National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Vegetation Inventory, Mapping, and Characterization Report, Tonto National Monument

Natural Resource Report NPS/SODN/NRR—2017/1498









ON THE COVER

Clockwise from top left: jojoba shrubland; spring annuals in bloom beneath the upper ruins; broom snakeweed - button brittlebush shrubland; and Arizona sycamore - Arizona walnut riparian forest. NPS photos.

Vegetation Inventory, Mapping, and Characterization Report, Tonto National Monument

Natural Resource Report NPS/SODN/NRR—2017/1498

Prepared by

Sarah Studd
J. Andrew Hubbard
Beth Fallon

Sonoran Desert Network
National Park Service
12661 East Broadway Boulevard
Tucson, AZ 85748

Sam Drake
Miguel Villarreal

Office of Arid Lands Studies
University of Arizona
1955 East Sixth Street
Tucson, AZ 85719

Editing and Design

Alice Wondrak Biel
Sonoran Desert Network
National Park Service
12661 East Broadway Boulevard
Tucson, AZ 85748

August 2017

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

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.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Sonoran Desert Network website, http://www.nature.nps.gov/im/units/sodn, as well as at the Natural Resource Publications Management web site, http://www.nature.nps.gov/publications/nrpm. To receive this report in a format optimized for screen readers, please e-mail irma@nps.gov.

Please cite this publication as:

Studd, S. E., J. A. Hubbard, B. Fallon, S. Drake, and M. Villarreal. 2017. Vegetation inventory, mapping, and characterization report, Tonto National Monument. Natural Resource Report NPS/SODN/NRR—2017/1498. National Park Service, Fort Collins, Colorado.

NPS 358/139825, August 2017

Contents

Figures v
Tables vii
Acronyms, Abbreviations, and Codes ix
Executive Summary xi
Acknowledgements xiii

1 Introduction 1
- 1.1 Background 1
- 1.2 Scope and products 1
- 1.3 The NPS Vegetation Inventory 1
- 1.4 The National Vegetation Classification Standard 3
- 1.5 The National Vegetation Classification 4
- 1.6 Terminology and naming conventions 5
- 1.7 Project area and description 6

2 Classification and Mapping of Plant Communities 13
- 2.1 Methods 13
- 2.2 Results 22

3 Accuracy Assessment 53
- 3.1 Methods 53
- 3.2 Results 54

4 Discussion 59
- 4.1 Vegetation characterization 59
- 4.2 National Vegetation Classification System placement 59
- 4.3 The flora 59
- 4.4 Final products and geodatabase delivery 60
- 4.5 Updating the map 61

5 Literature Cited 63

Appendices 67
- Appendix A: Vegetation Community Type Descriptions 67
- Appendix B: Dichotomous Key to Mapped Vegetation Types at Tonto National Monument 133
- Appendix C: Key to Vegetation Formations 136
- Appendix D: Example Datasheets 137
- Appendix E: Plant Species Lists Based on Observations During the Inventory 143
- Appendix F. Geodatabase Specifications, Description, and Schema 147

Figures

Main report

Figure 1-1. Map of Tonto National Monument in central Arizona 2

Figure 1-2. Topographical representation of Tonto National Monument, shown in 40-foot intervals, with the two major drainages highlighted. 7

Figure 1-3. Mean monthly precipitation (PPT) and maximum (Max)/minimum (Min) air temperature for Tonto National Monument, based on 1981–2010 climate normals 8

Figure 1-4. Arizona represented in terms of its three major physiographic regions 9

Figure 1-5. Soil families of Tonto National Monument 10

Figure 2-1. Aerial image mosaic of Tonto National Monument and environs. 14

Figure 2-2. Example of digitized draft polygons for Tonto NM, delineated on the basis of formation-level structural characteristics visible in the aerial images. 15

Figure 2-3. Classification plot locations at Tonto National Monument. 18

Figure 2-4. Sampling a classification plot. 19

Figure 2-5. Example dendrogram showing the results of an initial cluster analysis on intermediate plots (n=50) 20

Figure 2-6. Example diagram showing the eight groupings from the initial cluster analysis of subcanopy cover data, shown in ordination space (NMDS) with within-group similarity levels of 30% and 38% overlaid in green and blue-dash lines, respectively 21

Figure 2-7. Vegetation inventory map, Tonto National Monument. (P) signifies a proposed map class 23

Figure 2-8. *Platanus wrightii - Juglans major* Riparian Forest association at Tonto National Monument. 24

Figure 2-9. An example of the *Parkinsonia microphylla - Simmondsia chinensis* Wooded Shrubland association at Tonto National Monument. 26

Appendices

Figure F-1. Database relationships for the final map and related data products. 147

Tables

Main report

Table 1-1. Summary of the National Vegetation Classification Standard hierarchical approach, Version 1. 4

Table 1-2. Summary of the National Vegetation Classification Standard hierarchical approach, Version 2. 5

Table 2-1. Types of information and items noted on classification plots and polygons. 17

Table 2-2. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Group 797: Western Interior Riparian Forest & Woodland Group, Tonto National Monument. 27

Table 2-3. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Group 533: Prosopis glandulosa - P. velutina - Baccharis spp. North American Warm Desert Riparian Low Bosque & Shrubland Group, Tonto National Monument. 27

Table 2-4. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Group 281: Quercus turbinella - Ceanothus greggii - Arctostaphylos pungens Chaparral Group, Tonto National Monument. 27

Table 2-5. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Group 293: Carnegiea gigantea - Parkinsonia microphylla - Ambrosia deltoidea Mixed Cacti Desert Scrub Group (tentative assignment), Tonto National Monument. 28

Table 2-6. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Park Special, Tonto National Monument. 29

Table 2-7. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Non-Vegetated, Tonto National Monument. 29

Table 3-1. Thematic accuracy assessment error matrix 55

Table 4-1. Plant species observed during mapping efforts with a global rarity rank of G3 or higher. 60

Appendices

Table E-1. Plant species observed during mapping at Tonto National Monument, 2008–2010. 143

Acronyms, Abbreviations, and Codes

AA	accuracy assessment
ac	acres
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
ft	foot/feet
GCP	ground control point
GIS	geographic information system
GPS	global positioning system
ha	hectares
I&M	Inventory and Monitoring Division
ITIS	Integrated Taxonomic Information System
km	kilometers
m	meters
mi	miles
MMU	minimum mapping unit
NA	not applicable
NAD83	North American Datum of 1983
NHS	national historic site
NM	national monument
NMDS	non-metric multidimensional scaling
NMEM	national memorial
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
OALS	Office of Arid Land Studies
RMSE	root mean square error
RRQRR	Reversed Randomized Quadrant-Recursive Raster
SIMPROF	similarity profile
SODN	Sonoran Desert Network (National Park Service)
spp.	species (plural)
TONT	Tonto National Monument
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

A vegetation classification, description, and mapping effort was conducted at Tonto National Monument (NM) from 2008 to 2011 by the Sonoran Desert Network in cooperation with the University of Arizona's Office of Arid Lands Studies (OALS). This project was completed under the National Park Service (NPS) Vegetation Inventory Program, which aims to complete baseline 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. For Tonto NM, as well as other network parks, comprehensive vegetation data inform park management decisions and provide a foundation upon which to develop and implement specific research and monitoring programs. The data standard was designed to facilitate the production of uniform statistics about vegetation across the nation, enable the translation of data collected at various scales, and allow data sharing, aggregation, and comparison across regions.

Vegetation mapping and characterization comprised three major field phases: (1) concurrent, field-based data collection and mapping from aerial imagery, (2) development of vegetation community types at the National Vegetation Classification association level, and (3) map accuracy assessment. A survey of all classification plots and polygons was completed during March and April 2009. Vegetation association descriptions were drafted from these data to meet the National Vegetation Classification System (NVCS) standard, and were applied to each of the mapped areas. A formal accuracy assessment (AA), completed in spring 2010, consisted of a census approach in which each map unit (polygon) was assessed in its entirety. This effort sought to evaluate the per-class accuracy for map users and was conducted by a separate team in an unbiased manner. Following the AA, final products were developed, including this report, a digital map, and full vegetation descriptions.

A total of 23 vegetation associations were described and mapped at Tonto NM during this project, ranging from paloverde - jojoba-dominated wooded shrublands in the lower alluvial fans to Sonoran scrub oak - mountain mahogany shrublands at the upper-elevation mountain ridge sites. The vegetation is relatively diverse for a monument of only 453 hectares (1,120 ac), with influences of the Sonoran Desert and Colorado Plateau seen in the flora. Overall, the vegetation can be separated into a few broad categories, from most abundant to least, as follows: transitional Sonoran desert scrub, semi-desert shrublands, montane shrublands, mesquite and acacia washes and woodlands, and riparian forest.

After accuracy assessment (AA), four associations were combined into two map classes, as they were not distinguished in the field during the AA effort. The final map and spatial data products have symbolic representation showing both the map unit and association level data. For all but these two merged associations (*Simmondsia chinensis - Lycium fremontii* Shrubland and *Parkinsonia microphylla / Simmondsia chinensis - Ericameria laricifolia* Shrubland), the map class is exactly equal to the association. Overall accuracy for all classes was 80%, with a Kappa (a measure of overall accuracy minus chance agreement) of 79%. Individual class accuracies varied from 50 to 100%. Three of the associations had accepted corollaries within the National Vegetation Classification (NVC) at time of writing; all others were described solely from data collected at Tonto during this project. 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 enable updates to be made as new information becomes available (such as revised NVC codes or vegetation type names), or in the event of major disturbance events that could impact vegetation.

Acknowledgements

The authors would like to extend thanks to the staff of Tonto National Monument for their support of this project and assistance with logistics. Sonoran Desert Network data manager Kristen Bonebrake helped with database design and management. Beth Fallon, Laura Crumbacher, Greg Goodrum, Daniel Stauning, and Aaron Curtis, of the Sonoran Desert Network, collected and managed the field data. Accuracy assessments were conducted by researchers from the University of Arizona in cooperation with Sonoran Desert Network staff. Programmatic support was provided throughout by the national level Vegetation Inventory Program staff, K. Brown, and T. Cook. Finally, we would like to thank Kathryn Thomas, research ecologist with the U.S. Geological Survey Southwest Biological Science Center, and Amy Tendick, ecologist with the Northern Colorado Plateau Network, for their review and helpful comments.

1 Introduction

1.1 Background

Vegetation is a primary resource of natural areas, and description of vegetation composition, structure, and distribution is fundamental to effective land management. The term "vegetation" encompasses plants at multiple scales, from the most refined floristic levels (referred to as "plant communities" in this report) to the broadest physiognomic or lifeform levels, such as "tropical rainforest" or "savanna." This report describes the methods and results of a multi-year project (2008–2011) to classify, describe, and map vegetation at Tonto National Monument, located in Gila County, Arizona (Figure 1-1).

The National Park Service's (NPS) Sonoran Desert Network (SODN), part of the servicewide Inventory and Monitoring (I&M) Division, organized and coordinated vegetation classification, description, and mapping at Tonto National Monument (NM). For Tonto and other network parks, comprehensive vegetation data inform park management decisions and provide a foundation upon which to develop and implement specific research and monitoring programs.

This effort at Tonto NM is part of the NPS Vegetation Inventory (http://science.nature.nps.gov/im/inventory/veg/index.cfm), in cooperation with SODN and the University of Arizona's Office of Arid Lands Studies (OALS). The map is required to meet the standards of the NPS Vegetation 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). In addition to meeting the program standards, every effort was made to provide the mapping and classification data to park managers in a manner best suited to their specific management objectives and needs.

1.2 Scope and products

The aim of this project was to create a vegetation map at the National Vegetation Classification System (NVCS) alliance level or finer for a study area of about 550 hectares (1,360 ac). The 550-hectare study area included the 453 hectares (1,120 ac) within the park boundary plus a 100-meter buffer surrounding the unit, comprising 97 ha (240 ac); see Figure 1-1. Land within the park boundary accounted for 82.4% of the project area.

Products developed for Tonto NM 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). In the past, the program was 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 with support through Inventory & Monitoring Division base funds. Data products are currently available online through the NPS integrated resource management applications web portal (https://irma.nps.gov) and an interactive map viewer (http://science.nature.

