10	Wyoming Basins
11	Great Basin
17	Mojave Desert
18	Utah High Plateaus
19	Colorado Plateau
20	Southern Rocky Mountains
21	Arizona–New Mexico Mountains
24	Chihuahuan Desert
27	Central Shortgrass Pairie
28	Southern Shortgrass Prairie

Distribution

Globally— United States: AZ, CA(?), CO, NM, NV, OK, TX(?), UT, WY

Fort Bowie National Historic Site— This type is found in 2 polygons: W-PE01, W-PE02.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Stands included in this woodland alliance occur in the foothills and the lower montane zone in the southern Rocky Mountains; mountains, mesas, piedmonts and canyons in the Chihuahuan and Sonoran deserts and the Colorado Plateau; and breaks and escarpments in the southern Great Plains. Elevations range from 1406 to 2510 m. Climate is semi-arid and droughts are not uncommon. Summers are generally hot, and winters range from mild with cold periods and occasional snows (in southern New Mexico and Arizona) to more typical extended periods of freezing temperatures. The seasonality of precipitation varies from east to west, with summer rain more common in the southern and eastern portion of the alliance's range and winter precipitation more common in the western portion of the range. Mean annual precipitation ranges from 30 to 46 cm. Stands typically occur on nearly level to steep (to 80%), rocky slopes on hillsides and ridgetops. Aspect does not seem important except in elevational

extremes for a given latitude, where low-elevation stands are restricted to the more mesic north slopes, and canyons and high-elevation stands occur on south aspects. Sites are typically dry with shallow, rocky, calcareous and alkaline soils. Other sites include eroded "badlands," lava flows, scree slopes, and deep sands. Soil textures range from sandy loam to clay and are typically derived from limestone, sandstone, or shale. Other parent materials include andesite, basalt, granite, quartzite, monzonite, rhyolite, and mixed alluvium. Adjacent vegetation at higher elevations is typically woodland or forest dominated by *Pinus ponderosa*. Adjacent vegetation at lower elevations is often *Juniperus* spp.-dominated woodland and savanna, *Artemisia* spp.-dominated shrubland, or grassland.

Fort Bowie National Historic Site— Both stands of this woodland at FOBO occur on moderate (15–35%) to steep (35–50%) north-facing hillslopes. Surface cover is mostly gravel, loose rock, and bedrock outcrops, with litter present under tree canopies. Large rills may be present, containing sand, gravel, and rock. Parent material is calcareous and non-calcareous sedimentary rock and colluvium.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	*Pinus edulis, Juniperus monosperma*
Subcanopy (0.5–2 m)	*Rhus microphylla, Quercus turbinella, Ceanothus greggii, Cercocarpus montanus*
Field (0–0.5 m)	*Bouteloua curtipendula, Aristida purpurea, Tridens muticus*

Other Noteworthy Species

Fort Bowie National Historic Site— *Juniperus coahuilensis, Garrya wrightii*

Element Sources

Global Description Authors: K. Schulz, mod. J. Coles

Local Description Authors: B. Fallon, L. Crumbacher and S. Drake.

References:

Francis, R. E. 1986. Phyto-edaphic communities of the Upper Rio Puerco Watershed, New Mexico. Research Paper RM-272. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 73 pp.

Quercus emoryi - Juniperus monosperma Woodland Alliance (P)

Translated Name: Emory oak - One-seed juniper Woodland Alliance
NatureServe Code: NPS code is NPSSODN023

NOTE: Similar to A.483, *Quercus emoryi* Woodland Alliance

Summary

Globally— A similar alliance has been described, based on occurrences in Texas, that includes semi-evergreen woodlands dominated by *Quercus emoryi*. The following description is from the NatureServe summary for A.483. *Quercus grisea* is a component on drier sites. *Quercus gravesii, Quercus graciliformis*, and *Acer grandidentatum* are found on more mesic, subirrigated sites. *Juniperus deppeana* and *Juniperus pinchotii* may also be important. Other typical species include (from Texas occurrences) *Celtis laevigata* var. *reticulata, Juniperus coahuilensis, Prunus serotina* var. *virens, Baccharis neglecta, Croton* sp., *Brickellia* spp., *Mahonia trifoliolata (= Berberis trifoliolata), Mimosa dysocarpa, Leptochloa dubia, Bothriochloa barbinodis* (= var. *barbinodis*), and *Muhlenbergia emersleyi*. These woodlands are found in the Trans-Pecos Mountains of west Texas at 1,350–1,700 m (4,500–5,500 feet) elevation, especially over soils of alluvial origin in mountain valleys associated with igneous geology. These woodlands may occur as a mosaic with grasslands dominated by *Schizachyrium scoparium* var. *scoparium (= Schizachyrium scoparium* ssp. *neomexicanum)* or *Bouteloua eriopoda* and *Bouteloua curtipendula*, and may grade into woodlands of *Pinus cembroides, Pinus edulis*, and *Quercus* spp. on adjacent, steep mountain slopes. This alliance is distributed in the mountains of Arizona and New Mexico, west to the Davis and Chisos mountains in western Texas, and south, in the mountains of northern Mexico.

Fort Bowie National Historic Site— This is a highly variable mixed-species alliance (proposed), difficult to categorize into consistent associations at FOBO. It is generally dominated by *Quercus emoryi*, *Q. grisea*, or *Q. arizonica*, with *Juniperus monosperma* or *J. coahuilensis*. *Prosopis glandulosa* is a common associate (though often as a shrub), and others may include *Sideroxylon lanuginosum, Quercus toumeyi, Juniperus deppeana, Quercus turbinella,* and *Pinus edulis*. In stands occurring in intermittently flooded canyon bottoms, riparian associates, such as *Celtis laevigata* var. *reticulata* and *Juglans major*, are often present, while upland stands lack these species. Tree canopy height is generally 5–8 meters, but in a few stands it may be slightly less than 5 m. Tree canopy cover is generally between 20% and 60%. Shrub species diversity is usually high (around 10 species are usually present) and shrub cover may be significant (20–30%), but is less than tree cover. Common shrubs in addition to the ubiquitous *Prosopis glandulosa* are *Rhus microphylla, Arctostaphylos pungens, Garrya wrightii, Ericameria laricifolia*, *Mimosa aculeaticarpa* var. *biuncifera, Nolina microcarpa, Agave palmeri, Yucca baccata* and *Dasylirion wheeleri.* The field layer contains subshrubs, such as *Isocoma tenuisecta*, but is dominated by grasses, including *Bouteloua* species (notably *B. curtipendula*), *Eragrostis lehmanniana, Muhlenbergia emersleyi, Bothriochloa barbinodis*, and other species.

Classification

Classification Comments: Globally— It is noted that in some stands, trees are dense enough to be classified as forest and in others, sparse enough to become savannas. More work is needed to clarify the classification of these stands. Additionally, more compositional information is needed to fully describe associations in this alliance.

Fort Bowie National Historic Site— This description is based on 2008 field data (0 classification plots and 4 censused polygons).

Vegetation Hierarchy

Formation Class	II - Woodland
Formation Subclass	II.A - Evergreen woodland
Formation Group	II.A.2 - Temperate broad-leaved evergreen woodland
Formation Subgroup	II.A.2.N - Natural/Semi-natural temperate broad-leaved evergreen woodland
Formation Name	II.A.2.N.a - Temperate broad-leaved evergreen woodland
Alliance Name	*Quercus emoryi - Juniperus monosperma* Woodland Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

Distribution

Globally— Data are not available.

Fort Bowie National Historic Site— This type is found in 4 polygons: W-QE01, W-QE02, W-QE03 and W-QE04

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This woodland is often, but not always, associated with small to medium-sized washes at FOBO, occurring along drainages and on the low hills adjacent to them. While these drainages are (very) intermittently flooded by storms, soil development and soil moisture are apparently insufficient to support the *Fraxinus, Celtis,* and *Juglans* woodlands found in the largest washes at FOBO. Slopes along drainage axes are mostly gentle (1–6% or 6–15%), while the slopes up drainage banks are commonly steep (15–35% or greater). Aspect is variable with wash orientation, and this community occurs on both sides of the drainages it occupies. Substrate in the channels is sand, gravel, and rock of all sizes including bedrock outcrops; banks are generally rocky, with sandy loam soil on the hills above them.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	*Quercus emoryi, Juniperus monosperma, Q. grisea, Q. arizonica*
Canopy (2–5 m)	*Quercus emoryi, Juniperus monosperma, Prosopis glandulosa, Q. toumeyi*
Subcanopy (0.5–2 m)	*Mimosa aculeaticarpa* var. *biuncifera, Prosopis glandulosa, Quercus emoryi, Arctostaphylos pungens, Ericameria laricifolia*
Field (0–0.5 m)	Mixed *Bouteloua* species, *Eragrostis lehmanniana, Muhlenbergia emersleyi*

Other Noteworthy Species

Fort Bowie National Historic Site— *Celtis laevigata* var. *reticulata* occurs in many stands but is not abundant.

Element Sources

Global Description Authors: Data are not available.

Local Description Authors: B. Fallon, L. Crumbacher and S. Drake.

References:

Wooded Shrubland

Prosopis (*glandulosa, velutina*) Wooded Shrubland Alliance (P)

Translated Name: (Honey mesquite, Velvet mesquite) Wooded Shrubland Alliance
NatureServe Code: Data are not available. NPS code is NPSSODN022

NOTE: This wooded shrubland type bears similarities to many associations currently described under NVC group G289, Apacherian-Chihuahuan Mesquite Uplands scrub group.

Summary

Globally— Data are not available.

Fort Bowie National Historic Site— The uppermost stratum of this wooded shrubland is dominated by short (< 5 m) *Prosopis* trees comprising 30–35% cover, and it has significant shrub and herbaceous layers. Differentiation of *Prosopis glandulosa* var. *torreyana* from *Prosopis velutina* in the field is difficult in the Fort Bowie area because of their morphological similarity and likely hybridization. Thus, consistent distinction was not attempted for mapping, and this type may contain one species or the other, or both, or hybrids. The shrub stratum is co-dominated by *Prosopis* sp. and *Rhus microphylla*, generally followed by *Ziziphus obtusifolia* and *Condalia warnockii*. Other associates are *Sideroxylon lanuginosum*, *Lycium* sp., *Baccharis sarothroides*, and *Isocoma tenuisecta*. The field stratum may have a significant forb component (e.g., *Verbesina encelioides*), but is dominated collectively by a variety of grass species, including *Setaria leucopila, Leptochloa dubia, Sporobolus wrightii, Setaria grisebachii, Muhlenbergia arenicola*, and *Eragrostis cilianensis*.

Classification

Classification Comments: Globally— Data are not available.

Fort Bowie National Historic Site— This description is based on 2008 field data (0 classification plots and 1 censused polygon).

Vegetation Hierarchy

Formation Class	III – Shrubland
Formation Subclass	III.B – Deciduous shrubland
Formation Group	III.B.3 – Extremely xeromorphic deciduous shrubland
Formation Subgroup	III.B.3.N – Natural/semi-natural extremely xeromorphic deciduous shrubland
Formation Name	Data are not available
Alliance Name	*Prosopis (glandulosa, velutina)* Wooded Shrubland Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

Distribution

Globally— Data are not available.