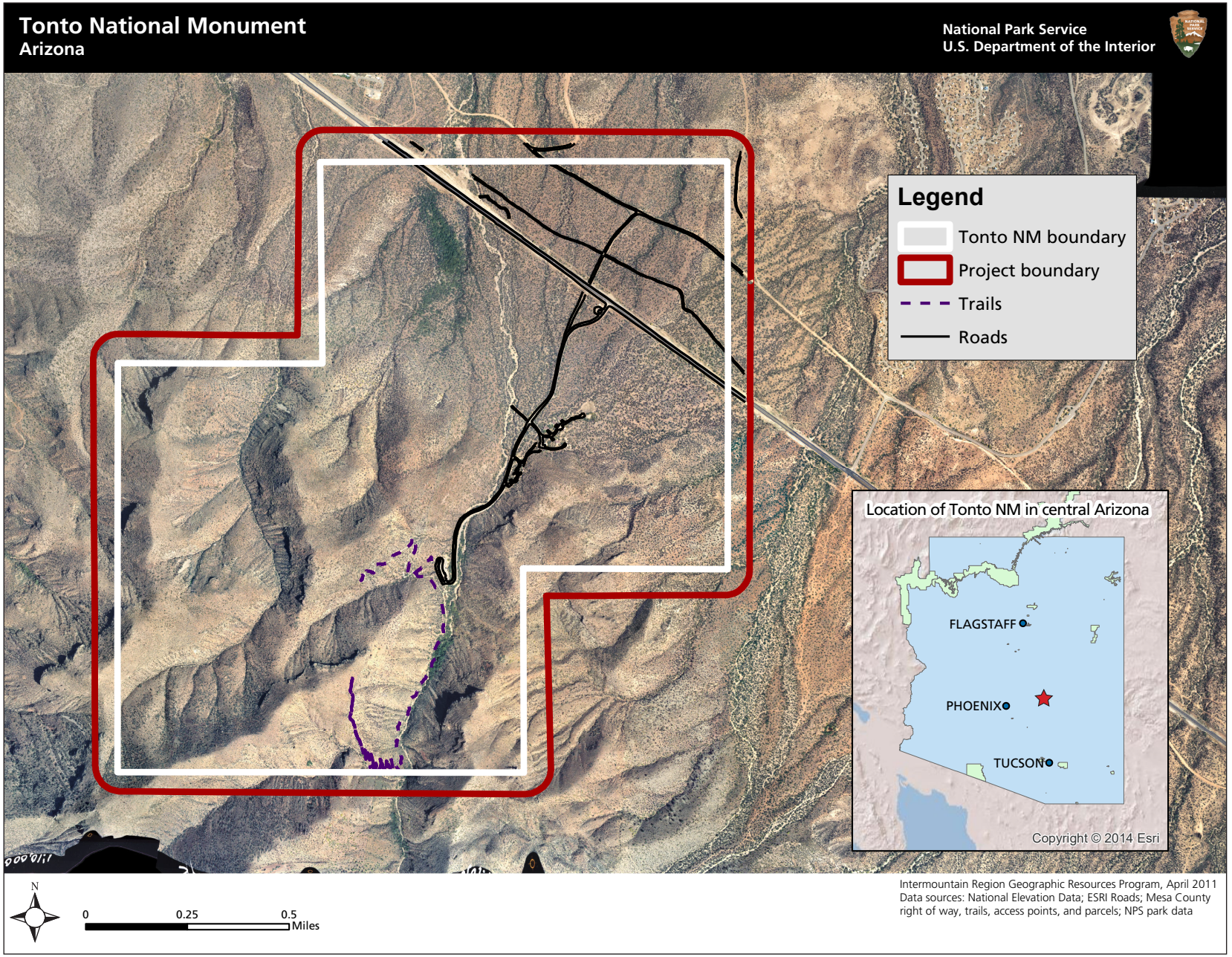


Figure 1-1. Map of Tonto National Monument in central Arizona. This graphic shows both the legal park boundary and project boundary, which includes a 100-meter buffer.

nps.gov/im/inventory/veg/). Products can be accessed on the IRMA site by utilizing the "data store" application on the home page, and then following the link to "Natural Resource Inventories." From there, the user can use a filter to narrow the search by selecting park unit and/or inventory type.

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

- Vegetation classification guidelines: National Park Service vegetation inventory, version 2.0 (Lea 2011)
- Methodology for assessing the utility of existing data for vegetation mapping (TNC and ESRI 1996; NPS edited 2009 version)
- National Vegetation Classification Standard, v. 2 (FGDC 2008)
- Thematic accuracy assessment procedures: National Park Service vegetation inventory, version 2.0 (Lea and Curtis 2010).

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

- Vegetation classification follows the FGDC standard for vegetation classification, which is the National Vegetation Classification Standard.
- Spatial data formatting follows FGDC standards for spatial data transfer.
- Metadata for each spatial dataset uses the FGDC metadata standard.
- Spatial data are provided with a horizontal positional accuracy that meets National Map Accuracy Standards at the 1:24,000 scale. Each well-defined object within the spatial database is within 1/50 of an inch display scale or 12.2 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 try to 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

Vegetation patterns vary continuously over landscapes. Classification systems attempt to categorize those patterns by identifying and describing plant assemblages 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 1994). In 1997, the FGDC formally adopted the NVCS version 1 (FGDC 1997). At the time of its adoption, the NVCS version 1 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, which was finalized and published in February 2008.

The NVCS evolved from vegetation classification primarily conducted by The Nature Conservancy (TNC), NatureServe, and the Natural Heritage Program network (Grossman et al. 1998) over more than two decades. 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 of the hierarchy are physiognomic, based pri-

marily 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.

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

The NVCS 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) 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

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

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

Level	Level name	Criteria	Example
L1 (Upper)	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 (Upper)	Formation Subclass	Combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate or aquatic conditions.	Temperate and Boreal Shrub and Herb Vegetation (Temperate and Boreal Shrubland & Grassland)
L3 (Upper)	Formation	Combinations of dominant and diagnostic growth forms that reflect global macroclimatic factors as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.	Temperate Shrub and Herb Vegetation (Temperate Shrubland & Grassland)
L4 (Mid)	Division	Combinations of dominant and diagnostic growth forms and a broad set of diagnostic plant taxa that reflect biogeographic differences in composition and continental differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon - Stipa - Bouteloua* Grassland & Shrubland Division (North American Great Plains Grassland & Shrubland)
L5 (Mid)	Macrogroup	Combinations of moderate sets of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences in composition and subcontinental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii - Schizachyrium scoparium -Sorghastrum nutans* Grassland & Shrubland Macrogroup (Great Plains Tall Grassland & Shrubland)
L6 (Mid)	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)
L7 (Lower)	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 (Lower)	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)

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 Tonto NM is based solely on data collected during this effort, and naming conventions were developed as fitting. For more information on the NVC, see the NPS Vegetation 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 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). Associations are defined as having consistent species composition, uniform physiognomy, and similar habitat conditions. All vegetation communities at Tonto NM were classified to the association level.

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 indicate the species is less consistently found 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).
- A "(P)" at the end of an 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 associations follows Kartesz (1999). Examples of association names from Tonto NM:

Parkinsonia microphylla / *Simmondsia chinensis* Wooded Shrubland

Platanus wrightii - Juglans major Semi-permanently Flooded Forest

Parkinsonia microphylla / *Eriogonum fasciculatum - Encelia frutescens* Shrubland.

1.7 Project area and description

1.7.1 Location and setting

Tonto National Monument encompasses 453 hectares and is located in the Salt River drainage of east-central Arizona, approximately 193 kilometers east of Phoenix, and about 51 kilometers northwest of Globe, Arizona. Elevation ranges from 695 meters (2,280 ft) on the northern boundary to 1,230 meters (4,035 ft) in the southwestern corner. The landscape is a complex of alluvial fans and bajada slopes skirting the mountainous terrain of the monument's upper elevations. The topography is characterized by two major drainages (Cave Canyon and Deadman Canyon) and other, smaller drainages, all running predominantly south to north. These steep drainages split local topography into generally eastern- and western-oriented slopes (Figure 1-2).

Tonto NM is situated at the northern end of the Sonoran Desert ecoregion, in the vegetation province described by Brown (1982) as the Arizona Upland subdivision. This rugged region is a part of the semiarid Transition physiographic zone of central Arizona (Waters 1998). This physiographic region separates the Sonoran Desert from the Colorado Plateau. The region's vegetation is characterized by the transition from the rugged ponderosa forests covering the uplands to the desert scrub of the Basin and Range-type

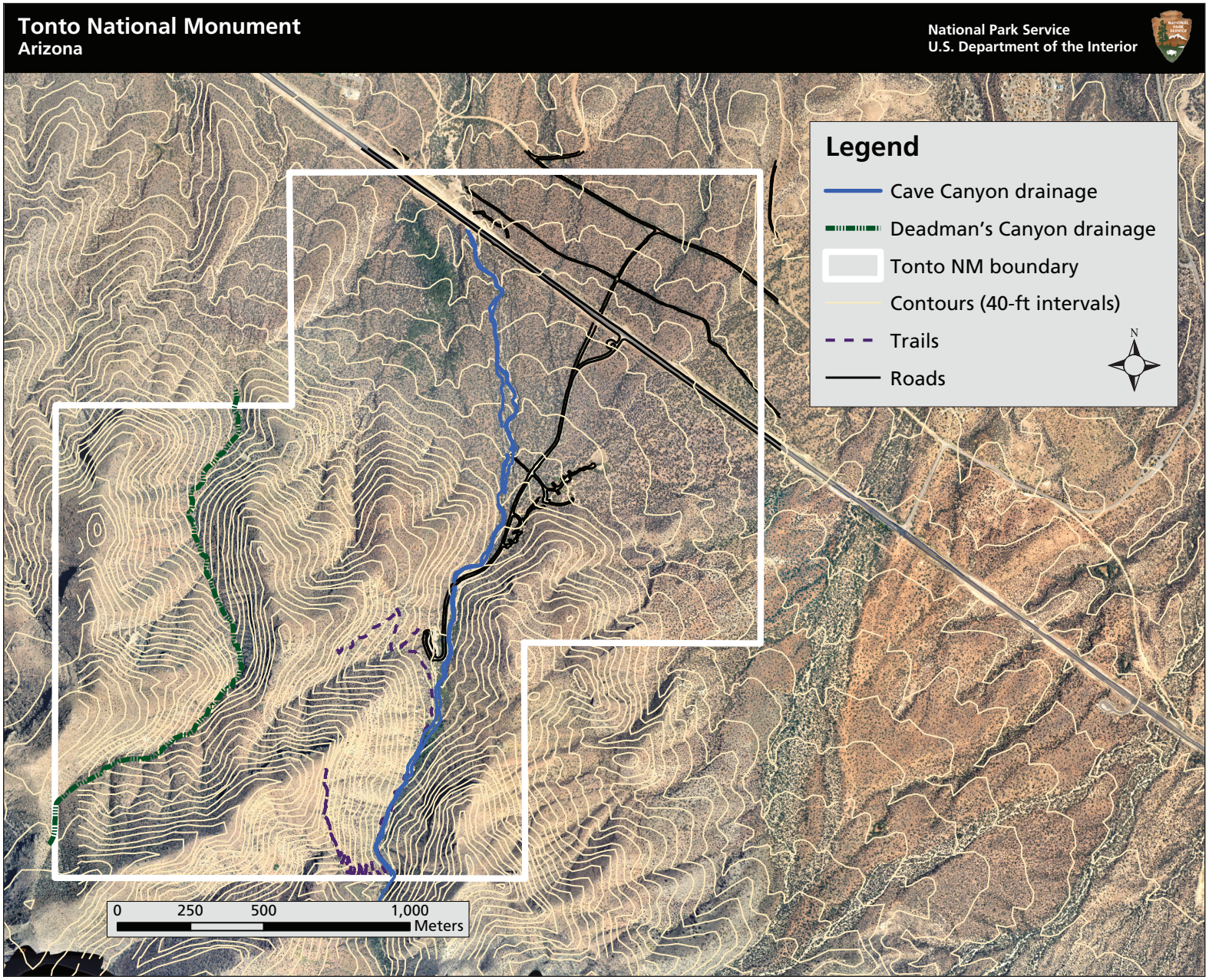


Figure 1-2. Topographical representation of Tonto National Monument, shown in 40-foot intervals, with the two major drainages highlighted.

lowlands that are characteristic of the upper Sonoran Desert (Van West et al. 2000).

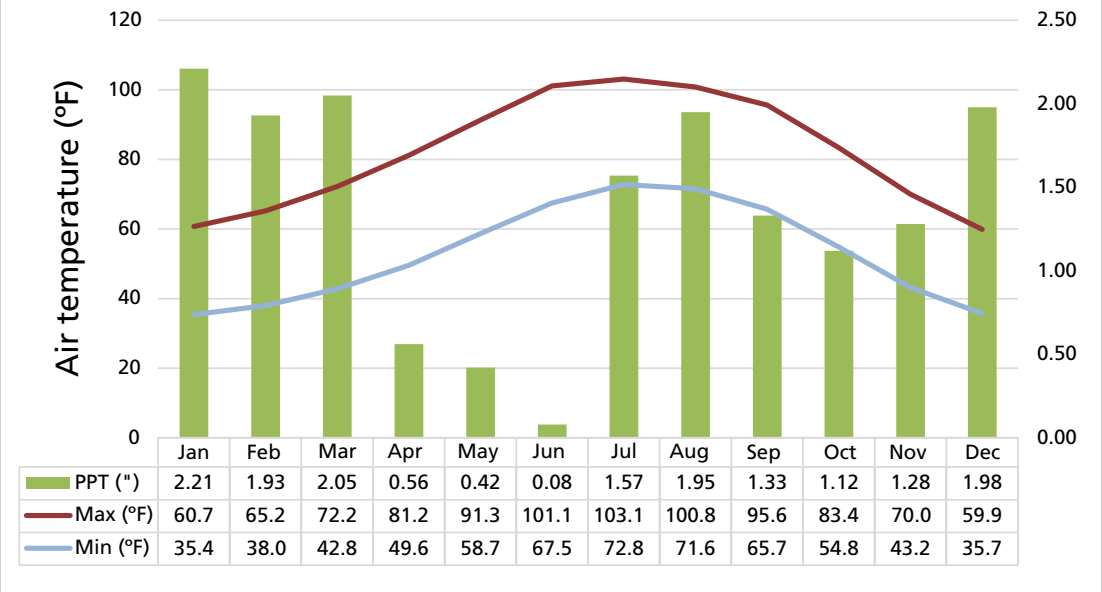
1.7.2 Park establishment and purpose

Tonto National Monument was established by presidential proclamation in 1907, to protect Salado Culture cliff dwellings and associated surface archeological sites present in its northeastern section. People of the Salado Culture inhabited the cliff dwellings for approximately 300 years, abandoning the site around 1450 AD. The monument was initially overseen by the U.S. Forest Service before becoming a National Park Service unit in 1933. Tonto National Forest surrounds the monument on all sides.

1.7.3 Climate, geology, and soils

Tonto NM experiences climate typical of the Sonoran Desert ecoregion: semi-arid with highly variable, bimodal precipitation, a considerable range in daily and seasonal air temperature, and relatively high potential evapotranspiration rates (Ingram 2000). About one third of the annual precipitation at Tonto NM falls during the summer monsoon season, when maximum air temperatures can approach 104°F (40°C) and lead to violent (and often localized) rainstorms (Figure 1-3). The thunderstorms are highly variable in time and space and primarily derive their moisture from the Gulf of California and the tropical Pacific Ocean (Sheppard et al. 2002). The bulk of the remaining annual precipitation falls in relatively gentle events of broad extent from November through March (Ingram 2000). Freezing temperatures can occur during winter months, though extended frosts are rare (NPS 2005).

Tonto NM is located in the Central Highlands Transition Zone Physiographic Province, which is characterized by Ponderosa pine and mixed-conifer forests. However, Tonto NM also lays close to the Basin and Range province, which corresponds more to Sonoran Desert vegetation (Figure 1-4). The monument's vegetation shows the influences of both. The nearby Globe-Miami area is well-known for its active copper mineral mines, with copper formed during metamorphic geologic processes. The University of Arizona extension describes each of the physiographic provinces as having varying water resources, with the "transition zone having a mixture of both fractured rock and alluvial basins. Fractured rock aquifers are much more limited than the aquifers in the Basin & Range" (http://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1501b.pdf).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PPT (")	2.21	1.93	2.05	0.56	0.42	0.08	1.57	1.95	1.33	1.12	1.28	1.98
Max (°F)	60.7	65.2	72.2	81.2	91.3	101.1	103.1	100.8	95.6	83.4	70.0	59.9
Min (°F)	35.4	38.0	42.8	49.6	58.7	67.5	72.8	71.6	65.7	54.8	43.2	35.7

Figure 1-3. Mean monthly precipitation (PPT) and maximum (Max)/minimum (Min) air temperature for Tonto National Monument, based on 1981–2010 climate normals (National Climate Data Center, ID#27281).

More specifically, the monument is characterized by Precambrian rocks which, through uplift and erosion processes, created and filled the Tonto basin with the Gila Conglomerate (Lindsay et al. 1994). Deposits are a combination of Tertiary sediments in the northwest and Precambrian sedimentary rocks of the Apache group in the southeast sections. Tertiary sediments do not have significant water-holding capacity. Soils associated with these sediments have high infiltration rates and sandy textures (Lindsay et al. 1994). The Precambrian rocks found at the higher elevations of Tonto NM include Mescal Limestone and Dripping Springs Quartzite, both impermeable except along fault-line sand fractures. The Gila Conglomerate covers this type in many areas but soils are shallow, with high surface-rock fragments and bedrock extrusions (Lindsay et al. 1994). The Dripping Springs quartzite is notable because it houses the alcoves with cliff dwellings. The alcoves were created by weathering and erosional processes that likely started 50,000–400,000 years ago. The people of the Salado culture utilized sedimentary and igneous rocks in the area to form tools and building materials (NPS 2006).



Figure 1-4. Arizona represented in terms of its three major physiographic regions (http://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1501b.pdf).

A U.S. Department of Agriculture (USDA) Soil Conservation Service soil survey was completed by Lindsay and others (1994), resulting in a map delineating 10 soil families within the monument (Figure 1-5). This project used the soil map to help identify potential breaks or transitions between vegetation types. The soil families broadly correlate to the landforms on which they are found (hills, bajadas, or drainages). There are generalized differences in the vegetation found there. The Boedecker and Tonto soil families occur in drainages, with the Boedecker family restricted to the Cave Creek riparian area that supports the small strip of gallery forest. The Tonto family occurs in the northwest corner of the park, corresponding to a small, unique area of mesquite woodland.

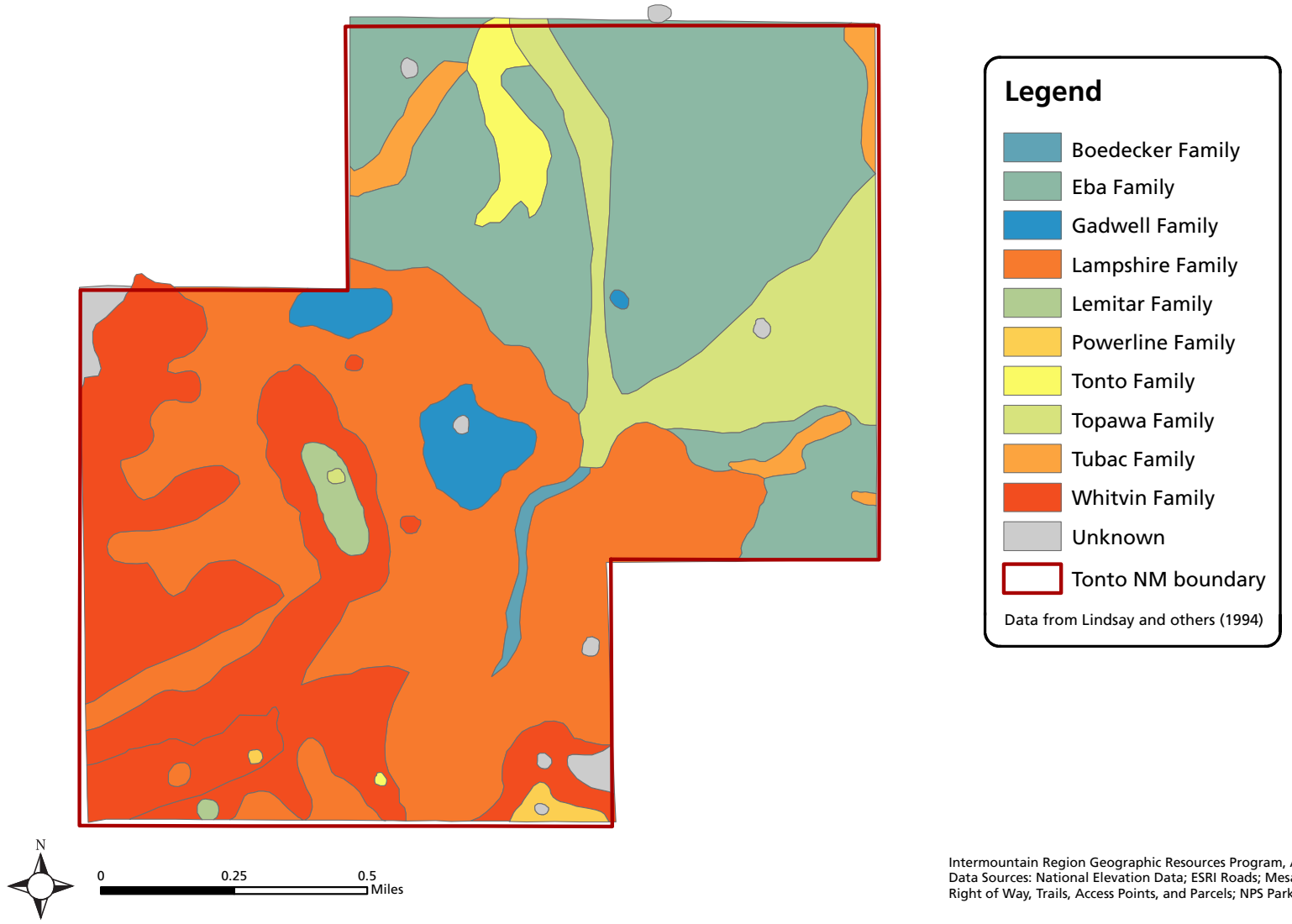
The bajada, or alluvial fan, soils include older surfaces that are mapped as the Eba and Topawa families and the Tubac family, formed by erosion uncovering old, fine-grained lacustrine sediments. These areas support jojoba and paloverde-dominated shrublands. These soil families cover a large percentage of the fan terraces and are all described as very deep, well-drained soils with moderate-to-high (Tubac only) available water capacity (Lindsay et al. 1994).

Hill or mountain soils include unstable, steep, colluvial sideslope soils. They are mapped predominantly as either Lampshire (28.8% of monument) or Whitvin family (22%). Several more stable summit soils that differ in composition based on age and composition of parent materials occur in smaller areas (Gadwell, Lemitar, and Powerline families; Figure 1-5). All of these soils are described as shallow to very shallow, with slow permeability, very rapid runoff (in part due to the steep gradients), low available water capacity, and shallow potential rooting depths. In these areas, the vegetation shifts more toward herbaceous lifeforms and shrubs. Trees are far less common here than in the fans and terraces.

Tonto National Monument
Arizona

National Park Service
U.S. Department of the Interior

Soil Families at Tonto National Monument



Intermountain Region Geographic Resources Program, April 2011
Data Sources: National Elevation Data; ESRI Roads; Mesa County Right of Way, Trails, Access Points, and Parcels; NPS Park Data

Figure 1-5. Soil families of Tonto National Monument.

1.7.4 The influences of grazing and fire

Grazing, fire, and invasive species at Tonto National Monument all contributed to changes in the vegetation that have taken place since the late 1800s, when EuroAmerican settlement first began. They have since become powerful drivers of the vegetation communities that are now present. When the monument was designated, no initial effort was made to reduce livestock grazing, and so the monument's water sources were developed for continued use by cattle. Cattle exclusion began in 1942, when 341 hectares (843 acres) of the monument were fenced. The monument's boundary fences were finally completed in 1981. Since that time, cattle have been excluded from grazing on the monument (Jenkins et al. 1995).

The influence of grazing in Sonoran Desert ecosystems can cause a decrease in vegetation cover, increased compaction, stream bank destabilization, increased runoff, and soil erosion (Albrecht et al. 2007). Though the exact impacts of more than 100 years of grazing on the vegetation of Tonto NM are difficult to discern, it is likely that the vegetation communities known to the Salado and, later, the Apache, were radically altered under the continual (year-round) grazing regime of the 1800s and 1900s.

Since the mid-twentieth century, fire has also played a key role in shaping the vegetation of Tonto NM. Five major fires have occurred on the monument—in 1947, 1964, 1970, 1974, and 1980—all apparently started by lightning strikes. The evidence suggests that one contributing cause of this relatively frequent fire activity was the arrival and spread of non-native species, such as red brome (*Bromus rubens*) and filaree (*Erodium cicutarium*), which provided sufficient fine fuels to support fire spread (Phillips 1997).