Fort Bowie National Historic Site— This type is found in 1 polygon: WS-P01.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— The single stand of this type at FOBO occurs on the flattish toeslope of a hill, which also includes a section of drainage. Vegetation cover is high and surface litter cover is 15–35%, so little substrate is exposed. Soil is silty loam with sparse gravel.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	*Prosopis* (*glandulosa, velutina*)
Subcanopy (0.5–2 m)	*Rhus microphylla, Prosopis (glandulosa, velutina)*
Field (0–0.5 m)	*Setaria leucopila, Verbesina encelioides*

Other Noteworthy Species

Fort Bowie National Historic Site— Condalia warnockii, Ziziphus obtusifolia

Element Sources

Global Description Authors: Data are not available.

Local Description Authors: B. Fallon, L. Crumbacher and S. Drake

References:

[*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance (P)

Translated Name: [One-seed juniper - Emory oak] / Mixed Shrub Wooded Shrubland Alliance
NatureServe Code: Data are not available. NPS code is NPSSODN024.

Summary

Globally— Data are not available.

Fort Bowie National Historic Site— This proposed alliance is widespread at FOBO and somewhat variable in its expression, though the variability is primarily in the relative cover of particular species within a fairly constant floristic composition. *Juniperus monosperma* and *Quercus emoryi* are almost always the dominant tree species; rarely, *Pinus edulis* may slightly dominate the tree stratum, and it is usually present as an associate. Less common tree associates are *Prosopis (velutina, glandulosa), Quercus arizonica*, and large *Quercus turbinella* individuals. However, tree canopy cover ranges from about 10% to 30%, and is always less than shrub cover, which ranges from 20% to 40%. Tree canopy height is usually short, at 3–5 meters, but sometimes reaches 6–8 meters. Shrub species richness is relatively high, with 10–15 species usually present. No single species is consistently dominant in this type. The dominant may be *Quercus turbinella*, *Prosopis (velutina, glandulosa)*, *Rhus microphylla*, *Nolina microcarpa*, *Mimosa aculeaticarpa* var. *biuncifera*, *Ericameria laricifolia, Arctostaphylos pungens,* or another species. Associate shrubs include *Aloysia wrightii, Dasylirion wheeleri, Yucca baccata, Agave palmeri, Calliandra eriophylla, Garrya wrightii, Cylindropuntia spinosior, Opuntia engelmannii, Cercocarpus montanus, Fouquieria splendens, Rhus trilobata, R. virens, Parthenium incanum, Dalea formosa, Ceanothus greggii, Atriplex canescens, Anisacanthus thurberi, Ferocactus wislizenii* and others. The field layer is dominated collectively by a mix of grasses, commonly with a total cover of 25–40%. A complex of *Bouteloua* species led by *B. curtipendula*, with some *Eragrostis lehmanniana*, is usually dominant, and *Muhlenbergia emersleyi* is frequently prominent. Possible associate grass species are numerous and, in most stands, grass species richness is high, with 10 or more species found.

Classification

Classification Comments: Globally— Data are not available.

Fort Bowie National Historic Site— This description is based on 2008 field data (9 classification plots and 22 censused polygons).

Vegetation Hierarchy

Formation Class	III - Shrubland
Formation Subclass	III.A – Evergreen shrubland
Formation Group	III.A.2 – Temperate evergreen shrubland
Formation Subgroup	III.A.2.N – Natural/semi-natural temperate evergreen shrubland
Formation Name	Data are not available
Alliance Name	[*Juniperus monosperma - Quercus emoryi*] / Mixed Shrub Wooded Shrubland Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

Distribution

Globally— Data are not available.

Fort Bowie National Historic Site— This type is found in 16 polygons: WS-JM01, WS-JM02, WS-JM03, WS-JM04,

WS-JM05, WS-JM06, WS-JM07, WS-JM08, WS-JM09, WS-JM11, WS-JM16, WS-JM18, WS-JM19, WS-JM20, WS-JM21, WS-JM22.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This is the most widespread community type at FOBO, and many stands are large, so it occurs in a variety of environmental settings. It is most often found on gravelly, dissected hillslopes, from crests down through toeslopes. Slope gradient is generally 15–35%, but ranges from 1–6% to over 50%. This wooded shrubland occurs on all aspects, but predominantly on north, northeast, and northwest aspects. Surface cover in all stands is dominated by gravel and rock, followed in most cases by bedrock and then bare soil. Soils generally consist of shallow sandy loams.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	*Quercus emoryi, Juniperus monosperma, Pinus edulis*
Canopy (2–5 m)	*Quercus emoryi, Juniperus monosperma, Pinus edulis*
Subcanopy (0.5–2 m)	*Quercus turbinella, Prosopis (velutina, glandulosa), Rhus microphylla, Nolina microcarpa, Mimosa aculeaticarpa* var. *biuncifera, Ericameria laricifolia*, numerous others
Field (0–0.5 m)	*Bouteloua* species, *Eragrostis lehmanniana, Muhlenbergia emersleyi*

Other Noteworthy Species

Fort Bowie National Historic Site— Prosopis (glandulosa, velutina) is usually present and may be a shrub, a tree, or both in a given stand.

Element Sources

Global Description Authors: Data are not available.

Local Description Authors: B. Fallon, L. Crumbacher and S. Drake

References:

Shrubland

Rhus microphylla Shrubland Alliance

Translated Name: Littleleaf sumac Shrubland Alliance
NatureServe Code: A.1040

Summary

Globally— Shrublands in this Chihuahuan Desert alliance occur on upland and basin sites in southern New Mexico. Elevation ranges from 1,250 to 1,500 m. The climate is semi-arid, with approximately two-thirds of the highly variable annual precipitation falling in July through October. These shrublands are found on several landforms and substrates, including gullied ancient river terraces. These "badlands" were composed of decomposed rhyolite tuff and alluvium. Ground cover was 30% bare ground, 15% gravel, 5% rock, 45% litter, 2% basal vegetation, and 3% moss. This stand grades into *Larrea tridentata*-dominated plains below and semi-desert grasslands at higher elevations. Communities in this alliance are described from sandy sites in the Tularosa Basin and Sacramento foothills, and on silty soils on upland piedmont swales. Sites are flat to moderately sloping, often with a cooler northwest aspect. There is a sparse to moderately dense short-shrub layer, dominated by the xeromorphic deciduous shrub *Rhus microphylla*. The herbaceous layer is very sparse in some stands to luxuriant in others, and is typically dominated by perennial bunch grasses. One stand contained shrub canopy covers of 15%, 5%, and 1% for *Rhus microphylla, Fallugia paradoxa*, and *Parthenium incanum*, respectively, with scattered *Nolina microcarpa, Yucca baccata*, and *Yucca elata*. Graminoid canopy cover was sparse, with 2% *Bouteloua curtipendula*, and lesser cover of *Aristida purpurea* var. *longiseta, Bouteloua eriopoda*, and *Bouteloua hirsuta*. Forbs were also sparse, with 1% canopy cover each of *Pectis filipes* and *Croton* spp., and <1% total canopy cover of 10 other forb species. Stands of *Rhus microphylla* have been reported with dense graminoid understories of *Sporobolus wrightii* or *Achnatherum hymenoides (= Oryzopsis hymenoides)*, along with other sand-adapted and sand-tolerant species.

Fort Bowie National Historic Site— *Rhus microphylla* is usually the dominant woody species in this alliance, though many stands may be closely co-dominated by other shrub species, such as *Aloysia wrightii, Prosopis (glandulosa, velutina)*, *Condalia warnockii,* or *Cercocarpus montanus*. A variety of associate shrubs may be present, including the four just mentioned and *Fouquieria splendens, Cylindropuntia spinosior, Yucca baccata, Agave palmeri, Parthenium incanum, Krascheninnikovia lanata, Dasylirion wheeleri, Rhus trilobata, Ceanothus greggii, Dalea formosa, Gutierrezia sarothrae, Ericameria laricifolia, Nolina microcarpa*, and others. A few trees may be present, most commonly *Pinus edulis* and *Juniperus monosperma*. The herbaceous layer is usually somewhat sparse (<30% cover), and usually dominated by a mix of *Bouteloua* species and other grasses, notably *Eragrostis lehmanniana*.

Classification

Classification Comments: Globally— Data are not available.

Fort Bowie National Historic Site— This description is based on 2008 field data (3 classification plots and 7 censused polygons).

Vegetation Hierarchy

Formation Class	III - Shrubland
Formation Subclass	III.B - Deciduous shrubland
Formation Group	III.B.3 - Extremely xeromorphic deciduous shrubland
Formation Subgroup	III.B.3.N - Natural/Semi-natural extremely xeromorphic deciduous shrubland
Formation Name	III.B.3.N.a - Extremely xeromorphic deciduous subdesert shrubland without succulents
Alliance Name	*Rhus microphylla* Shrubland Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
24	Chihuahuan Desert

Distribution

Globally— Mexico(?), United States: NM

Fort Bowie National Historic Site— This type is found in 4 polygons: S-RM04, S-RM05, S-RM06, S-RM07.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Shrublands in this Chihuahuan Desert alliance occur on upland and basin sites in southern New Mexico. Elevation ranges from 1,250 to 1,500 m. The climate is semi-arid, with approximately two-thirds of the highly variable annual precipitation falling in July through October. These shrublands are found on several landforms and substrates. Bourgeron and others (1993b) described it on gullied ancient river terraces. These "badlands" were composed of decomposed rhyolite tuff and alluvium. Ground cover was 30% bare ground, 15% gravel, 5% rock, 45% litter, 2% basal vegetation, and 3% moss. This stand grades into *Larrea tridentata*-dominated plains below and semi-desert grasslands at higher elevations. Muldavin and others (1998a) described communities in this alliance from sandy sites in the Tularosa Basin and Sacramento foothills, and on silty soils on upland piedmont swales. Sites are flat to moderately sloping, often with a cooler northwest aspect.

Fort Bowie National Historic Site— This shrubland is most often found on gravelly, rocky hillslopes, from crests down through footslopes, usually on north, northwest or northeast aspects. Slope gradient is 6–15% or 15–35%. Surface cover in all stands is dominated by gravel and rock, followed in most cases by bedrock and then bare soil. Soils are generally shallow and consist of sandy loams to loams.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	none
Subcanopy (0.5–2 m)	*Rhus microphylla, Aloysia wrightii, Prosopis (glandulosa, velutina)*
Field (0–0.5 m)	*Bouteloua* species, mixed grasses, *Parthenium incanum*

Other Noteworthy Species

Fort Bowie National Historic Site— *Yucca baccata, Agave palmeri, Ceanothus greggii, Krascheninnikovia lanata*

Element Sources

Global Description Authors: K. Schulz

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References:

Bourgeron, P. S., L. D. Engelking, H. C. Humphries, E. Muldavin, and W. H. Moir. 1993b. Assessing the conservation value of the Gray Ranch: Rarity, diversity and representativeness. Unpublished report prepared for The Nature Conservancy by the Western Heritage Task Force, Boulder, CO. (Volume I and II).

Muldavin, E., V. Archer, and P. Neville. 1998a. A vegetation map of the Borderlands Ecosystem Management Area. Final report submitted to USDA Forest Service, Rocky Mountain Experiment Station, Flagstaff, AZ, by the New Mexico Natural Heritage Program, University of New Mexico, Albuquerque, NM. 58 pp.