Sonoran Desert ecosystems did not evolve with fire, and so are not fire-adapted (Brooks and Chambers 2011). One consequence of fire on vegetation has been a notable shift in composition toward non-native annuals that can survive under frequent fire conditions (Phillips 1997). Repeat photography in Phillips's 1997 fire history of Tonto NM illustrated that saguaro cacti (*Carnegia gigantea*) have been negatively impacted by the altered fire regime. The report also detailed negative impacts on a variety of other native plants. Phillips (1997) concluded that in portions of the southern part of the park, "the vegetative composition and structure have been so altered by fire that the original vegetative community is no longer present." As described in Hubbard and others (2013), the five main fires from 1947 to 1980 had a high degree of spatial overlap and predominantly affected the middle to higher elevations of the park, leaving the lower desert scrub communities relatively unaffected.

Today, the vegetation of Tonto NM is dominated by species associated with the upland Sonoran Desert, namely paloverde (*Parkinsonia* spp.), saguaro, jojoba (*Simmondsia chinensis*), and creosote bush (*Larrea tridentata*). However, evidence from packrat middens has suggested that higher-elevation species, such as juniper (*Juniperus* spp.), piñon (*Pinus* spp.), and other species associated with the cooler climate of the Colorado Plateau, were far more prevalent at the end of the Wisconsin glacial maximum (approximately 10,000 ybp; McAuliffe and Van Devender 1998). The evidence presented by McAuliffe and Van Devender also indicated that precipitation in the late Pleistocene was higher than it is at present. With the end of the glacial maximum, the pattern that developed was one of significant variability in precipitation lasting throughout the last 10,000 years, with a trend toward increasing aridity.

1.7.5 Previous vegetation studies

Previous inventories of the monument's flora and fauna recorded 297 plant species (Burgess 1965; Brian 1991; Phillips 1992; Jenkins et al. 1995; Phillips 1997), 229 vertebrate species (Swann et al. 1996; Hiett and Halvorson 1999), and more than 340 invertebrate species (Price and Fondriest 1995). Each of these efforts produced reports that included species lists and summaries of prior research.

There have been two previous inventories of plants at the monument (Burgess 1965; Jenkins et al. 1995) and four additional studies of note: two that mapped the distributions

of selected non-native species (Phillips 1992; Studd et al. 2011), one that investigated the effects of fire on plants (Phillips 1997), and one that revisited line-intercept plots after 25 years (Brian 1991). In addition, there have been numerous plant-specimen collections, dating back to 1912.

Vegetation at the monument was described by Jenkins and others (1995) as including five types:

Interior southwestern riparian deciduous forest and woodland dominated by Arizona sycamore (*Platanus wrightii*), Arizona walnut (*Juglans major*), blue wildrye (*Elymus glaucus*), and netleaf hackberry (*Celtis laevigata* var. *reticulata*). This unusual vegetation community is represented by one small, spring-fed riparian area with gallery forest in Cave Canyon.

Sonoran riparian woodland dominated by jojoba, velvet mesquite (*Prosopis velutina*), and catclaw acacia (*Senegalia greggii*).

Interior chaparral dominated by alderleaf mountain mahogany (*Cercocarpus montanus*), Sonoran scrub oak, desert needlegrass (*Achnatherum speciosum*), and crucifixion thorn (*Canotia holacantha*).

Semidesert grassland dominated by Emory's globemallow (*Sphaeralcea emoryi*), brownplume wirelettuce (*Stephanomeria pauciflora*), desert needlegrass, Lehmann lovegrass (*Eragrostis lehmanniana*), jojoba, common sotol (*Dasylirion wheeleri*), broom snakeweed (*Gutierrezia sarothrae*), and sideoats grama (*Bouteloua curtipendula*).

Sonoran desertscrub dominated by jojoba, broom snakeweed, Fremont's desertthorn (*Lycium fremontii*), yellow paloverde (*Parkinsonia microphylla*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), and Arizona spikemoss (*Selaginella arizonica*).

See Jenkins and others (1995) for more detailed descriptions of community designations. Their inventory produced the first vegetation map of the monument. It also provided an annotated plant list, including records from previous studies and collections. Like many others from the same time period in Arizona, the Jenkins and colleagues (1995) mapping effort was completed using the Brown, Lowe, and Pase (BLP) system, as described in Brown (1982), which was the most comprehensive classification system available. The BLP system has no direct crosswalk to the NVC, but does have hierarchical similarities that allow for comparisons. Most of the entries are at the "series" level (akin to the alliance or group level in the NVC). However, full descriptions of the series, or the associations subsumed within them, were lacking. For these reasons, this project collected new field data to facilitate a park-specific classification and develop association descriptions that conform to and help populate the developing NVC.

1.7.6 Exotic and non-native plants

As in many other landscapes across the region, several non-native and/or invasive plant species have become established throughout Tonto NM. Multiple studies have documented their presence, abundance, and/or distribution (Phillips 1992; Halvorson and Guertin 2003; Studd et al. 2011; Hubbard et al. 2013). The majority of the species are grasses, with the three most abundant and widespread (based on Studd et al. 2011) being the annuals, red brome and wild oats (*Avena fatua*), and the perennial, Lehmann's lovegrass. No significant changes to the distribution of these species were noted during the vegetation inventory work and no new non-native species were observed.

2 Classification and Mapping of Plant Communities

2.1 Methods

2.1.1 Planning and scoping

Scoping was completed during an all-hands meeting at the monument in 2008, where the Sonoran Desert Network presented plans for the project. The park superintendent and chief of resources approved the proposal. Discussions took place regarding methods, logistical needs, and data availability.

Planning for this project involved researching existing vegetation datasets and acquiring recent aerial imagery for the park. Due to the relatively small size of the project area, the mapping team decided that a complete census of each map unit was feasible. The project was completed through the combined efforts of SODN and OALS. Tonto NM personnel provided invaluable logistical support for all field-based components of the project. OALS was responsible for core technical preparations, including review of the aerial photographs and drafting of the initial polygons. OALS staff conducted several site visits to assist in field mapping and later provided a team to conduct accuracy assessments. SODN staff conducted the field-data collection for classification, conducted the ground mapping of the vegetation, drafted the vegetation association descriptions, and prepared the report and spatial database with relevant attributes for mapped polygons and vegetation plots (see sections 2.1.4.1 and 2.1.4.2).

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 Tonto NM is relatively small, this method worked well and was achieved by way of a census. Data collection for classification plots and field mapping took place during March and April 2009. Two teams of two people conducted all the work under the guidance of SODN biologists and ecologists.

2.1.3 Digital imagery acquisition and processing

The ortho imagery used during mapping at Tonto NM was created from a set of nine color contact prints flown on April 28, 2004. The images were taken by D. Major of Cooper Aerial Surveys of Tucson. The final mosaicked image (Figure 2-1) was created by IntraSearch Inc. Colorado, using 1-meter USGS DOQQ data and USGS 10-meter DEM data to produce a final orthorectified image output of 0.6-m resolution. The reported scale for all images is 1:10,000. All information on processing reported here was taken from the metadata associated with the color mosaicked image. Scanned images were orthorectified in PCI Geomatics OrthoEngine 7 (www.pcigeomatics.com) using a cubic convolution method, with approximately nine ground control points per scan. Accuracy was assessed by overlaying the image onto original DOQQ data in ArcView 3.3.

The imagery used in this project was managed by Tonto NM staff, who made it available for use. Due to its high spatial resolution and relatively recent acquisition, coupled with a lack of major disturbances in intervening years, no newer imagery was purchased. These color air-photos consist of three bands (red, green, and blue). They enable true color representation but are not appropriate for image analysis or classification in the same way that satellite imagery with four or more bands (including the near-infrared band) would be. The photos were collected during the same month (but not year) as the field data collected during this project.



Figure 2-1. Aerial image mosaic of Tonto National Monument and environs.

The digital aerial photos for Tonto NM were then evaluated in ArcGIS (ESRI) to define and delimit distinct vegetation structural characteristics at what will hereafter be termed the "formation" level. Formations were defined by a combination of structural properties, including height, texture, color, and the relative percent cover of tree, shrub, and herbaceous vegetation. For Tonto NM, polygons (a closed line encompassing an area) were hand-digitized in ArcMap 9.0 (ESRI) around each visibly distinct formation across the entire park area, including a ~100-m buffer at the park boundary. Polygon lines were drawn such that homogeneity of visible characteristics was maximized within each polygon while minimizing the amount and size of structurally different inclusions of less than 0.5 hectares (1.24 ac) in size (Figure 2-2). Other spatial data were used to assist in this process, including digital elevation models (DEM) and contour lines.

A minimum mapping unit of 0.5 hectares was observed, as set forth in the NVC standards. Distinct areas smaller than 0.5 hectares had to be included in an adjacent or enveloping polygon. All polygons were drawn such that adjacent polygon boundaries were shared, (i.e., there were no gaps between polygons) and complete coverage of the study area was achieved.

Polygons were attributed with the formation type name (e.g., forest, woodland, grassland) as interpreted from the imagery alone. No field data were used in this first stage of draft map-boundary delineation. Each polygon was assigned a unique alphanumeric identifier consisting of a letter to represent the formation type (W=woodland, S=shrubland) followed by consecutive numbers (W01, W02). These identifiers were utilized in all subsequent field-data collection or polygon modifications to enable tracking of these original polygons. These polygons were

considered and are hereafter referred to as the "draft" polygons. Draft polygons were the units on which polygon-scale field-data collection was based, as formation was considered the initial and coarsest level of division of the vegetation units. However, it was understood that field observations would undoubtedly modify some of these boundaries on the basis of floristic composition and structural attributes not visible in the imagery.

2.1.4 Field-data collection

2.1.4.1 Polygons

Field-data collection was initiated after draft polygons were completed. The approach involved visiting every draft polygon to collect data on the composition, canopy cover, and structural characteristics of the vegetation and to evaluate and correct (if necessary) the draft boundary. Data collected on polygons and classification plots (see section 2.1.4.2) included basic metadata and strict naming conventions to facilitate tracking of polygon edits and boundary changes. Vegetation data included species-level cover estimates, ranking of dominants, and notation of lifeform (e.g., tree vs. shrub). Landscape characteristics, such as slope, topographic position, and surface cover estimates by class, were also recorded for each sampling area. The field-data collection methods were designed to meet the core data requirements of the National Vegetation Classification Standard version 2 (FGDC 2008; Jennings et al. 2009).

The study area was divided into a grid of rectangular sections measuring approximately 1,200 × 750 meters (3,937 × 2,461 ft) (n=10), with each section overlapping approximately 50 meters (164 ft) with all adjacent sections. This assisted us in editing polygons that spanned across sections and proved useful for planning and communicating with park staff about work locations. Hard copies of these smaller sections, with draft polygon boundaries overlaid, were printed at 11 × 17", maintaining a