Prosopis (glandulosa, velutina) Shrubland Alliance

Translated Name: (Honey mesquite, velvet mesquite) Shrubland Alliance
NatureServe Code: A. 1043 *Prosopis velutina* Shrubland Alliance

Summary

Globally— This shrubland alliance occurs in the Chihuahuan and Sonoran deserts. Sites include sandy plains, mesas, bajadas, drainage terraces and channels, floodplains, and rocky slopes. Although *Prosopis velutina* is deep-rooted, it typically occurs on sites with shallow water tables, especially along arroyos. Sites are generally flat or on gentle to moderate south-facing slopes. Substrates are generally coarse-textured, but may include gravelly clay loams. Some sites are moderately saline. Shrublands included in this alliance are dominated by the shrub/small tree *Prosopis velutina*. *Acacia greggii* and *Celtis laevigata* var. *reticulata* are frequent riparian scrub co-dominants. These shrublands often have high shrub diversity and may include *Acacia constricta, Chilopsis linearis, Ericameria laricifolia, Gutierrezia sarothrae, Hymenoclea salsola, Isocoma tenuisecta, Juniperus monosperma, Larrea tridentata, Mimosa aculeaticarpa* var. *biuncifera (= Mimosa biuncifera)*, and *Rhus* spp. The herbaceous layer has sparse to moderate cover of medium-tall and short perennial grasses. Characteristic perennial grasses include *Aristida* spp., *Bouteloua curtipendula, Bouteloua eriopoda, Dasyochloa pulchella (= Erioneuron pulchellum), Elymus elymoides, Hilaria belangeri, Muhlenbergia porteri*, and *Sporobolus* spp. Annual grasses are present, but have sparse cover. Forbs are also sparse, but may include species of *Datura, Mentzelia, Polanisia*, and *Rumex*. Succulents are often present and may include *Agave* spp., *Ferocactus wislizeni, Opuntia* spp., *Yucca baccata*, or *Yucca elata,*depending on geography. Diagnostic of this alliance is the dominance of *Prosopis velutina* in the shrub layer.

Fort Bowie National Historic Site— *Prosopis glandulosa* is the most common dominant species, but *P. velutina* or hybrids may dominate some stands. For any of these species, the shrub lifeform, with heights generally less than 2 meters, is prevalent, but some individuals with a tree lifeform and reaching 4–5 meters may be present. Scattered individuals of other tree species may be present in this shrubland, including *Juniperus monosperma, Juniperus coahuilensis, Celtis laevigata* var. *reticulata, Quercus emoryi*, and *Q. turbinella*. Common associate shrubs, such as *Ericameria laricifolia, Rhus microphylla, Krascheninnikovia lanata, Parthenium incanum*, and *Mimosa aculeaticarpa* var. *biuncifera*, may collectively contribute significant cover, approaching that of the dominant *Prosopis*. Numerous other shrub species may be present with more minor cover, including *Yucca baccata, Nolina microphylla, Agave palmeri, Fouquieria splendens, Cylindropuntia spinosior, C. phaeacantha, Dasylirion wheeleri, Opuntia engelmannii, Ferocactus wislizenii, Dalea formosa, Aloysia wrightii, Calliandra eriophylla, Sideroxylon lanuginosum, Ziziphus obtusifolia, Atriplex canescens, Isocoma tenuisecta, Gutierrezia sarothrae, Garrya wrightii, Arctostaphylos pungens, Yucca elata*, and others. Shrub species diversity is generally high. The herbaceous layer is generally dominated by a mix of *Bouteloua* species, commonly with *Eragrostis lehmanniana*, which may be the clear dominant in some stands. A variety of other grass species may be present, including *Aristida ternipes, A. purpurea, Setaria leucopila, Chloris virgata, Panicum hirticaule, Muhlenbergia porteri, Digitaria californica, Leptochloa dubia, Bothriochloa barbinodis, Panicum obtusum, Sporobolus contractus, Eragrostis cilianensis*, and others. The herbaceous layer generally ranges from 20% to 50% cover.

Classification

Classification Comments: Globally— Classification of *Prosopis velutina*-dominated stands needs clarification. Because *Prosopis velutina* can have both shrub and tree growth forms, there may be confusion classifying a given stand. For example, what characteristic separates a *Prosopis velutina* arroyo riparian shrubland from a *Prosopis velutina* "bosque" or riparian woodland? Some arroyo riparian stands in Arizona are similar to stands in the *Baccharis sarothroides*-, *Acacia greggii*-, and *Parkinsonia* spp.-dominated alliances in species composition and separated mainly by dominance. Also, the formation in which this alliance is classified does not allow succulents. However, many stands in this alliance have a fairly consistent presence of succulents, usually species of *Opuntia* and *Yucca*.

Fort Bowie National Historic Site— This description is based on 2008 field data (9 censused polygons).

Vegetation Hierarchy

Formation Class	III – Shrubland
Formation Subclass	III.B – Deciduous shrubland
Formation Group	III.B.3 – Extremely xeromorphic deciduous shrubland
Formation Subgroup	III.B.3.N – Natural/semi-natural extremely xeromorphic deciduous shrubland
Formation Name	Data are not available
Alliance Name	*Prosopis (glandulosa, velutina)* Shrubland Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

Distribution

Globally— Arizona; New Mexico

Fort Bowie National Historic Site— This type is found in 9 polygons: S-P01, S-P02, S-P03, S-P04, S-P05, S-P06, S-P08, S-P09, S-P10.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Shrublands included in this alliance occur in the Chihuahuan and Sonoran deserts. Elevation ranges from 400 to 1,520 m. Climate is arid to semi-arid. Summers are hot. Winter temperatures are generally mild, with freezing temperature more common in the higher-elevation Chihuahuan Desert. Precipitation varies with geography. Mean annual precipitation ranges from about 22 cm at the Jornada Experimental Range, in southeastern New Mexico, to 28 cm at Tucson, Arizona, but can vary greatly from year to year. At the Jornada Experimental Range, annual precipitation ranged from 7 to 45 cm, with drought not uncommon (Herbel et al. 1972). Annual precipitation has bimodal distribution, with the proportion of summer precipitation decreasing westward (Barbour and Major 1977). At the Jornada Experimental Range, about two-thirds of the annual precipitation occurs in July through October and a third during the winter months. At Tucson, Arizona, about half of the annual rain falls in July to October, with the balance during the winter months. The most arid season is late spring and early summer. The summer rain often occurs as high-intensity convective storms. Sites include sandy plains, mesas, bajadas, drainage terraces and channels, floodplains, and rocky slopes. Although *Prosopis velutina* is deep-rooted, tapping water tables as deep as 50 m (Burgess 1995), it typically occurs on shallow water tables, especially along arroyos. Sites are generally flat or on gentle to moderate south-facing slopes. Parent material is usually sandy or gravelly alluvium, or eolian sand derived from limestone and metamorphic rocks. Substrates are generally coarse-textured, but may include gravelly clay loams. Some sites are moderately saline. These shrublands may grade into grasslands dominated by *Bouteloua gracilis, Sporobolus airoides, Pleuraphis mutica*, or be surrounded by a matrix of desert shrublands dominated by *Larrea tridentata* or *Ambrosia* spp.

Fort Bowie National Historic Site— This shrubland is found on gravel-covered, dissected hillslopes, from crests to toeslopes, on any aspect. Gradients may be gentle at 1–6%, but are more commonly 6–15% or 15–35%. Surface cover in almost all stands is predominantly gravel, with some loose rock but little bedrock outcrop. Soils are generally sandy loams.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	*Prosopis (glandulosa, velutina)*
Subcanopy (0.5–2 m)	*Prosopis (glandulosa, velutina),* mixed shrubs
Field (0–0.5 m)	*Bouteloua* species, *Eragrostis lehmanniana*, mixed grasses

Other Noteworthy Species

Fort Bowie National Historic Site— *Ericameria laricifolia* is present in most stands, and is sometimes the second dominant after *Prosopis*.

Element Sources

Global Description Authors: K. Schulz

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References: NatureServe.org

Quercus turbinella Shrubland Alliance

Translated Name: Turbinella live oak Shrubland Alliance
NatureServe Code: A.793

NOTE: This type resembles many associations currently described under the NVC revised group G281, Arizona desert margin group. None is adequate for this type as seen at Fort Bowie NHS, and all are described from other states. The alliance description given below is from the earlier NVC hierarchy which has now dissolved alliance level types.

Summary

Globally— This alliance includes evergreen shrublands where *Quercus turbinella* forms thickets with other desert shrubs. Important shrub associates can include *Arctostaphylos* spp., *Cercocarpus montanus, Coleogyne ramosissima, Ephedra viridis, Juniperus osteosperma, Rhus virens, Rhus trilobata, Rhus microphylla, Fraxinus greggii, Ceanothus greggii, Quercus mohriana, Quercus pungens*, and *Garrya wrightii*. Ground cover is typically sparse with scattered grasses, forbs, and ferns. Some typical herbaceous components include *Bouteloua curtipendula, Bouteloua eriopoda, Aristida* spp., *Astrolepis sinuata (= Notholaena sinuata)*, and *Notholaena standleyi*. Shrublands in this alliance are small in extent and occur in a matrix of succulent desert scrub and semi-desert grassland. *Quercus turbinella* shrublands are typically found on steep, rocky slopes, often sheltered slopes in limestone canyons, in the mountains of Nevada, Arizona, New Mexico, and western Texas.

Fort Bowie National Historic Site— This shrubland Alliance is dominated by *Quercus turbinella*, with *Garrya wrightii* co-dominant. Maximum canopy height of these species is about 3.5 meters, but most cover occurs in the subcanopy of 0.5 to 2 meters. Total shrub cover is relatively high at about 70%. A few trees, including *Juniperus monosperma* and *Quercus emoryi*, are present with <5% cover. Associated shrub species include *Mimosa aculeaticarpa* var. *biuncifera, Prosopis glandulosa, Yucca baccata, Agave palmeri, Cylindropuntia spinosior, Opuntia engelmannii, Nolina microcarpa, Ericameria laricifolia, Arctostaphylos pungens, Dasylirion wheeleri, Ferocactus wislizenii, Fouquieria splendens* and others. The herbaceous layer is dominated by a mix of *Bouteloua* species, particularly *B. curtipendula* and *B. eriopoda*, with *Eragrostis lehmanniana* and a notable component of the sub-shrub *Gymnosperma glutinosum*.

Classification

Classification Comments: Globally— Stands described by Warren and others (1982) have a very sparse vegetation layer (1-10% and 10-25%) and would be better classified as a sparsely vegetated alliance. Wells (1960) does not support *Quercus turbinella - Ephedra viridis* Shrubland (CEGL000980).

Fort Bowie National Historic Site— This description is based on 2008 field data (1 classification plot and 1 censused polygon).

Vegetation Hierarchy

Formation Class	III – Shrubland
Formation Subclass	III.A – Evergreen shrubland
Formation Group	III.A.2 – Temperate broadleaved evergreen shrubland
Formation Subgroup	III.A.2.N – Natural/Semi-natural temperate broad-leaved evergreen shrubland
Formation Name	III.A.2.N.c – Sclerophyllous temperate broad-leaved evergreen shrubland
Alliance Name	*Quercus turbinella* Shrubland Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
11	Great Basin
17	Mojave Desert
18	Utah High Plateaus
19	Colorado Plateau
22	Apache Highlands
24	Chihuahuan Desert

Distribution

Globally— Mexico(?), United States: AZ, NM, NV, TX, UT, WY

Fort Bowie National Historic Site— This type is found in 1 polygon: S-QT01.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Shrublands included in this alliance occurs in the foothills and lower slopes of isolated desert mountain ranges and canyons from Nevada to western Texas. Elevations range from 850–1,800 m. Climate is semi-arid. From one-half to two-thirds of the 40–65 cm mean annual precipitation occurs during July–September as the result of convectional thunderstorms. The balance occurs during winter as occasional rains. Late spring and early summer are typically dry. Summers are hot and winters can have periods of cold weather and occasional snows. Stands occur on nearly level to steep (to 80%), rocky slopes on all aspects. Soils are typically deep, coarse-textured, and poorly developed. Texture vary from cobbly and gravelly loamy sand to gravelly loam. Parent materials are varied and include weathered granite, schist, diabase, sandstone, shale, limestone, slate, gneiss, quartzite, monzonite, and basalt. Occasionally stands occur on fine-textured soil that may be too warm for *Juniperus* (Carmichael et al. 1987). Leaf litter occasionally accumulates 28 cm deep (Warren and Treadwell 1980). Litter layers affect soil development, rates of erosion, and fire regimes and behavior (Kemp 1965). Vegetation at higher elevations is often woodlands dominated by species of *Quercus*, *Pinus,* or *Juniperus*. At lower elevations, there is desert scrub dominated by species of *Acacia, Mimosa, Prosopis,* or *Encelia*.

Fort Bowie National Historic Site— The single stand of this shrubland at FOBO occurs on a dissected north-facing hillslope, from near the crest to the toeslope. Gradients range from 15% to 50%, with most of the slope about 35%. Gravel is the predominant surface cover, at 35–60%.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	*Quercus turbinella, Garrya wrightii*
Subcanopy (0.5–2 m)	*Quercus turbinella, Garrya wrightii*
Field (0–0.5 m)	*Bouteloua* species, *Eragrostis lehmanniana, Gymnosperma glutinosum*

Other Noteworthy Species

Fort Bowie National Historic Site— *Arctostaphylos pungens, Nolina microcarpa, Ericameria laricifolia, Yucca baccata*

Element Sources

Global Description Authors: K. Schulz

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References:

Carmichael, R. S., O. D. Knipe, C. P. Pase, and W. W. Brady. 1978. Arizona chaparral: Plant associations and ecology. Research Paper RM-202. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 16 pp.

Kemp, K. 1965. A study of litter and vegetation on the upper chaparral area of central Arizona. Unpublished thesis, University of Arizona, Tucson. 79 pp.

Warren, P. L., and B. D. Treadwell. 1980. Vegetation of the Three-Bar Wildlife Study Area, Mazatzal Mountains, Arizona. Unpublished report prepared for Arizona Game and Fish Department.

Warren, P. L., K. L. Reichhardt, D. A. Mouat, B. T. Brown, and R. R. Johnson. 1982. Vegetation of Grand Canyon National Park. Cooperative National Park Resources Studies Unit Technical Report 9. Tucson, AZ. 140 pp.

Wells, P. V. 1960. Physiognomic intergradation of vegetation on the Pine Valley Mountains in southwestern Utah. Ecology 41:553-556.

Larrea tridentata Shrubland

Translated Name: Creosotebush Shrubland
NatureServe Code: CEGL005145

NOTE: This type is similar to the association shown below which falls under group G295, Sonoran-Mojave Creosote-bush - White bursage Desert Scrub group; however, it also bears some similarity to associations listed under group G288, Chihuahuan Creosote bush Mixed Desert Scrub group—the associations of which are currently not fully described. Future classification and resolution of the NVC is needed to clarify correct placement.

Summary

Globally— This creosotebush shrubland association is currently described from Grand Canyon National Park and Grand Canyon-Parashant National Monument, in Arizona. More survey and classification work are needed to fully characterize this type. It often occurs on sideslopes but can occupy a variety of other landforms, including drainage bottoms, alluvial fans, and valley bottoms. It usually occurs at 375–750 m (1,250–2,550 feet) elevation, but can be found as high as 1,350 m (4,450 feet), and occurs across all aspects. It is typically found on low gradients (1–10°), but can occasionally occur on steeper slopes (10–30°). Soils are well- to rapidly drained silty or sandy loams, and the bedrock is often limestone. Vegetation is characterized by a homogenous tall-shrub layer of *Larrea tridentata* and lacks well-represented or co-dominant shrub components in any of the other strata. *Opuntia acanthocarpa, Ferocactus cylindraceus*, and *Krameria grayi,* or *Krameria erecta* occasionally occur in the sparse short-shrub layer. *Ambrosia dumosa* and *Opuntia basilaris* occasionally occur in a very weak dwarf-shrub layer. *Vulpia octoflora* is very common in the graminoid understory, and *Bromus rubens* also occasionally occurs. *Antheropeas lanosum, Plantago ovata, Cryptantha* sp., *Gilia* sp., and *Amsinckia menziesii* are common components of a fairly well-developed herb layer.

Fort Bowie National Historic Site— This shrubland is dominated by *Larrea tridentata*, with several associated shrub species present. The most frequent associates, and most abundant in a given stand, are *Rhus microphylla, Prosopis (glandulosa, velutina),* and *Parthenium incanum*. Less common associates which may be present, but contributing relatively little cover (generally <1% each) include *Aloysia wrightii, Yucca baccata, Nolina microcarpa, Ziziphus obtusifolia, Calliandra eriophylla, Opuntia phaeacantha, Fouquieria splendens,* and *Dalea formosa*. Total shrub cover ranges from about 20% to about 50%. Trees are absent except for an occasional *Juniperus monosperma* individual. The field stratum is dominated by a mix of grasses that may include *Bouteloua curtipendula, B. eriopoda, Eragrostis lehmanniana, Tridens muticus, Muhlenbergia porteri, Setaria leucopila,* and others.

Classification

Classification Confidence: Data are not available.
Classification Comments: Globally— Data are not available.

Fort Bowie National Historic Site— This description is based on 2008 field data (0 classification plots and 2 censused polygons).

Vegetation Hierarchy

Formation Class	III - Shrubland
Formation Subclass	III.A - Evergreen shrubland
Formation Group	III.A.5 - Extremely xeromorphic evergreen shrubland
Formation Subgroup	III.A.5.N - Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation Name	III.A.5.N.a - Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland
Alliance Name	*Larrea tridentata* Shrubland Alliance
Association Name	*Larrea tridentata* Shrubland

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
CES302.756	Sonora-Mojave Creosotebush-White Bursage Desert Scrub

NatureServe Conservation Status

Global Status: GNR (23Jun2010)
Rounded Global Status: GNR - Not Yet Ranked

Distribution

Globally— United States: AZ

Fort Bowie National Historic Site— This type is found in 2 polygons: S-LT01, S-LT02.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This shrubland is found on the lower footslopes and toeslopes of limestone hills at FOBO. Gradients are gentle at 1-6%, and aspect is variable. The predominant surface cover is gravel and rock, and soils are fine sandy loams.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	none
Subcanopy (0.5–2 m)	*Larrea tridentata, Rhus microphylla, Prosopis (glandulosa, velutina)*
Field (0–0.5 m)	*Parthenium incanum, Bouteloua curtipendula, Muhlenbergia porteri, Eragrostis lehmanniana, Tridens muticus*

Other Noteworthy Species

Fort Bowie National Historic Site— Aloysia wrightii, Yucca baccata

Element Sources

Global Description Authors: Western Ecology Group, R. Meszaros

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References:

Fouquieria splendens / Parthenium incanum Shrubland

Translated Name: Ocotillo / Mariola Shrubland
NatureServe Code: CEGL001378

Summary

Globally— Association is listed but not fully described in NatureServe Explorer. It is shown as occurring in New Mexico and Texas and has not yet been fully described to include data from Arizona.

Fort Bowie National Historic Site— *Fouquieria splendens* is a characteristic species of this association, and is by far the tallest shrub present at 2–3 meters, but may not be dominant by density or canopy cover, depending on how this is measured for its unusual morphology. *Parthenium incanum* is generally the dominant shrub by cover, but may be co-dominant with *Rhus microphylla, Aloysia wrightii* or another species. A number of other shrub species are generally present. These may include *Prosopis (glandulosa, velutina), Dasylirion wheeleri, Yucca baccata, Agave palmeri, Nolina microcarpa, Cylindropuntia spp., Larrea tridentata, Calliandra eriophylla, Ceanothus greggii, Cercocarpus montanus, Opuntia engelmannii, Ericameria laricifolia*, and others. Trees are often absent, though occasional *Juniperus monosperma* individuals may be found in this type. Grass cover is sparse. Dominant species are generally a mix of *Bouteloua eriopoda, B. curtipendula, Tridens muticus, Heteropogon contortus,* and several other species, with *Eragrostis lehmanniana* prevalent in some stands. The field stratum (0–0.5 m) is often dominated by *Parthenium incanum, Calliandra eriophylla*, and other short shrubs.

Classification

Classification Confidence: 3 - weak
Classification Comments: Globally— Data are not available.

Fort Bowie National Historic Site— This description is based on 2008 field data (2 classification plots and 12 censused polygons).

Vegetation Hierarchy

Formation Class	III - Shrubland
Formation Subclass	III.A - Evergreen shrubland
Formation Group	III.A.5 - Extremely xeromorphic evergreen shrubland
Formation Subgroup	III.A.5.N - Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation Name	III.A.5.N.a - Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland
Alliance Name	*Fouquieria splendens* Shrubland Alliance
Association Name	*Fouquieria splendens / Parthenium incanum* Shrubland

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
CES302.734	Chihuahuan Mixed Desert and Thornscrub

NatureServe Conservation Status

Global Status: GNR (23Feb1994)
Rounded Global Status: GNR - Not Yet Ranked

Distribution

Globally— United States: NM, TX, AZ(?)

Fort Bowie National Historic Site— This type is found in 11 polygons S-FSPI02, S-FSPI03, S-FSPI04, S-FSPI05, S-FSPI06, S-FSPI07, S-FSPI08, S-FSPI09, S-FSPI10, S-FSPI11, S-FSPI12.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This is a common shrubland association at FOBO, but its distribution is limited to the calcareous hillslopes of a wide band of limestone running through the eastern half of the park. It occurs on hillcrests through toeslopes, generally with gradients of 6–15% or 15–35%, and on all aspects though most frequently on south- or west-facing slopes. The predominant surface cover is gravel, with rock and bedrock, and soils are shallow.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	*Fouquieria splendens*
Subcanopy (0.5–2 m)	*Fouquieria splendens, Parthenium incanum*
Field (0–0.5 m)	*P. incanum, Calliandra eriophylla, Bouteloua eriopoda, B. curtipendula, Tridens muticus, Eragrostis lehmanniana*

Other Noteworthy Species

Fort Bowie National Historic Site— Rhus microphylla, Aloysia wrightii, Larrea tridentata, Prosopis (glandulosa, velutina), Agave palmeri, Yucca baccata, Dasylirion wheeleri

Element Sources

Global Description Authors: Western Ecology Group

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References:

Fouquieria splendens / Opuntia engelmannii Shrubland (P)

Translated Name: Ocotillo / Engelmann pricklypear Shrubland
NatureServe Code: Data are not available. NPS code NPSSODN0016

NOTE: This type may be resolved to fall under the current NVC group G288, Chihuahuan Creosote bush Mixed Desert Scrub group, or may bear similarity to the listed, but not described *Fouquieria splendens - Calliandra eriophylla* Shrub-land (provisional) association.

Summary

Globally— Data are not available.