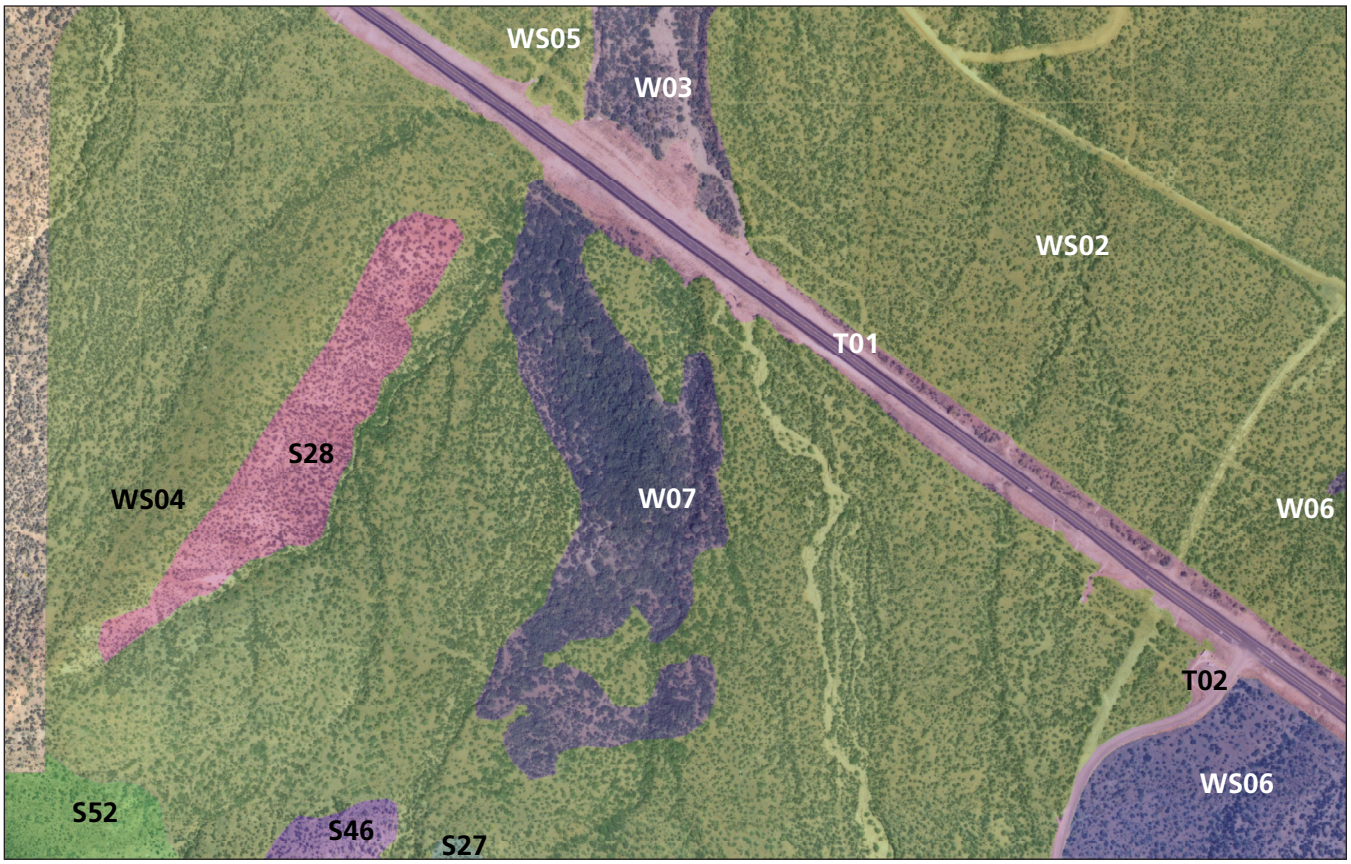


Figure 2-2. Example of digitized draft polygons for Tonto NM, delineated on the basis of formation-level structural characteristics visible in the aerial images.

scale adequate for visual image interpretation—and used in the field. To provide field crews with additional landscape information, topographic maps were printed at the same scale and bounding coordinates. The contour lines helped us to refine the boundaries of draft polygons when changes in aspect and slope correlated well with breaks or divides between community or formation types. Each polygon was fully 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 association or conversely merged with a neighboring polygon that was too floristically similar to be distinct. Boundary modifications and splits were sketched on the hardcopy prints using colored pencils (and explained in words on field datasheets) and later transferred to a master set of paper maps from which digital edits were made to the draft polygons in ArcMap.

Handheld GPS units equipped with mapping software and a large screen to visualize polygons were used for navigation to sites and to orient observers to their current location relative to landscape features and the imagery. These units were pre-loaded with the draft polygons and other spatial files (e.g., plot locations, contour lines, trails, roads) that are viewable on screen and can be manipulated by zooming and changing symbologies. These units were also used to collect spatial data for plot corner and photo-point locations.

We recorded species-level canopy-cover data for all species present in the polygon using ocular estimates and Daubenmire cover classes (<1%, 1–5%, 6–10%, 11–25%, 26–33%, 34–50%, 51–75%, 76–95%, 96–100%). Ranks of 1, 2, and 3 were assigned to the dominant three species in each of four height strata. Lifeform (shrub versus tree) and estimates of average height were also recorded for each (Appendix D contains example datasheets). Ranked dominance was a relative measure; no minimum cover value was needed to attain a ranked score. Rather, the top three species contributing the most cover in each stratum were ranked. All less-common associates were listed by stratum and assigned cover classes.

Every attempt was made to census all species present in the polygon. Although sampling was scheduled to optimize the number of species that were identifiable and at their peak in the growing season, some species were undoubtedly missed, and cover estimates may be low in some cases. Annual species are likely underrepresented, but as they have such high inter-annual variation, little weight is placed on their abundance unless it is an area dominated by this lifeform. In some cases, the cover of species thought to be significant ecological indicators of the type was not high enough for those species to be ranked as dominant. These instances were noted in a narrative section on the back of the datasheet. For each polygon, a narrative was written describing how its vegetation differed from that of neighboring areas and identifying any topographic variables that served as bounding features. This served as a justification for the polygon's uniqueness and as an interpretive tool for the data analyst when trying to evaluate similar areas.

Descriptive, qualitative landscape and soil measures were recorded for each polygon (Table 2-1 and Appendix D). The data collected followed the recommendations of the program documents (Jennings et al. 2006), plus some additional disturbance variables of interest. As with the vegetation data, conspicuous inclusions, gradients of change, and differences from the surrounding areas were recorded for soil and landscape features (e.g., rock outcrops, small drainages). This information was collected to help us better understand the area's placement within the landscape at large, accounting for contributing factors such as hydrology, parent material, soil development, and landform.

2.1.4.2 Classification plots

The 2009 "Standards for associations and alliances of the U.S. National Vegetation Classification" (Jennings et al. 2009) states 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

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

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

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, if necessary, to account for any under- or unsampled areas.

Thirty-six 20 × 50-meter plots were initially sampled to collect classification data (Figures 2-3, 2-4). 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 number of this initial round of plots was determined by evaluating previous vegetation studies—primarily, SODN's previous monitoring work and the Jenkins (1995) study, which had identified five major types at the park. The number of plots used was a best estimate based on the small size of the unit and relatively similar vegetation distribution. Plot and polygon data were reviewed by way of a manual ordination (grouping), and it was determined that an additional 14 subjectively placed plots were needed in order to characterize vegetation that was deemed undersampled by the existing plots but had been captured in the polygon-scale data. The final 50 classification plots were used for analysis.

Additional data were available from 21 long-term monitoring plots of 20 × 50 meters, established by SODN in autumn 2009. These data included comprehensive species lists, with associated cover values and/or frequency estimates for the plots. These data were used to further validate and refine the groupings later determined using the classification plots.

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 meters per side were used, considerably improving the field mapper's ability to view the entire area more or less simultaneously when estimating species dominance.

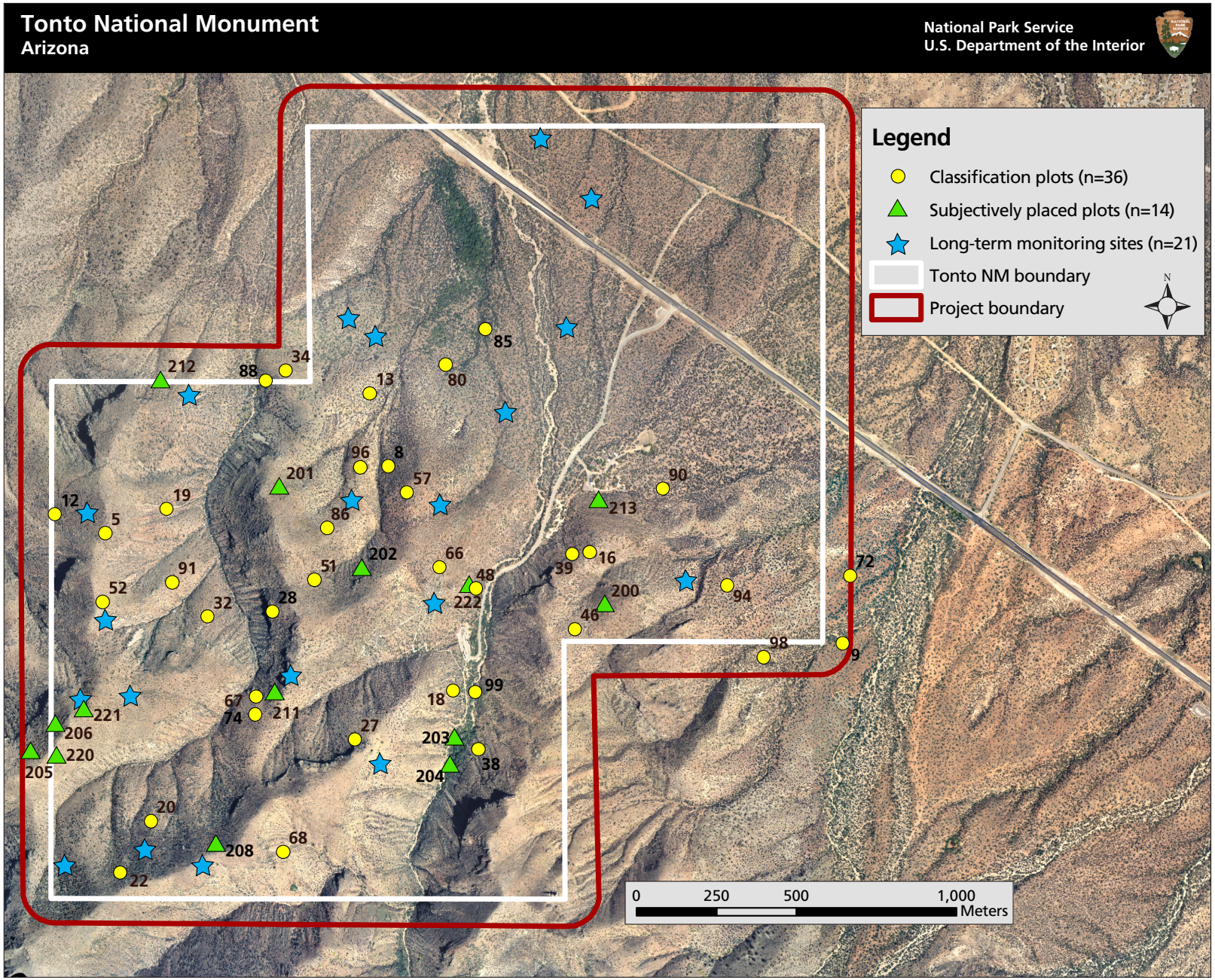


Figure 2-3. Classification plot locations at Tonto National Monument.

The same vegetation cover and dominance information was recorded in the plots as in the polygons (see Table 2-1), differing only in scale of observation. 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 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 tapes from the origin corner were recorded, 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. Blank example datasheets are shown in Appendix D.

2.1.5 Data management and archiving

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 or scans will remain at the SODN office. Final products, including this report, spatial data, and photographs, are available through the NPS Vegetation Inventory webpage (http://science.nature.nps.gov/im/inventory/veg/products.cfm) and via the NPS integrated resource management applications portal (https://irma.nps.gov/portal) by searching by park and keywords, or by author.



Figure 2-4. Sampling a classification plot.

Each polygon was edited to reflect any boundary changes and was attributed to reflect changed polygon identification numbers and tentative alliance or association 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.

2.1.6 Vegetation classification analysis

The classification analysis was completed in two ways: first, by 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), and second, by using a multivariate statistics software. The former was intended to provide an initial first cut and grouping of the data, and to highly familiarize the team with the data (feasible due to the small size of the park). For the latter, midpoint cover-class values for all species at all plot and polygon locations were exported from the Access database post-quality assessment and imported into the software Plymouth Routines In Multivariate Ecological Research (PRIMER) for analysis

(Clarke and Warwick 2001). Cluster analyses (or classification) and ordination procedures were utilized to summarize the polygon and plot data and to reveal community-level patterns and structure from the multivariate data. The original data matrices had species as variables (rows) and plots/polygons as samples (columns). The matrix values were the midpoint of each percent cover class used in data collection. Using the resemblance tool in PRIMER with the Bray-Curtis coefficient (Bray and Curtis 1957; see Clarke and Warwick 2001 for details on use in this context), the raw data matrix was transformed into a similarity matrix to perform the cluster analysis. This transformed the raw data values into ranked or relative similarities between every pair of samples based on similar abundances of shared species.