Fort Bowie National Historic Site— *Fouquieria splendens* is the characteristic species of this proposed Association, but may not appear dominant by density or canopy cover. Beneath the 2–3-m "canopy" of *F. splendens*, *Opuntia engelmannii* is generally the dominant shrub. Some stands may have significant cover of *Acacia greggii, Prosopis (glandulosa, velutina), Calliandra eriophylla,* or another species, with *O. engelmannii* sub-dominant. A number of other shrub species are generally present. These may include *Aloysia wrightii, Yucca baccata, Agave palmeri, Dasylirion wheeleri, Parthenium incanum, Mimosa aculeaticarpa* var. *biuncifera*, *Ferocactus wislizenii, Ericameria laricifolia*, *Cylindropuntia* spp., and other species. Trees are often absent, though occasional *Juniperus monosperma* individuals may be found in this type. Grass cover is typically sparse (<20%), except where the often-dominant *Eragrostis lehmanniana* is present.

Classification

Classification Confidence: Data are not available.
Classification Comments: Globally— Data are not available.

Fort Bowie National Historic Site— This description is based on 2008 field data (1 classification plot and 2 censused polygons).

Vegetation Hierarchy

Formation Class	III - Shrubland
Formation Subclass	III.A - Evergreen shrubland
Formation Group	III.A.5 - Extremely xeromorphic evergreen shrubland
Formation Subgroup	III.A.5.N - Natural/Semi-natural extremely xeromorphic evergreen shrubland
Formation Name	III.A.5.N.a - Broad-leaved and microphyllous evergreen extremely xeromorphic subdesert shrubland
Alliance Name	*Fouquieria splendens* Shrubland Alliance
Association Name	*Fouquieria splendens* / *Opuntia engelmannii* Shrubland

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

NatureServe Conservation Status

Global Status: Data are not available.
Rounded Global Status: Data are not available.

Distribution

Globally— Data are not available.

Fort Bowie National Historic Site— This type is found in 2 polygons: S-FSOE01, S-FSOE02.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This shrubland occurs at FOBO on some of the calcareous hillslopes of a wide band of limestone running through the eastern half of the park, generally on backslopes to footslopes with 15–35% or 35–50% gradients and south to southwest aspects. Rock and gravel make up the predominant surface cover, with some bedrock outcrop, and soils are shallow.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	*Fouquieria splendens*
Subcanopy (0.5–2 m)	*Fouquieria splendens, Opuntia engelmannii*, mixed shrubs
Field (0–0.5 m)	*Eragrostis lehmanniana*, mixed shrubs

Other Noteworthy Species

Fort Bowie National Historic Site— Parthenium incanum, Yucca baccata, Agave palmeri, Prosopis (glandulosa, velutina), Ferocactus wislizenii

Element Sources

Global Description Authors: Data are not available.

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References:

Herbaceous

Quercus emoryi / Bouteloua spp. Wooded Herbaceous

Translated Name: Emory oak / mixed grama species Wooded Herbaceous
NatureServe Code: CEGL000683 (*Quercus emoryi*/*Bouteloua curtipendula* Woodland)

Summary

Globally— This diverse Madrean woodland savanna association is known from the "borderlands" area of southeastern Arizona and southwestern New Mexico, extending west to Buenos Aires National Wildlife Refuge and east into Trans-Pecos Texas, and in the Sierra Del Carmen of northeastern Coahuila, Mexico. Stands occur on gentle to moderate hillslopes of northerly aspects, and elevations range from 1,380 to 1,980 m (4,528–6,500 feet). Substrates are igneous volcanic rhyolites, andesites, and tuffs. This association is characterized by moderately open canopies (30% cover) dominated by *Quercus emoryi*. *Quercus grisea* or *Quercus arizonica*, along with *Juniperus deppeana*, *Pinus discolor*, or *Pinus cembroides,* can be present, but they are not dominant or co-dominant. The understory is moderately diverse (55 species have been recorded for the association), characteristically grassy, and dominated by *Bouteloua curtipendula*. Other common grasses include *Bouteloua gracilis*, *Muhlenbergia emersleyi*, and *Eragrostis intermedia*.

Fort Bowie National Historic Site— *Quercus emoryi* dominates the tree stratum (2–5 meters tall) with 5–15% canopy cover, and *Juniperus monosperma* is usually present as a sub-dominant. Other tree species may be present with very low cover, including *Juniperus coahuilensis, Juniperus deppeana, Quercus arizonica, Pinus edulis*, or *Prosopis glandulosa*. A diverse shrub stratum is present, comprising 10–25% cover, without a consistent dominant species. The most common shrub species are *Prosopis (glandulosa, velutina), Ericamerica laricifolia, Mimosa aculeaticarpa* var. *biuncifera, Arctostaphylos pungens, Nolina microcarpa, Yucca baccata, Dasylirion wheeleri, Agave palmeri,* and *Calliandra eriophylla*. The herbaceous layer comprises 40–70% cover and contains a variety of grasses, with a complex of *Bouteloua* species collectively dominant. These include *Bouteloua curtipendula, B. gracilis, B. aristidoides, B. eriopoda, B. repens,* and *B. hirsuta*. *Muhlenbergia emersleyi* and the introduced *Eragrostis lehmanniana* may also be prevalent. Associated grass species include *Bothriochloa barbinodis, Aristida ternipes, Eragrostis cilianensis, Heteropogon contortus, Aristida purpurea, Panicum hirticaule*, *Chloris virgata,* and others.

Classification

Classification Comments: Globally— The western Sierra Madre representatives of this type may have somewhat different understory compositions from those of the eastern Sierra Madre.

Fort Bowie National Historic Site— This description is based on 2008 field data (11 classification plots and 4 censused polygons).

Vegetation Hierarchy

Formation Class	V - Herbaceous Vegetation
Formation Subclass	V.A - Perennial graminoid vegetation
Formation Group	V.A.6 - Temperate or subpolar grassland with a sparse tree layer
Formation Subgroup	V.A.6.N - Natural/Semi-natural temperate or subpolar grassland with a sparse tree layer
Formation Name	V.A.6.N.h - Short temperate or subpolar grassland with a sparse broad-leaved evergreen or semi-evergreen tree layer
Association Name	*Quercus emoryi* / *Bouteloua* spp. Wooded Herbaceous

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
CES302.735	Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
CES305.795	Madrean encinal

Distribution

Globally— Mexico, United States

Fort Bowie National Historic Site— This type is found in 4 polygons: WH-QE01, WH-QE02, WH-QE03, WH-QE04.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— This diverse Madrean woodland savanna association is known from the "borderlands" area of southeastern Arizona and southwestern New Mexico, extending west to Buenos Aires National Wildlife Refuge and east into Trans-Pecos Texas, and in the Sierra Del Carmen of northeastern Coahuila, Mexico. Stands occur on gentle to moderate hillslopes of northerly aspects, and elevations range from 1,380 to 1,980 m (4,528-6,500 feet). Substrates are igneous volcanic rhyolites, andesites, and tuffs.

Fort Bowie National Historic Site— This association occurs at FOBO in relatively large stands covering the undulating granodiorite hills typical of the area. It is found from hillcrests to toeslopes, on gradients up to about 35%, and on all aspects. Surface cover is predominantly gravel, with rock and bedrock outcrops, and soils are sandy loams.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	*Quercus emoryi, Juniperus monosperma*
Subcanopy (0.5–2 m)	*Prosopis (glandulosa, velutina), Ericameria laricifolia*
Field (0–0.5 m)	Mixed *Bouteloua* species, *Eragrostis lehmanniana*

Other Noteworthy Species

Fort Bowie National Historic Site— *Mimosa aculeaticarpa* var. *biuncifera, Nolina microcarpa, Yucca baccata, Agave palmeri, Dasylirion wheeleri*

Element Sources

Global Description Authors: E. Muldavin, mod. K.A. Schulz

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References: www.natureserve.org

Rhus microphylla / Bouteloua spp. Shrub Herbaceous Alliance (P)

Translated Name: Littleleaf sumac / mixed grama grass Shrub Herbaceous Alliance
NatureServe Code: NPSSODN018

NOTE: Similar to CEGL001354 *Rhus microphylla/Bouteloua curtipendula* Shrubland identified in the current NVC (but not described) from New Mexico.

Summary

Globally— Data are not available.

Fort Bowie National Historic Site— This proposed shrub herbaceous alliance is floristically similar to the *Rhus microphylla* Shrubland Alliance also found at FOBO, but has considerably higher herbaceous cover (30–85%) and a higher ratio of herbaceous cover to shrub cover, 2:1 or greater. *Rhus microphylla* is the dominant woody species in this alliance, though some stands may be closely co-dominated by other shrub species, such as *Prosopis (glandulosa, velutina)* or *Aloysia wrightii*. A variety of associate shrubs may be present, including *Fouquieria splendens, Mimosa aculeaticarpa* var. *biuncifera, Yucca baccata, Agave palmeri, Calliandra eriophylla, Dasylirion wheeleri, Gutierrezia sarothrae, Opuntia engelmannii, Cylindropuntia spinosior, Larrea tridentata, Ericameria laricifolia, Parthenium incanum,* and others. A few trees may be present, most commonly *Juniperus monosperma*. The herbaceous layer is difficult to characterize because there is no consistently dominant species or group of species, grass species diversity is fairly high, usually with 8–10 or more species present, and the mix of species is variable among stands. *Eragrostis lehmanniana* is frequently but not always found in this type. Other species include *Bouteloua eriopoda, B. curtipendula, B. hirsuta, B. chondrosioides, B. gracilis, Bothriochloa barbinodis, Tridens muticus, Muhlenbergia porteri, M. arenicola, Setaria leucopila, S. grisebachii, Heteropogon contortus, Aristida purpurea, Sporobolus wrightii, Eragrostis cilianensis, Chloris virgata, Leptochloa dubia, Digitaria californica, Panicum obtusum,* and others.

Classification

Classification Comments: Globally— Data are not available.

Fort Bowie National Historic Site— This description is based on 2008 field data (0 classification plots and 4 censused polygons).

Vegetation Hierarchy

Formation Class	V - Herbaceous Vegetation
Formation Subclass	V.A - Perennial graminoid vegetation
Formation Group	V.A.7 - Temperate or subpolar grassland with a sparse shrub layer
Formation Subgroup	V.A.7.N - Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer
Formation Name	V.A.7.N.m - Short temperate or subpolar grassland with a sparse xeromorphic (evergreen and/or deciduous) shrub layer
Alliance Name	*Rhus microphylla* / *Bouteloua* spp. Shrub Herbaceous Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

Distribution

Globally— Data are not available.

Fort Bowie National Historic Site— This type is found in 3 polygons: SH-RM02, SH-RM03, SH-RM04.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This community occurs at FOBO on hillslopes of any aspect, usually footslopes and toeslopes, but can range up to crests. Gradients are 1–6% or 6–15%. The predominant surface cover, apart from the grass and grass litter, which may be dense, is generally gravel and rock. Soils are sandy loams to silty loams.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	none
Subcanopy (0.5–2 m)	*Rhus microphylla, Prosopis (glandulosa, velutina), Aloysia wrightii*
Field (0–0.5 m)	*Eragrostis lehmanniana, Bouteloua* species, mixed grasses

Other Noteworthy Species

Fort Bowie National Historic Site— *Juniperus monosperma* (present but few), *Fouquieria splendens*, *Yucca baccata*, *Mimosa aculeaticarpa* var. *biuncifera*

Element Sources

Global Description Authors: Data are not available.

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References:

Prosopis (glandulosa, velutina) / Bouteloua spp. Shrub Herbaceous Alliance (P)

Translated Name: (Honey mesquite, Velvet mesquite) / Mixed Grama Species Shrub Herbaceous Alliance
NatureServe Code: NPSSODN017

NOTE: Similar to the now-outdated A.1550 *Prosopis glandulosa* Shrub Herbaceous Alliance. This type will likely be resolved to fall under group G289, Apacherian–Chihuahuan Mesquite Uplands Scrub group in the NVC, wherein currently 20 associations with either *P. glandulosa* or *P. velutina* are dominant. This includes a *Prosopis velutina* / mixed grass shrubland and a *Prosopis glandulosa* / *Bouteloua gracilis* shrubland, again both listed but currently not described.