Prior to constructing similarity matrices, data were usually square-root transformed to balance the contributions from common and rare species in the measure of similarity between two samples (Clarke and Warwick 2001). See Clarke and Warwick (2001) for a complete discussion of the rationale for transformations in the context of similarity matrices. The clustering process organizes samples into groups based on the vegetation composition similarity values between each pair of samples. Hierarchical clustering with group average linking (Clarke 1993) was used to arrange and display the samples in a dendrogram (Figure 2-5). This tool also provided a user-defined gauge of the statistical relevance of the groupings by way of a SIMPROF (similarity profile test), which is a permutation test of the null hypothesis that "a specified set of samples, which are not

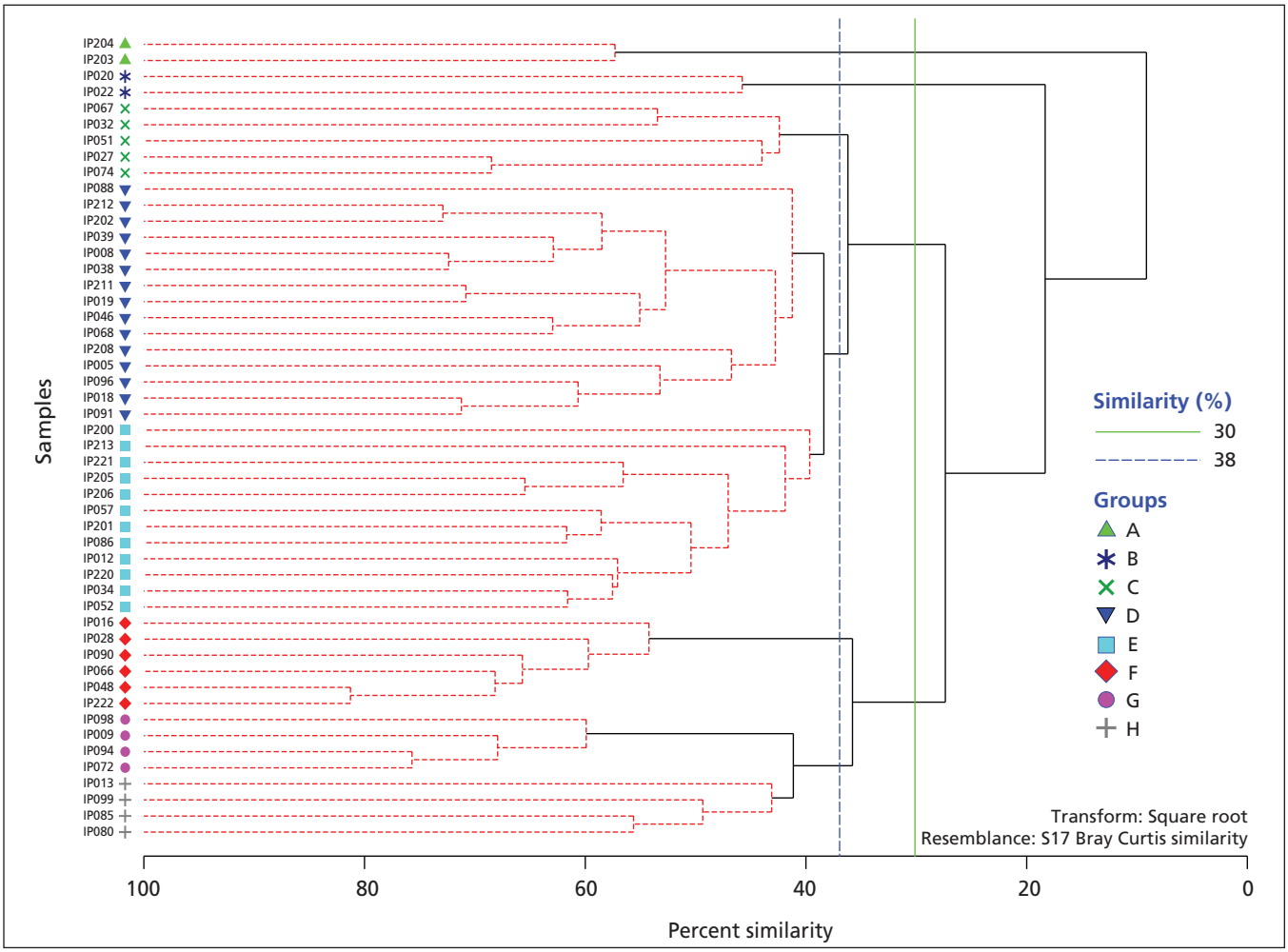


Figure 2-5. Example dendrogram showing the results of an initial cluster analysis on intermediate plots (n=50). Data are only shown for subcanopy height (0.5–2 m) plant-cover data in this example. Separate analyses were run on field (<0.5 m tall), canopy (2–5 m) and top canopy data (>5 m) and all data combined. This cluster returned eight significant groups ($P \leq 0.05$ at or above 40% within-group similarity). Each significant group is identified by the cluster of red lines beneath a black branch.

a priori divided into groups, do not differ from one another in multivariate structure" (Clarke and Gorley 2006). SIMPROF can be run simultaneously within the clustering routine or as a standalone test. When run as a standalone test, evidence of group structure is given via a single Pi value (the test statistic) and a significance value (e.g., 0.1%). When run within the cluster, the first split and each successive division of dendrogram is given a Pi and significance value.

Cluster groups identified as having significant differences at the $P \leq 0.05$ level were then ordinated using the non-metric multidimensional scaling method (NMDS) in PRIMER. NMDS was chosen over other ordination methods (e.g., principal component analysis) because it preserves the Euclidian distances of the ranked similarities (formed in the triangular similarity matrix) when "mapping" those onto the abstract axes. The resulting "map" can then be interpreted as showing which samples are more similar to one another than to other samples by simple distance (Figure 2-6). Once groupings were determined, further analysis was conducted using the similarities percentages (SIMPER) function in PRIMER, which lists in tabular form the species from each sample that contribute most to the similarities within and between groups. This routine enabled us to identify the dominant species within each group as well as species that, while less common, represented the differences driving the group separations.

The methods above served as the basis for all investigative analysis but do not specify all of the subsequent combinations or subsettings of the datasets that proceeded from the first results given. Dendrogram groupings were evaluated primarily on whether they met the criteria of having (1) significant differences at the $P \leq 0.05$ and (2) within-group similarity values between 15 and 35%.

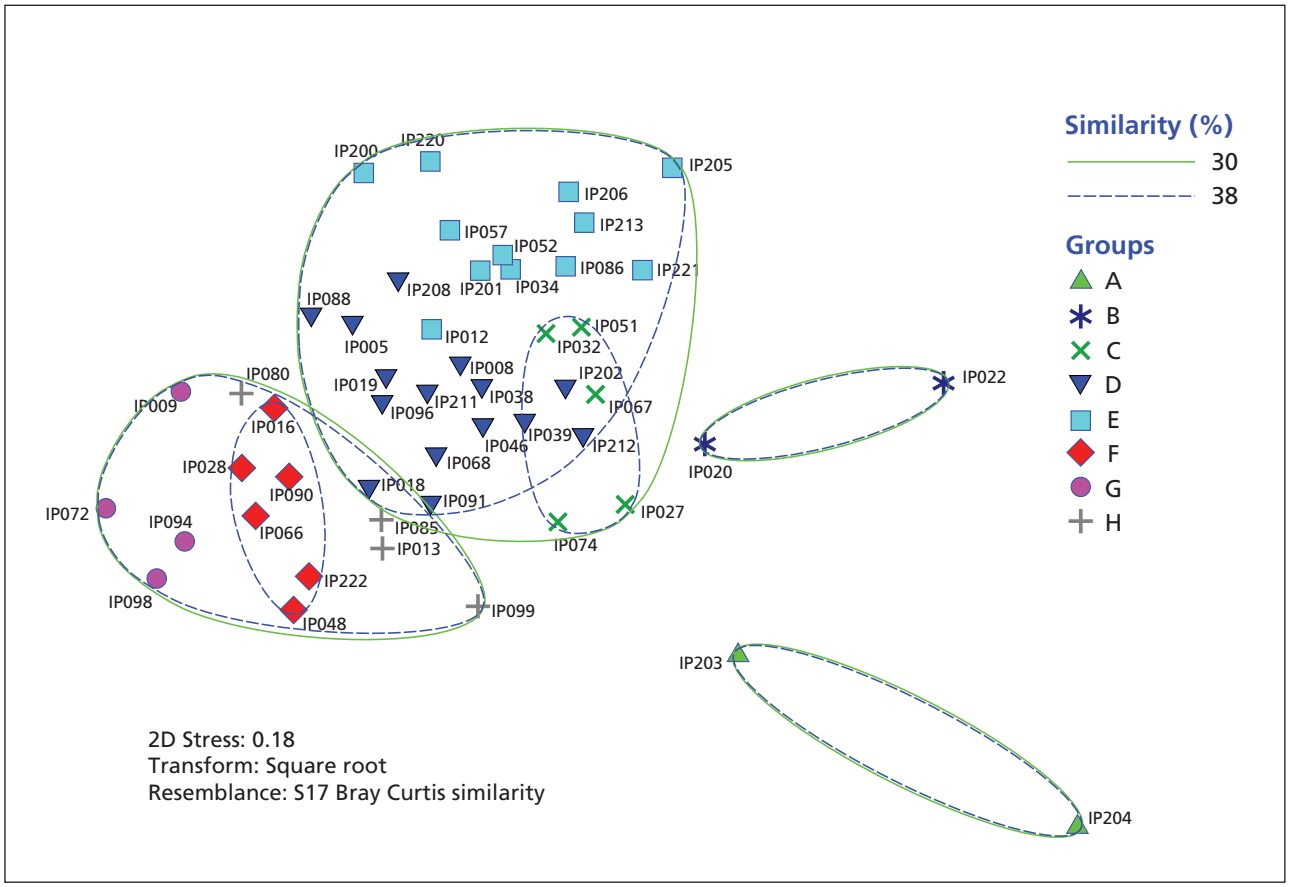


Figure 2-6. Example diagram showing the eight groupings from the initial cluster analysis of subcanopy cover data, shown in ordination space (NMDS) with within-group similarity levels of 30% and 38% overlaid in green and blue-dash lines, respectively. This NMDS indicates some overlap in species composition between some of the groups in the middle (C, D, and E) with the points close together and highlights the separation (e.g., contrasting species composition) between groups A (riparian forest) and B (high-elevation oak scrub) to all others.

The raw datasheets and narrative descriptions were all reviewed again after these groups were drafted to make final assignments and determinations.

All data were evaluated by the two project ecologists and the mapping team's 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 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 and have the additional notation of "P" at the end of the type name, indicating they are in "proposed" status. One type has the notation "PS," for "park special," a term reserved for vegetation thought to only exist as a result of park-specific circumstances, such as regular disturbance (e.g., mowing or planting) or active management (e.g., restoration or thinning).

2.2 Results

2.2.1 Classification results

The classification work led to the identification of 23 different vegetation types at the association level, attributed to 82 polygons (Figure 2-7):