Summary

Globally— Data are not available.

Fort Bowie National Historic Site— *Prosopis (glandulosa, velutina)* is most commonly the dominant woody species in this proposed type, growing as a shrub generally under 2 meters tall. *Rhus microphylla*, *Aloysia wrightii* and *Ericameria laricifolia* are common shrub associates, and one of these species may actually dominate *Prosopis* in canopy cover. *Fouquieria splendens* is also a common associate. A number of other shrubs may be present with little cover, including *Mimosa aculeaticarpa* var. *biuncifera*, *Acacia greggii, Dasylirion wheeleri, Agave palmeri, Yucca baccata, Opuntia engelmannii, Ferocactus wislizenii, Cylindropuntia spinosior, Gutierrezia sarothrae, Calliandra eriophylla*, and others. A few trees may be present: *Juniperus monosperma, J. deppeana, J. coahuilensis, Pinus edulis*, *Quercus emoryi*, or other species. *Bouteloua* species and other grasses comprise more cover than the woody species. A complex of *Bouteloua curtipendula, B. gracilis, B. aristidoides, B. eriopoda, B. repens, B. hirsuta,* and other grasses usually makes up most of the herbaceous cover, but in some stands *Eragrostis lehmanniana* may be dominant.

Classification

Classification Comments: Globally— The taxonomy of *Prosopis* may further complicate the classification. There are three varieties of *Prosopis glandulosa*: *Prosopis glandulosa* var. *glandulosa,* which occurs in New Mexico, Texas, Colorado, Kansas, Oklahoma, and Louisiana; *Prosopis glandulosa* var. *torreyana,* which occurs in California, Nevada, Utah, Arizona, New Mexico, and Texas; and *Prosopis glandulosa* var. *prostrata,* which occurs only in Texas. *Prosopis velutina* is restricted to California, Arizona, and New Mexico. Szaro (1989) describes a *Prosopis velutina* riparian community type (shrublands and woodlands) from southwestern New Mexico to western Arizona. In addition, *Prosopis glandulosa* var. *torreyana* and *P. velutina* are known to intergrade where ranges overlap in southern Arizona (Kearney and Pebbles 1969). See Benson and Darrow (1981) for more discussion.

Fort Bowie National Historic Site— This description is based on 2008 field data (3 classification plots and 9 censused polygons).

Vegetation Hierarchy

Formation Class	V - Herbaceous Vegetation
Formation Subclass	V.A - Perennial graminoid vegetation
Formation Group	V.A.7 - Temperate or subpolar grassland with a sparse shrub layer
Formation Subgroup	V.A.7.N - Natural/Semi-natural temperate or subpolar grassland with a sparse shrub layer
Formation Name	V.A.7.N.m - Short temperate or subpolar grassland with a sparse xeromorphic (evergreen and/or deciduous) shrub layer
Alliance Name	*Prosopis (glandulosa, velutina)* / *Bouteloua* spp. Shrub Herbaceous Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

Distribution

Globally— Data are not available.

Fort Bowie National Historic Site— This type is found in 8 polygons: SH-P01, SH-P02, SH-P03, SH-P04, SH-P05, SH-P06, SH-P08, SH-P09.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This community is widespread at FOBO and occurs on the dissected hills, from crests to toeslopes, on all aspects. Gradients are usually gentle to 35%, but may be 35–50%. The predominant surface cover is most often gravel, sometimes rock. Soils are sandy loams, generally shallow and gravelly.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	none
Subcanopy (0.5–2 m)	*Prosopis (glandulosa, velutina), Rhus microphylla, Ericameria laricifolia*
Field (0–0.5 m)	Mixed *Bouteloua* species, *Eragrostis lehmanniana*

Other Noteworthy Species

Fort Bowie National Historic Site— Aloysia wrightii, Fouquieria splendens

Element Sources

Global Description Authors: Data are not available.

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References:

Bouteloua - Mixed Grass Herbaceous Alliance (P)

Translated Name: Grama – Mixed Grass Herbaceous Alliance
NatureServe Code: Data are not available. NPSSODN021

NOTE: Similar to CEGL002250 *Bouteloua curtipendula - Bouteloua* (*eriopoda, gracilis*) Herbaceous vegetation. It also bears similarities to several partially described associations within NVC G490 Apacherian-Chihuahuan Semi-Desert Grassland & Steppe Group; however, these are mostly described from New Mexico, Texas, and other parts of Arizona.

Summary

Globally— Data are not available.

Fort Bowie National Historic Site— This proposed alliance is dominated by grasses, generally with <10% cover of trees and shrubs, though some stands may have higher cover of weedy subshrubs, such as *Isocoma tenuisecta*, *Gutierrezia sarothrae*, *Salsola kali,* or *Amaranthus palmeri*. Total herbaceous canopy cover (not foliar cover), including subshrubs and forbs, is high, sometimes 90% or greater. A mix of *Bouteloua* species, possibly including *B. curtipendula, B. eriopoda, B. gracilis, B. hirsuta, B. repens,* or *B. chondrosioides,* is present, and is often collectively dominant, but dominance (never clear) and species composition vary among stands, and even among patches within stands. *Eragrostis lehmanniana* is present in most stands, and may be dominant or co-dominant with one or several other species. Common associates that may be abundant include *Aristida ternipes, Setaria leucopila, Bothriochloa barbinodis, Leptochloa dubia* and *Sporobolus wrightii*. Other associates may include *Chloris virgata, Eragrostis cilianensis, Muhlenbergia porteri, M. arenicola, Digitaria californica,Heteropogon contortus, Setaria grisebachii, Aristida purpurea, Panicum hirticaule, Sporobolus contractus, Eriochloa lemmonii,* and others.

Classification

Classification Comments: Globally— Data are not available.

Fort Bowie National Historic Site— This description is based on 2008 field data (1 classification plot and 4 censused polygons).

Vegetation Hierarchy

Formation Class	V - Herbaceous Vegetation
Formation Subclass	V.A - Perennial graminoid vegetation
Formation Group	V.A.5 - Temperate or subpolar grassland
Formation Subgroup	V.A.5.N - Natural/Semi-natural temperate or subpolar grassland
Formation Name	V.A.5.N.f - Short bunch temperate or subpolar grassland
Alliance Name	*Bouteloua* spp. - Mixed Grass Herbaceous Alliance

Ecological Systems Placement

Ecological System Unique ID	Ecological System Name
Data are not available.	Data are not available.

Distribution

Globally— Data are not available.

Fort Bowie National Historic Site— This type is found in 3 polygons: H-B02, H-B03, H-B04.

Environmental Setting

USFWS Wetland System: N.

Environmental Summary: Globally— Data are not available.

Fort Bowie National Historic Site— This grassland is found at FOBO on the toe of a broad, dissected fan, just above Siphon Canyon, in the area of the historical Butterfield stage route, the cemetery, and the current hiking trail from the parking lot to the fort ruins. In this area, some mesquite shrub clearing has been done in recent years. Slope gradients are gentle at 0–6%, and the overall aspect is northeast. The predominant surface cover, apart from grass and grass litter, is gravel, with some bare soil and loose rock. Soils are sandy loams to silty loams, and relatively deep for this area.

Most Abundant Species

Fort Bowie National Historic Site—

Stratum	Species
Top Canopy (>5 m)	none
Canopy (2–5 m)	none
Subcanopy (0.5–2 m)	none
Field (0–0.5 m)	*Bouteloua* species, *Eragrostis lehmanniana*, mixed grasses

Other Noteworthy Species

Fort Bowie National Historic Site—

Element Sources

Global Description Authors: Data are not available.

Local Description Authors: B. Fallon, L. Crumbacher, S. Drake

References:

Appendix C. 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)**

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: 0.05.3

Proofread by: _____ Copied by: _____ Entered by: _____ Verified by: _____ Plot ID: _____

Location and Event Information

Park:	Sub-Map #:	Date (mm/dd/yyyy):	Time (00:00):
Poly ID(s):		Field Poly ID:	Plot ID:
Observer(s):	Recorder:	Tentative Formation:	Keyed Formation:
UTM NAD83:		Protocol Name: VegMap	Protocol Version: 0.05.3

Soil/Landscape Parameters

(X)	Topographic Position (X all that apply)
	Crest/summit
	Shoulder
	Backslope
	Footslope
	Toeslope
	No Slope (N/A)
	Other:

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

Area Surface Cover (circle one class per feature)

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

(X)	Parent Material (X all that apply)
	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

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

Erosion Features (circle one class per feature)

Tunneling	None	Rare	Common	Prolific
Sheet	None	Rare	Common	Prolific
Rill	None	Rare	Common	Prolific
Gully	None	Rare	Common	Prolific
Pedestals	None	Rare	Common	Prolific
Terracettes	None	Rare	Common	Prolific
Burrowing	None	Rare	Common	Prolific

Aspect (circle dominant aspect)

N NNE **NE** ENE
E ESE **SE** SSE
S SSW **SW** WSW
W WNW **NW** NNW

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

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

Nail location:

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: 0.05.3

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

Park:	Sub-Map #:	Date (mm/dd/yyyy):		Time (00:00):	
Poly ID(s):		Field Poly ID:		Plot ID:	
Observer(s):	Recorder:	Tentative Formation:		Keyed Formation:	
UTM NAD83:		____m Bearing:	___m Bearing:	Protocol Name: VegMap	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

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

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

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

Disturbance Types

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

GPS Unit Name & Field data/GPS accuracy notes:

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

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

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

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: **Polygon Soil/Landscape** Version: 0.04

Proofread by: _____ Copied by: _____ Entered by: _____ Verified by: _____ New Poly ID: _____

Location and Event Information

Park:	Sub-Map #:	Date (mm/dd/yyyy):	Time (00:00):
Poly ID(s):		Field Poly ID:	
Observer(s):	Recorder:	Tentative Formation:	Keyed Formation:
Protocol Name: VegMap		Protocol Version: 0.05	

Soil/Landscape Parameters

(X)	Topographic Position (X all that apply)
	Crest/summit
	Shoulder
	Backslope
	Footslope
	Toeslope
	No slope (N/A)
	Other:

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

Area Surface Cover (circle one class per feature)

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

(X)	Parent Material (X all that apply)
	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

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

Erosion Features (circle one class per feature)

Tunneling	None	Rare	Common	Prolific
Sheet	None	Rare	Common	Prolific
Rill	None	Rare	Common	Prolific
Gully	None	Rare	Common	Prolific
Pedestals	None	Rare	Common	Prolific
Terracettes	None	Rare	Common	Prolific
Burrowing	None	Rare	Common	Prolific

Aspect (circle all that apply)

N NW W SW S SE E NE

If you find this datasheet completed, please call (520) 731-3420 ext. 5.