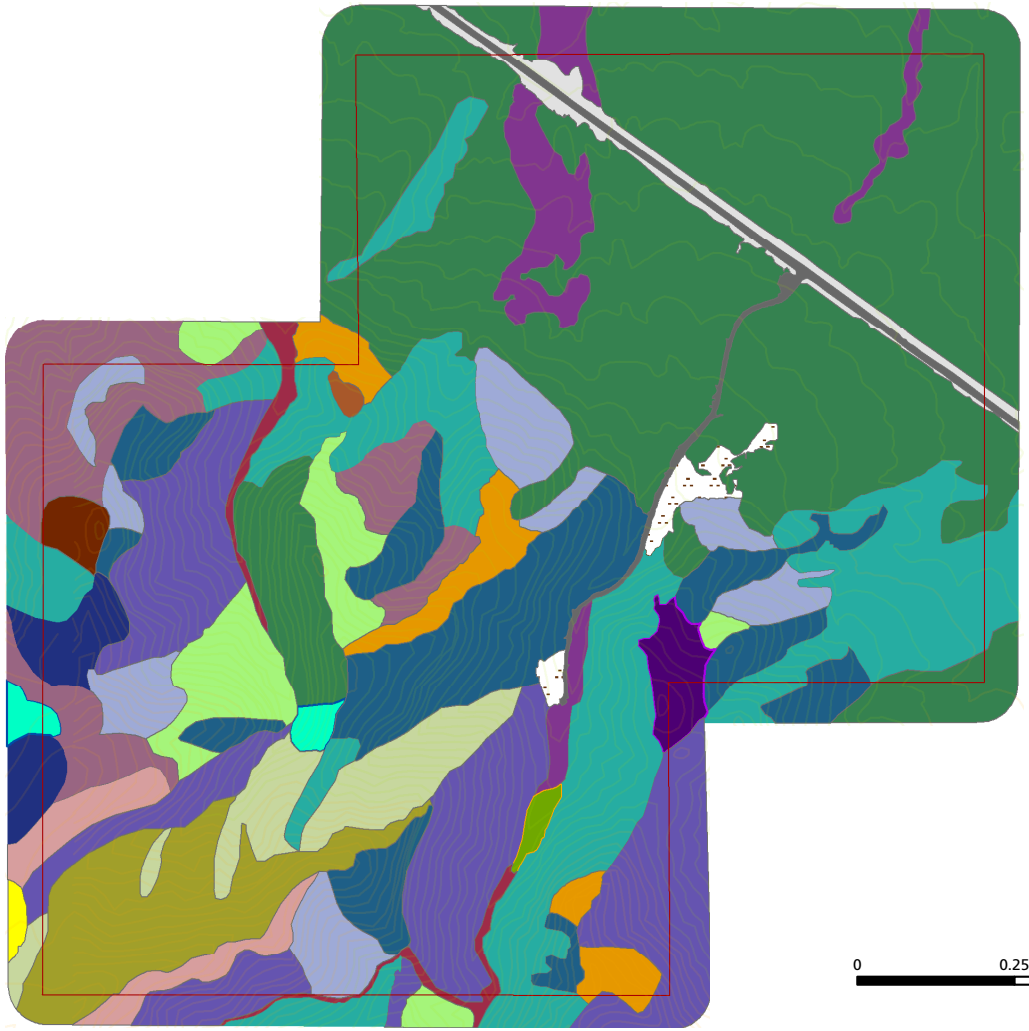
1. *Platanus wrightii - Juglans major* Riparian Forest
2. *Prosopis velutina - Senegalia greggii* Wet Scrub
3. *Prosopis velutina* Woodland (P)
4. *Quercus turbinella - Cercocarpus montanus* var. *glaber* Shrubland
5. (*Parkinsonia microphylla*) / *Encelia farinosa* Shrubland (P)
6. *Encelia frutescens - Gutierrezia sarothrae* Shrubland (P)
7. *Simmondsia chinensis - Encelia farinosa* Shrubland (P)
8. *Simmondsia chinensis - Encelia frutescens* Shrubland (P)
9. *Cylindropuntia acanthocarpa* Shrubland (P)
10. *Parkinsonia microphylla* / *Simmondsia chinensis* Wooded Shrubland (P)
11. *Parkinsonia microphylla* / *Simmondsia chinensis - Ericameria laricifolia* Wooded Shrubland (P)
12. *Parkinsonia microphylla* / *Eriogonum fasciculatum - Encelia frutescens* Wooded Shrubland (P)
13. *Canotia holacantha* Shrubland (P)
14. *Dodonaea viscosa* Shrubland (P)
15. *Simmondsia chinensis* / *Eriogonum wrightii* Shrubland (P)
16. *Simmondsia chinensis - Eriogonum fasciculatum* Shrubland (P)
17. *Simmondsia chinensis - Ericameria laricifolia* Shrubland (P)
18. *Simmondsia chinensis* / *Selaginella arizonica* Shrubland (P)
19. *Simmondsia chinensis - Sphaeralcea* spp. Shrubland (P)
20. *Simmondsia chinensis - Opuntia engelmannii* Shrubland (P)
21. *Simmondsia chinensis* Shrubland (P)
22. *Simmondsia chinensis - Lycium fremontii* Shrubland (P)
23. *Vachellia constricta* - Mixed-shrub Shrubland (PS)

Polygons ranged in size from 0.6 to 73 ha (1.5–180 ac). These field-mapped polygons represented the best approximation of distinct community boundaries defined by the criteria provided in a series of standard operating procedures and a key to formations (Appendix C) given to field crews. In terms of the USNVC definitions, these areas would be akin to "stands," considered as "contiguous areas of vegetation that are relatively homogeneous in species composition, structure and ecological setting" (Lea 2011). An additional three polygons delineate

Tonto National Monument
Arizona

National Park Service
U.S. Department of the Interior

Vegetation Inventory Map



Vegetation association map classes

- *Platanus wrightii - Juglans major* Riparian Forest
- *Prosopis velutina - Senegalia greggii* Wet Scrub
- *Prosopis velutina* Woodland (P)
- *Quercus turbinella - Cercocarpus montanus* var. *glaber* Shrubland
- (*Parkinsonia microphylla*) / *Encelia farinosa* Shrubland (P)
- *Encelia frutescens - Gutierrezia sarothrae* Shrubland (P)
- *Simmondsia chinensis - Encelia farinosa* Shrubland (P)
- *Simmondsia chinensis - Encelia frutescens* Shrubland (P)
- *Cylindropuntia acanthocarpa* Shrubland (P)
- *Parkinsonia microphylla / Simmondsia chinensis* Wooded Shrubland (P)
- *Parkinsonia microphylla / Eriogonum fasciculatum - Encelia frutescens* Wooded Shrubland
- *Canotia holacantha* Shrubland (P)
- *Dodonaea viscosa* Shrubland (P)
- *Simmondsia chinensis / Eriogonum wrightii* Shrubland (P)
- *Simmondsia chinensis - Eriogonum fasciculatum* Shrubland (P)
- *Simmondsia chinensis - Ericameria laricifolia* Shrubland (P)
- *Simmondsia chinensis / Selaginella arizonica* Shrubland (P)
- *Simmondsia chinensis - Sphaeralcea* spp. Shrubland (P)
- *Simmondsia chinensis / Opuntia engelmannii* Shrubland (P)
- *Simmondsia chinensis* Shrubland (P)
- *Vachellia constricta* - Mixed Shrub/Transportation (PS)
- Park facilities
- Road
- Park boundary

N

0 0.25 0.5 1 Mile

Produced by Sonoran Desert Network, Tucson, AZ

December 2016

Data sources: NPS park data, NPS vegetation data
TONT_FinalProducts.mxd

Figure 2-7. Vegetation inventory map, Tonto National Monument. (P) signifies a proposed map class. (PS) signifies a park special map class.

the interior park road and park facilities, such as housing and the maintenance yard. Because the entire park unit was mapped census-style, the 85 polygons have contiguous coverage (Figure 2-7). After accuracy assessment (AA), four associations were combined into two map classes, as they were not distinguished in the field during the AA effort. The final map and spatial data products have symbolic representation showing both the map unit and association level data. For all but these two merged associations (*Simmondsia chinensis - Lycium fremontii* Shrubland and *Parkinsonia microphylla / Simmondsia chinensis - Ericameria laricifolia* Shrubland), the map class is exactly equal to the association. The final map graphic is shown in Figure 2-7.

The vast majority of the vegetation at Tonto NM (>90%) was shrubland, dominated by large shrubs (often jojoba), with scattered short trees and variable amounts of cacti, subshrubs, and forbs. The monument's non-riparian areas fell into two broad categories of shrubland vegetation, separated roughly by elevation and slope position. The highest elevations within the monument are also the more rugged and steep mountain slopes. Influenced by cooler temperatures, these communities begin to resemble interior chaparral vegetation more than Sonoran Desert vegetation. Species such as eastern Mojave buckwheat (*Eriogonum fasciculatum*), crucifixion thorn (*Canotia holocantha*), jojoba, and, occasionally, Sonoran scrub oak and alderleaf mountain mahogany were common and indicative of these higher slope communities.

The lower elevations and lower slope positions, including the rolling foothills and upper bajada surfaces, reflected their Sonoran Desert influences, with yellow paloverde, saguaro cactus, and brittlebush (*Encelia farinosa*) playing significant roles. However, the monument contained considerable areas of mixed species within zones of transition between the major types. These conglomerates proved challenging to both classification and mapping. Part of this was because several species were both prolific and widespread, occurring in most associations across this relatively small monument. Jojoba was the dominant species in 12 of the 23 associations described.



Figure 2-8. *Platanus wrightii - Juglans major* Riparian Forest association at Tonto National Monument.

There was only one riparian-dominated association at Tonto NM, located along Cave Canyon in the vicinity of Cave Canyon Spring. Although the *Platanus wrightii - Juglans major* Riparian Forest association covers a relatively small area of the monument, it comprised a high degree of biodiversity and provides key ecosystem services, such as mitigating flooding and supporting core habitat for many wildlife species (Figure 2-8). The other more mesic association, *Prosopis velutina* / *Senegalia greggii* Wet Scrub, is found along the larger and more incised dry-wash drainage bottoms. Mesquite-dominated woodlands were rare and restricted to the lower bajada.

Three polygons were mapped along transportation corridors. Vegetation data were collected for one of these polygons, for which a semi-natural association description was written with a "park special" designation. This area contains the right-of-way on either side of US Highway 88 and is maintained by the Arizona Department of Transportation. It is frequently disturbed by mowing. In the past, some areas disturbed during culvert installation and road maintenance

have been seeded for restoration. These data were included in the classification despite these considerations, which were included in final type results.

2.2.2 National Vegetation Classification placement

The vegetation was initially mapped and subsequently classified at the association (and even sub-association) level, within the framework of the older "alliance" concept, which broadly encompassed associations that contained a single upperstory dominant (at Tonto, the ever-present jojoba). Absent a fully developed NVC framework, determining associations is difficult with such geographically limited data. For that reason, it was encouraged and recommended that descriptions be drawn solely from the park data (C. Lea, personal communication). This project followed that guidance. This manner of classifying the data, combined with the small park size, allowed for relatively minor and localized differences to be recognized and described. It is likely that many of the locally described associations from Tonto NM may eventually support fewer regional associations and several alliances as additional classification and mapping efforts are completed in the Sonoran Desert ecoregion. Until more data are collected over the larger region and a meta-analysis is completed, however, these considerations are speculative.

Of the 23 associations, only three had accepted NVC association corollaries (and alliances) with full descriptions available on the usnvc.org website. It should be noted that in some cases, an "accepted" association may exist within the NVC, with a code assigned, but the data available to describe the vegetation are insufficient or non-existent. This is often true of associations that are recognized only after being discussed or referenced in published reports of various origins. In these cases, the community is thought to reasonably exist, and will be tentatively included in the NVC hierarchy—but the entries lack the detail necessary to assess their similarity to the project data at hand.

Therefore, while some Tonto-specific associations appear similar to NVC associations that are similarly named, and therefore presumably have the same dominant species, there are not enough data to support their actual agreement. For that reason, all but the three aforementioned associations have been assigned NPSSODN### placeholder association codes in lieu of NVC association codes, and the names are suffixed with "(P)" for proposed. The reader should refer to the full written association descriptions in Appendix A to learn more about similar known vegetation associations and the authors' understanding of potential future NVC placements at the alliance level. More detail is provided in Section 4.2 of this report.

For example, many of the associations described at Tonto appear to fall within a single NVC alliance: A.3282, *Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance. This alliance is identified as occurring within the Central Highlands project area and in southern California's Cahuilla Mountains. Several of the dominant, co-dominant, and subdominant species match those observed at Tonto. However, there is only moderate correlation with some other listed species—and overall, the description is focused more on the California variety. Under this alliance, only three associations are currently recognized and only one as yet has a description or data available. One of the undescribed associations, *Simmondsia chinensis - Parkinsonia microphylla* Shrubland (CEGL000983), could be the same as the *Parkinsonia microphylla - Simmondsia chinensis* Wooded Shrubland described at Tonto NM (Figure 2-9). More regional data analyses are needed to finalize and describe these associations and the hierarchy in general. However, the authors do feel that most of the Tonto NM vegetation associations will likely fall within the A.3283 alliance in future NVC iterations.

One association was given "park special" status, indicating that it is thought to be unnaturally influenced and not representative of naturally occurring communities in the surrounding locality. Originally, this long polygon was mapped simply as "transportation." It was subsequently described as an *Acacia constricta* (now *Vachellia constricta*) mixed shrub type. However, it was not part of the accuracy assessment (AA) evaluation.

Tables 2-2 to 2-7 shows a hierarchical listing of all the Tonto NM associations with NVC alliance and group (the division above alliance) membership listed where known and where anticipated (shown by "tentative assignment" at the end of each name). Also given are total hectares and polygons for each type. Following the table are one-page summaries of each of the 23 associations that were identified and mapped at Tonto during this project.

The one-page summaries are abridged versions of the full association descriptions given in Appendix A. Each summary briefly describes the floristic and structural characteristics of the vegetation and shows a representative area of satellite imagery, a photograph, and distribution across the monument.



Figure 2-9. An example of the *Parkinsonia microphylla - Simmondsia chinensis* Wooded Shrubland association at Tonto National Monument.

Table 2-2. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Group 797: Western Interior Riparian Forest & Woodland Group, Tonto National Monument.

Alliance	Association	Community type	Total area (ha)	Total # of polygons	Map class area (ha)	Map class # of polygons
A.3801		*Platanus wrightii* Flooded Forest Alliance				
	CEGL000645	*Platanus wrightii - Juglans major* Riparian Forest	1.13	1	1.13	1

Table 2-3. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Group 533: *Prosopis glandulosa - P. velutina - Baccharis* spp. North American Warm Desert Riparian Low Bosque & Shrubland Group, Tonto National Monument.