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

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Inventory and Monitoring Program

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USGS-NPS Vegetation Mapping Program Field Data Sheet: **Polygon Vegetation** Version: 0.04 Page ____ of ____

Proofread by: _____ Copied by: _____ Entered by: _____ Verified by: _____ GIS Edits done by: _____ New Poly ID: _____

Location and Event Information

Park:	Sub-Map #:	Date (mm/dd/yyyy):	Time (00:00):
Poly ID(s):		Field Poly ID:	
Observer(s):	Recorder:	Tentative Formation:	Keyed Formation:
Protocol Name: VegMap		Protocol Version: 0.05	

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 sp					Total cover all sp				Total cover all sp		

List other common associates

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

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

Disturbance Types:

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

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

PHOTOS: From approximate center of polygon take 4 photos, one in each cardinal direction, in order (N E S W). Write photo number (last four digits from upper right corner) in table and record camera used.
**** Please note the numbers of any additional photos taken and a description of what they depict.**

Camera Name:
North
East
South
West

NOTES: Describe the overall vegetative community, especially noting differences from other similar communities. Explain or diagram any polygon splits/additions/subtractions/boundary changes.

Fort Bowie NHS Vegetation Mapping

Field Data Sheet: **Thematic Accuracy Assessment**

Date (mm/dd/yyyy):	Time (00:00):	Observer(s):	Recorder:
Polygon Object ID:		Sub-map:	Unit Code: FOBO
Approximate polygon center (UTM NAD83):			

Keyed Formation:

Dominant Formation-defining species:

Trees | Shrubs | Herbaceous | Other/None

Based on your observation of this polygon and the vegetation type descriptions provided to you, check the label that best fits this polygon:

	Fraxinus velutina Forest & Woodland
	Celtis laevigata var. reticulata – Juglans major Woodland Association
	Pinus discolor – Juniperus monosperma Woodland Association
	Quercus emoryi – Juniperus monsperma Woodland
	Prosopis (glandulosa, velutina) Woodland

	[*Juniperus monosperma – Quercus emoryi*] / mixed shrub Wooded Shrubland
	Rhus microphylla Shrubland
	Prosopis (glandulosa, velutina) Shrubland

	Quercus turbinella Shrubland
	Fouquieria splendens – Parthenium incanum Shrubland Association
	Fouquieria splendens – Opuntia engelmannii Shrubland Association

	Quercus emoryi / mixed *Bouteloua* spp. Wooded Herbaceous
	Prosopis (glandulosa, velutina) / mixed *Bouteloua* spp. Shrub Herbaceous
	Bouteloua spp. – mixed grass Herbaceous

The fit of the vegetation type description to this polygon is (circle one) :

Excellent Good Fair Poor

If poor or fair, write in name of alternate vegetation type (does not need to be from above list)

Record any notes pertinent to your assessment of this polygon. Describe any recent (within the past year) disturbance that may have changed the vegetation type in this polygon, such as flooding, fire, tree cutting, etc. Use back of sheet as needed.

FOBO_AA_Datasheet.ppt

If you find this datasheet completed, please call (520) 621-4501.

Appendix E. Accuracy Assessment Documentation of Changes to Polygon Attribution

This appendix provides a detailed listing of changes made to polygon attributes post-accuracy assessment. Each case is treated individually and referenced using both the polygon ID assigned during the AA and given in parentheses is the final map class code found in the digital map.

Polygon 63 (WH-QE02): accept AA. This polygon could fit either the map class or the AA class, depending on the precise relative cover of grass vs. shrubs. Perceptions of this are probably seasonal.

Polygon 68 (S-RM06): accept AA and change to *Rhus microphylla* shrubland. Map data show <10% tree cover, and *Rhus microphylla* is the dominant shrub, so this polygon was poorly classified originally.

Polygon 98 (W-QE02): accept AA. This polygon could fit either the map class *Juniperus monosperma - Quercus emoryi* / Mixed Shrub Wooded Shrubland or the AA class, *Quercus emoryi - Juniperus monosperma* Woodland, depending on the precise relative cover of trees vs. shrubs. This could not be determined accurately from the satellite imagery, and the AA data were emphatic with an "excellent" fit, so the classification of woodland was accepted.

Polygon 32 (S-LT01): accept AA. This was such a poor-fit polygon that the accuracy assessors did not check any box, instead suggesting a new type, *Larrea tridentata* Shrubland. Review of the map datasheets showed that this could in fact be a slightly better classification than *Rhus microphylla* Shrubland, so a new map class was created and assigned to this polygon and one other. In the latter case, the map class and AA class agreed (on *Rhus microphylla* Shrubland), but the accuracy assessors' notes and a re-check in the field supported the change to *Larrea tridentata* Shrubland.

Polygon 40 (WS-JM14): accept AA and change from *Prosopis velutina* Shrubland to *Juniperus monosperma - Quercus emoryi* / Mixed Shrub Wooded Shrubland. Review of mapping datasheets and ground photos showed this polygon to have been poorly classified originally.

Polygon 52 (S-FSPI01): accept AA. This polygon is floristically intermediate between two types, and on the borderline between a shrub herbaceous type and a shrubland. Classification emphasis was placed on the characteristic *Fouquieria splendens*, making the AA class somewhat better than the mapping class.

Polygon 11 (SH-RM02): override AA and map class, change to new type: *Rhus microphylla* / Mixed Grass Shrub Herbaceous vegetation. It was determined that some stands of the *Rhus microphylla* type would be more properly classified as a shrub herbaceous type, so this was created.

Polygon 12 (SH-RM01): accept AA but modify polygon classification to *Rhus microphylla* / Mixed Grass Shrub Herbaceous vegetation, as for polygon 11.

Polygon 35 (SH-RM04): override AA and map class, modify polygon classification to *Rhus microphylla* / Mixed Grass Shrub Herbaceous vegetation, based on review of map datasheets, photos and AA datasheet.

Polygon 285 (SH-RM03): override AA and map class, modify polygon classification to *Rhus microphylla* / Mixed Grass Shrub Herbaceous vegetation, based on review of map datasheets and AA datasheet.

Polygon 25 (SH-P06): accept AA. Review of the original field data and photographs for this polygon revealed poor initial classification. The polygon was modified to be *Prosopis* (*glandulosa*, *velutina*)/*Bouteloua* spp. Shrub Herbaceous Alliance.

Appendix F. List of All Plant Species Observed During the Vegetation Mapping Inventory

Scientific name	Common name	Nativity	Duration
Forbs/Herbs			
Acalypha neomexicana	New Mexico copperleaf	Native	Annual
Allionia incarnata	trailing windmills	Native	Annual
Amaranthus palmeri	carelessweed	Native	Annual
Ambrosia confertiflora	weakleaf burr ragweed	Native	Perennial
Artemisia dracunculus	tarragon	Native	Perennial
Artemisia ludoviciana	white sagebrush	Native	Perennial
Astrolepis sp.	cloakfern	N/A	N/A
Bahia absinthifolia	hairyseed bahia	Native	Perennial
Boerhavia erecta	erect spiderling	Native	Annual
Bommeria hispida	copper fern	Native	Perennial
Chamaesaracha sordida	hairy five eyes	Native	Perennial
Cheilanthes sp.	lipfern	N/A	N/A
Dalea nana	dwarf prairie clover	Native	Perennial
Dalea pogonathera	bearded prairie clover	Native	Perennial
Dalea wrightii	Wright's prairie clover	Native	Perennial
Datura wrightii	sacred thorn-apple	Native	Annual
Desmodium neomexicanum	New Mexico ticktrefoil	Native	Annual
Eriogonum polycladon	sorrel buckwheat	Native	Annual
Froelichia arizonica	Arizona snakecotton	Native	Perennial
Gomphrena nitida	pearly globe amaranth	Native	Annual
Hedeoma oblongifolia	oblongleaf false pennyroyal	Native	Perennial
Heterotheca subaxillaris	camphorweed	Native	Annual
Lotus greenei	Greene's bird's-foot trefoil	Native	Perennial
Machaeranthera tagetina	mesa tansyaster	Native	Annual
Mimulus guttatus	seep monkeyflower	Native	Annual
Mirabilis laevis var. *villosa*	wishbone bush	Native	Perennial
Nicotiana obtusifolia	desert tobacco	Native	Annual
Penstemon sp.	beardtongue	Native	Perennial
Physalis longifolia	longleaf groundcherry	Native	Perennial
Polanisia dodecandra	redwhisker clammyweed	Native	Annual
Proboscidea parviflora	doubleclaw	Native	Annual
Pseudognaphalium canescens	Wright's cudweed	Native	Annual
Salsola kali	Russian thistle	Non-Native	Annual
Salsola tragus	prickly Russian thistle	Non-Native	Annual
Silene antirrhina	sleepy silene	Native	Annual
Verbesina encelioides	golden crownbeard	Native	Annual
Verbesina rothrockii	Rothrock's crownbeard	Native	Perennial
Xanthisma gracile	slender goldenweed	Native	Perennial
Graminoids			
Achnatherum eminens	southwestern needlegrass	Native	Perennial
Aristida divaricata	poverty threeawn	Native	Perennial
Aristida purpurea	purple threeawn	Native	Annual

Scientific name	Common name	Nativity	Duration
Aristida schiedeana	single threeawn	Native	Perennial
Aristida ternipes	spidergrass	Native	Perennial
Bothriochloa barbinodis	cane bluestem	Native	Perennial
Bouteloua aristidoides	needle grama	Native	Annual
Bouteloua barbata	sixweeks grama	Native	Annual
Bouteloua chondrosioides	sprucetop grama	Native	Perennial
Bouteloua curtipendula	sideoats grama	Native	Perennial
Bouteloua eriopoda	black grama	Native	Perennial
Bouteloua gracilis	blue grama	Native	Perennial
Bouteloua hirsuta	hairy grama	Native	Perennial
Bouteloua repens	slender grama	Native	Perennial
Chloris virgata	feather fingergrass	Non-Native	Annual
Cyperus sp.	flatsedge	N/A	N/A
Dasyochloa pulchella	low woollygrass	Native	Perennial
Digitaria californica	Arizona cottontop	Native	Perennial
Elionurus barbiculmis	woolyspike balsamscale	Native	Perennial
Enneapogon desvauxii	nineawn pappusgrass	Native	Perennial
Eragrostis cilianensis	stinkgrass	Non-Native	Annual
Eragrostis intermedia	plains lovegrass	Native	Perennial
Eragrostis lehmanniana	Lehmann lovegrass	Non-Native	Perennial
Erioneuron avenaceum	shortleaf woollygrass	Native	Perennial
Hesperostipa neomexicana	New Mexico feathergrass	Native	Perennial
Heteropogon contortus	tanglehead	Native	Perennial
Hilaria belangeri	curly-mesquite	Native	Perennial
Hilaria mutica	tobossa grass	Native	Perennial
Koeleria macrantha	prairie Junegrass	Native	Perennial
Leptochloa dubia	green sprangletop	Native	Perennial
Muhlenbergia alopecuroides	bristly wolf's tail	Native	Perennial
Muhlenbergia arenicola	sand muhly	Native	Perennial
Muhlenbergia emersleyi	bullgrass	Native	Perennial
Muhlenbergia minutissima	annual muhly	Native	Annual
Muhlenbergia polycaulis	cliff muhly	Native	Perennial
Muhlenbergia porteri	bush muhly	Native	Perennial
Panicum bulbosum	bulb panicgrass	Native	Perennial
Panicum hirticaule	Mexican panicgrass	Native	Annual
Panicum obtusum	vine mesquite	Non-Native	Perennial
Schizachyrium cirratum	Texas bluestem	Native	Perennial
Scleropogon brevifolius	burrograss	Native	Perennial
Setaria grisebachii	Grisebach's bristlegrass	Native	Annual
Setaria leucopila	streambed bristlegrass	Native	Perennial
Sporobolus airoides	alkali sacaton	Native	Perennial
Sporobolus contractus	spike dropseed	Native	Perennial
Sporobolus cryptandrus	sand dropseed	Native	Perennial
Sporobolus wrightii	big sacaton	Native	Perennial
Trachypogon spicatus	spiked crinkleawn	Native	Perennial
Tridens muticus	slim tridens	Native	Perennial
Vulpia octoflora	sixweeks fescue	Native	Annual

Scientific name	Common name	Nativity	Duration
Subshrubs			
Brickellia baccharidea	resinleaf brickellbush	Native	Perennial
Brickellia californica	California brickellbush	Native	Perennial
Brickellia lemmonii	Lemmon's brickellbush	Native	Perennial
Castilleja lanata	Sierra woolly Indian paintbrush	Native	Perennial
Cevallia sinuata	stinging serpent	Native	Perennial
Chamaecrista nictitans	partridge pea	Native	Annual
Chloracantha spinosa	spiny chloracantha	Native	Perennial
Croton pottsii	leatherweed	Native	Perennial
Dalea albiflora	whiteflower prairie clover	Native	Perennial
Dalea formosa	featherplume	Native	Perennial
Ericameria laricifolia	turpentine bush	Native	Perennial
Eriogonum wrightii	bastardsage	Native	Perennial
Gutierrezia microcephala	threadleaf snakeweed	Native	Perennial
Gutierrezia sarothrae	broom snakeweed	Native	Perennial
Gymnosperma glutinosum	gumhead	Native	Perennial
Isocoma tenuisecta	burroweed	Native	Perennial
Krameria lanceolata	trailing krameria	Native	Perennial
Krascheninnikovia lanata	winterfat	Native	Perennial
Marrubium vulgare	horehound	Non-Native	Perennial
Nolina microcarpa	sacahuista	Native	Perennial
Pectis longipes	longstalk cinchweed	Native	Perennial
Psilostrophe cooperi	whitestem paperflower	Native	Perennial
Solanum elaeagnifolium	silverleaf nightshade	Native	Perennial
Sphaeralcea laxa	caliche globemallow	Native	Perennial
Sphaeralcea wrightii	Wright's globemallow	Native	Perennial
Stephanomeria pauciflora	brownplume wirelettuce	Native	Perennial
Thamnosma texana	rue of the mountains	Native	Perennial
Thelesperma longipes	longstalk greenthread	Native	Perennial
Tiquilia canescens	woody crinklemat	Native	Perennial
Trichostema arizonicum	Arizona bluecurls	Native	Perennial
Trixis californica	American threefold	Native	Perennial
Viguiera dentata	toothleaf goldeneye	Native	Perennial
Zinnia grandiflora	Rocky Mountain zinnia	Native	Perennial
Shrubs			
Aloysia wrightii	Wright's beebrush	Native	Perennial
Anisacanthus thurberi	Thurber's desert honeysuckle	Native	Perennial
Arctostaphylos pungens	pointleaf manzanita	Native	Perennial
Atriplex canescens	fourwing saltbush	Native	Perennial
Baccharis pteronioides	yerba de pasmo	Native	Perennial
Baccharis salicifolia	mule's fat	Native	Perennial
Baccharis sarothroides	desertbroom	Native	Perennial
Baccharis sergiloides	desert baccharis	Native	Perennial
Calliandra eriophylla	fairyduster	Native	Perennial
Ceanothus greggii	desert ceanothus	Native	Perennial
Celtis laevigata	sugarberry	Native	Perennial
Cercocarpus montanus	alderleaf mountain mahogany	Native	Perennial

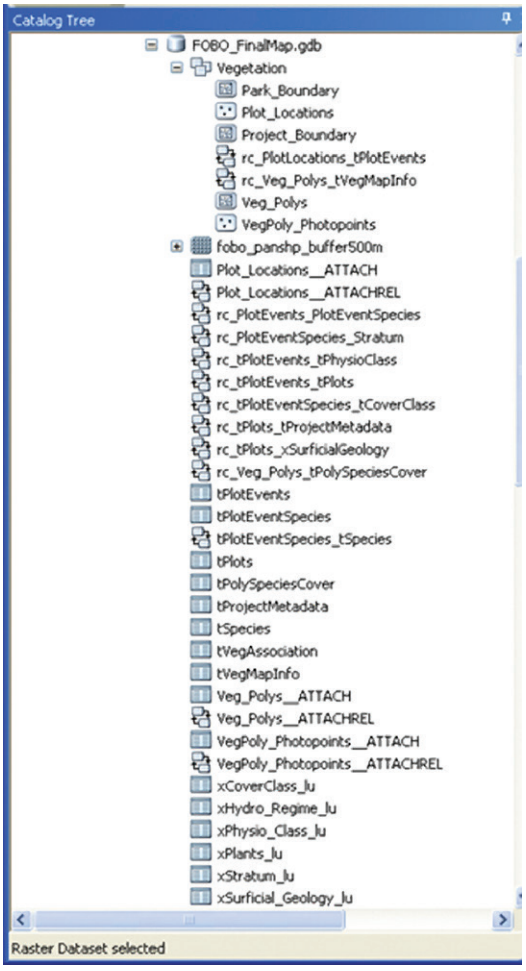
Scientific name	Common name	Nativity	Duration
Condalia warnockii	Warnock's snakewood	Native	Perennial
Fouquieria splendens	ocotillo	Native	Perennial
Garrya wrightii	Wright's silktassel	Native	Perennial
Larrea tridentata	creosote bush	Native	Perennial
Lycium pallidum	pale desert-thorn	Native	Perennial
Mimosa aculeaticarpa	catclaw mimosa	Native	Perennial
Mimosa aculeaticarpa var. *biuncifera*	catclaw mimosa	Native	Perennial
Parthenium incanum	mariola	Native	Perennial
Rhus microphylla	littleleaf sumac	Native	Perennial
Rhus trilobata sp.	skunkbush sumac	Native	Perennial
Rhus trilobata var. *pilosissima*	pubescent squawbush	Native	Perennial
Rhus virens	evergreen sumac	Native	Perennial
Robinia neomexicana	New Mexico locust	Native	Perennial
Sideroxylon lanuginosum	gum bully	Native	Perennial
Ziziphus obtusifolia	lotebush	Native	Perennial
Succulent			
Agave palmeri	Palmer's century plant	Native	Perennial
Agave parryi	Parry's agave	Native	Perennial
Cylindropuntia spinosior	walkingstick cactus	Native	Perennial
Dasylirion wheeleri	common sotol	Native	Perennial
Echinocereus coccineus	scarlet hedgehog cactus	Native	Perennial
Echinocereus pectinatus	rainbow cactus	Native	Perennial
Ferocactus wislizeni	candy barrelcactus	Native	Perennial
Mammillaria sp.	globe cactus	N/A	N/A
Mammillaria grahamii	Graham's nipple cactus	Native	Perennial
Mammillaria heyderi var. *macdougalii*	Macdougal's nipple cactus	Native	Perennial
Opuntia chlorotica	dollarjoint pricklypear	Native	Perennial
Opuntia engelmannii	cactus apple	Native	Perennial
Opuntia macrocentra	purple pricklypear	Native	Perennial
Opuntia phaeacantha	tulip pricklypear	Native	Perennial
Yucca baccata	banana yucca	Native	Perennial
Tree			
Acacia greggii	catclaw acacia	Native	Perennial
Arctostaphylos pringlei	Pringle manzanita	Native	Perennial
Celtis laevigata var. *reticulata*	netleaf hackberry	Native	Perennial
Fraxinus velutina	velvet ash	Native	Perennial
Garrya flavescens	ashy silktassel	Native	Perennial
Juglans major	Arizona walnut	Native	Perennial
Juniperus coahuilensis	redberry juniper	Native	Perennial
Juniperus deppeana	alligator juniper	Native	Perennial
Juniperus monosperma	one-seed juniper	Native	Perennial
Juniperus osteosperma	Utah juniper	Native	Perennial
Morus microphylla	Texas mulberry	Native	Perennial
Pinus discolor	border pinyon	Native	Perennial
Pinus edulis	twoneedle pinyon	Native	Perennial
Populus fremontii	Fremont cottonwood	Native	Perennial
Prosopis glandulosa	honey mesquite	Native	Perennial

Scientific name	Common name	Nativity	Duration
Prosopis velutina	velvet mesquite	Native	Perennial
Ptelea trifoliata	common hoptree	Native	Perennial
Quercus arizonica	Arizona white oak	Native	Perennial
Quercus emoryi	Emory oak	Native	Perennial
Quercus grisea	gray oak	Native	Perennial
Quercus pungens	pungent oak	Native	Perennial
Quercus rugosa	netleaf oak	Native	Perennial
Quercus toumeyi	Toumey oak	Native	Perennial
Quercus turbinella	Sonoran scrub oak	Native	Perennial
Salix gooddingii	Goodding's willow	Native	Perennial
Sapindus saponaria	wingleaf soapberry	Native	Perennial
Yucca elata	soaptree yucca	Native	Perennial
Vine			
Galactia wrightii	Wright's milkpea	Native	Perennial
Ipomoea coccinea	redstar	Non-Native	Annual
Ipomoea hederifolia	scarletcreeper	Native	Annual
Janusia gracilis	slender janusia	Native	Perennial
Maurandella antirrhiniflora	roving sailor	Native	Perennial
Phaseolus sp.	tepary bean	Native	Perennial
Vitis arizonica	canyon grape	Native	Perennial

Species are arranged by lifeform. Non-native species are in bold text.

Appendix G. Geodatabase Specifications, Description, and Schema

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



Geodatabase schema.

Feature class and related table descriptions:

Veg_Polys: 74 polygon features, each attributed with community type, type codes, and map class codes. 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.

tPolySpeciesCover: This table was generated by building a query in the Access database storing project data. Species records were exported as a list within each height class and their mid-point cover class values are given. This table is related to the Veg_Polys feature class (mapping units) such that the user can select any polygon and see which species were observed there. Conversely, the user can select species or even species with a certain cover value and use the relationship in the opposite direction (i.e., to view which polygonal areas have that particular species in that particular abundance). This feature alone is a powerful exploratory tool within this GDB.

Plot Locations: 21 point locations. This was data collected in the field. This table is related to tPlotEvents, which lists basic information on plot location and shape, date sampled, and soil cover characteristics and total cover by strata for vegetation.

tPlotEvents is 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. These were recorded in the field on handheld Trimble GPS units and subsequently merged and imported into the GDB.

Fobo_panshp_buffer500m: This raster dataset was imported into the GDB. It is the Quickbird imagery used during the field-mapping effort and is included for reference and background. It was pansharpened and has a resolution of ~0.6 meters.

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 can click on any polygon or photo point and a window will open showing a small icon of the attachment and displaying the attributes of the feature.

Geodatabase Elements

Geodatabase:

- FOBO_FinalMap.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_PhotoPoints – Four photos are taken at each point; one for each cardinal direction.

Raster Datasets:

- 4-band Quickbird imagery for the study area.

Tables:

- tPlotEvents – Plot metadata and veg info
- tPlotEventSpecies – Recorded species within plot
- tPlots – Landscape attribute data
- tPolySpeciesCover – Species list and their cover values for each polygon sampled
- tProjectMetadata - Metadata
- tSpecies – Species list
- tVegAssociation – Western veg associations list
- tVegMapInfo - Association data and codes
- xCoverClass_lu – lookup table for cover classes
- xHydroRegime_lu – lookup table for hydro regimes
- xLandform_lu – lookup table for landforms
- xMapClass_lu – lookup table for map classes
- 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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