Alliance	Association	Name	Total area (ha)	Total # of polygons	Map class area (ha)	Map class # of polygons
A.3877		*Prosopis glandulosa - Prosopis velutina - Prosopis pubescens* Wet Scrub Alliance				
	CEGL005340	*Prosopis velutina - Senegalia greggii* Wet Scrub association	4.44	2	4.44	2
	NPSSODN069	*Prosopis velutina* Woodland (P)	14.46	4	14.46	4

Table 2-4. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Group 281: *Quercus turbinella - Ceanothus greggii - Arctostaphylos pungens* Chaparral Group, Tonto National Monument.

Alliance	Association	Name	Total area (ha)	Total # of polygons	Map class area (ha)	Map class # of polygons
A.0793		*Quercus turbinella* Chaparral Alliance				
	CEGL000979	*Quercus turbinella - Cercocarpus montanus* var. *glaber* Shrubland	22.36	1	22.36	1

Table 2-5. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Group 293: *Carnegiea gigantea - Parkinsonia microphylla - Ambrosia deltoidea* Mixed Cacti Desert Scrub Group (tentative assignment), Tonto National Monument.

Alliance	Association	Name	Total area (ha)	Total # of polygons	Map class area (ha)	Map class # of polygons
N/A		Unknown Alliance placement				
	NPSSODN072	*(Parkinsonia microphylla) / Encelia farinosa* Shrubland (P)	45.91	10	45.91	10
	NPSSODN071	*Encelia frutescens - Gutierrieza sarothrae* Shrubland (P)	11.24	4	11.24	4
	NPSSODN073	*Simmondsia chinensis - Encelia farinosa* Shrubland (P)	57.30	6	57.30	6
	NPSSODN079	*Simmondsia chinensis - Encelia frutescens* Shrubland (P)	23.63	8	23.63	8
	NPSSODN070	*Cylindropuntia acanthocarpa* Shrubland (P)	0.61	1	0.61	1
A.3283		*Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance **(tentative assignment)**				
	NPSSODN075	*Parkinsonia microphylla / Simmondsia chinensis* Wooded Shrubland (P)	49.46	4	192.48 (merged)	7 (merged)
	NPSSODN085	*Parkinsonia microphylla / Simmondsia chinensis - Ericameria laricifolia* Wooded Shrubland (P) (in map class with NPSSODN075)	143.02	3		
	NPSSODN081	*Parkinsonia microphylla / Eriogonum fasciculatum - Encelia frutescens* Wooded Shrubland (P)	2.46	1	2.46	1
	NPSSODN066	*Canotia holocantha* Shrubland (P)	28.54	6	28.54	6
	NPSSODN067	*Dodonaea viscosa* Shrubland (P)	17.60	5	17.60	5
	NPSSODN068	*Simmondsia chinensis / Eriogonum wrightii* Shrubland (P)	15.71	4	15.71	4
	NPSSODN083	*Simmondsia chinensis - Eriogonum fasciculatum* Shrubland (P)	2.58	2	2.58	2
	NPSSODN084	*Simmondsia chinensis - Ericameria laricifolia* Shrubland (P)	0.78	1	0.78	1
	NPSSODN078	*Simmondsia chinensis / Selaginella arizonica* Shrubland (P)	8.10	2	8.10	2
	NPSSODN080	*Simmondsia chinensis - Sphaeralcea* spp. Shrubland (P)	4.20	1	4.20	1
	NPSSODN074	*Simmondsia chinensis - Opuntia engelmannii* Shrubland (P)	7.85	3	7.85	3
	NPSSODN082	*Simmondsia chinensis* Shrubland (P)	51.00	10	73.99 (merged)	12 (merged)
	NPSSODN076	*Simmondsia chinensis - Lycium fremontii* Shrubland (P) (in map class with NPSSODN082)	22.99	2		

Table 2-6. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Park Special, Tonto National Monument.

Alliance	Association	Name	Total area (ha)	Total # of polygons	Map class area (ha)	Map class # of polygons
	NPSSODN077	*Vachellia constricta* - Mixed Shrub Shrubland (PS)	9.76	1	9.76	1

Table 2-7. Vegetation community types, their placement within the NVCS, and number of polygons attributed with that type and the total area, Non-Vegetated, Tonto National Monument.

Alliance	Association	Name	Total area (ha)	Total # of polygons	Map class area (ha)	Map class # of polygons
	Anderson16	Park facilities	3.5	2	3.5	2
	Anderson14	Road	1.75	1	1.75	1

Platanus wrightii - Juglans major Riparian Forest

Arizona sycamore - Arizona walnut Riparian Forest

Common species

Juglans major
Platanus wrightii
Celtis laevigata var. *reticulata*
Prosopis velutina
Bromus diandrus
Rubus arizonensis

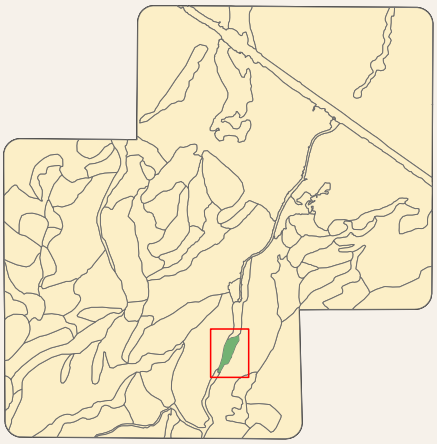
This forest association is characterized by tall Arizona walnut (*Juglans major*) and Arizona sycamore (*Platanus wrightii*) trees forming a shady forest canopy over Cave Canyon spring. Arizona dewberry (*Rubus arizonensis*) forms a thick mat at the base of the many netleaf hackberry (*Celtis laevigata* var. *reticulata*) and velvet mesquite (*Prosopis velutina*) trees growing on the surrounding slopes.

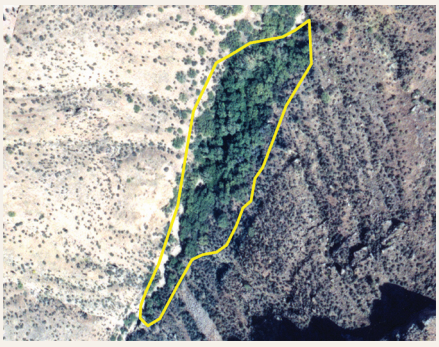
Together, the sycamore (~26–33%) and walnut (~34–50%) trees form a mostly closed canopy with occasional open spaces. Height for both species averages around 14 meters. Arizona walnut is more abundant immediately adjacent to the drainage, whereas Arizona sycamore occurs most densely at a distance from the water source. The edges and banks of the drainage support a rich lower-canopy layer, in which netleaf hackberry and mesquite are densely mixed as both trees and tall shrubs. These are not considered to be dominant, comprising an estimated total cover of only 5%. These two species are found throughout, are well represented in the subcanopy (0.5–2 m), and mix with numerous other shrubs, with a total combined cover of 35%. Notable associates in the subcanopy are Fremont's desert-thorn (*Lycium fremontii*), lotebush (*Ziziphus obtusifolia*), and Arizona dewberry. The latter grows as a vine covering existing shrubs or as a low, shrubby ground cover in thick patches along the banks.

Total field-layer (<0.5 m) cover is ~30%. Much of this cover is the non-native grass, ripgut brome (*Bromus diandrus*), and a number of annuals that contribute to a thick herbaceous layer beneath the canopies on either side of the bank. Arizona dewberry and blue wild rye (*Elymus glauca*) each contribute between 1% and 5% of the total cover, but were not considered dominants.

This association occurs only in one small spring-fed riparian area of Cave Canyon drainage.







Prosopis velutina - Senegalia greggii Wet Scrub

Velvet mesquite - Catclaw acacia Wet Scrub

Common species

Prosopis velutina
Parkinsonia microphylla
Senegalia greggii
Simmondsia chinensis

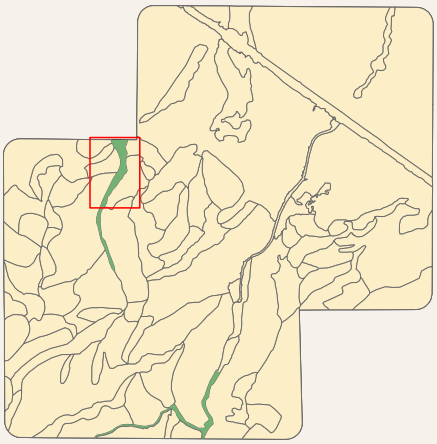
This scrubland association is characterized by low-growing and wide-spreading velvet mesquite (*Prosopis velutina*) trees across drainage bottoms dominated by open rock and sand. The surrounding, high-cut terraces and walls host a mixed community of shrubs, including catclaw acacia (*Senegalia greggii*). Tree cover is low in these exposed canyon bottoms, generally 10–15% total. Velvet mesquite comprises 6–10% cover and is 2.5–3 meters tall. Yellow paloverde (*Parkinsonia microphylla*) may be a co-dominant tree. Other tree species possibly present include blue paloverde (*Parkinsonia florida*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), and black elderberry (*Sambucus nigra*). The trees occur primarily on the terraces or rocky islands sitting above the bottom of the drainages, and are generally well-spaced.

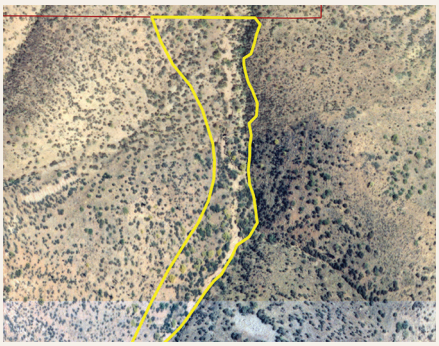
Subcanopy (0.5–2 m) cover is ~20% and species composition varies as a reflection of the surrounding slopes. Catclaw acacia (*Senegalia greggii*) is prevalent, and generates 1–10% cover. Jojoba (*Simmondsia chinensis*) may provide about as much cover as the acacia, particularly on the steep walls and terraces. Sweetbush (*Bebbia juncea*) commonly grows in the drainage bottoms, while spearleaf brickellbush (*Brickellia atractyloides*) prefers the rocky sides. A variety of other shrub species may be present, again reflective of the adjacent communities.

Some perennial forbs, subshrubs, and vines occur on the rocky channel floors. Bunchgrasses, such as sideoats grama (*Bouteloua curtipendula*), Lehmann's lovegrass (*Eragrostis lehmanniana;* non-native), and Boer lovegrass (*Eragrostis curvula* var. *confertiflora;* non-native), grow in the rocky islands present in wider areas of the drainages.

This association occurs in the narrow, rocky-bottomed, open channels of drainages in the canyons of Tonto National Monument. The drainages are sometimes only a few meters wide, with the slopes of high ridges ascending above. In some areas, the canyons are bordered by sheer walls cut into the conglomerate. In other areas, the surrounding mountainsides slope more gently into the channel.







Prosopis velutina Woodland (P)
Velvet mesquite Woodland

Common species

Prosopis velutina
Parkinsonia microphylla
Senegalia greggii
Hymenoclea salsola
Simmondsia chinensis
Celtis laevigata var. *reticulata*

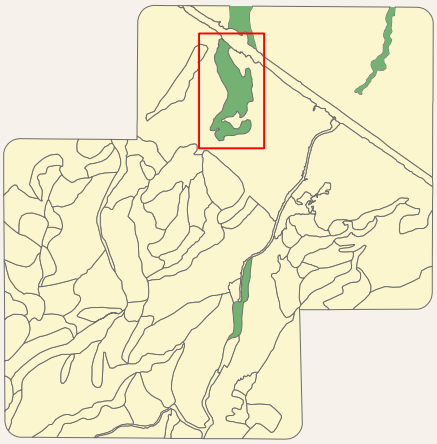
This proposed association is characterized by a canopy dominated by velvet mesquite (*Prosopis velutina*), with common associates netleaf hackberry (*Celtis laevigata* var. *reticulata*), catclaw acacia (*Senegalia greggii*), and occasional tree-like yellow paloverde (*Parkinsonia microphylla*). Total tree cover in the 2–5 meter height range is between 30% and 55% across all stands. Mesquite always creates the majority of the cover, but with a broad range (11–25% to 34–50% cover classes). Tree height varies from 3 to 4.5 meters. *Mesquite* occupies the banks, terraces, and upland areas near drainages. Other associates have relatively low cover (1–2%) and are not always consistent across the type. These include yellow paloverde and blue paloverde (*Parkinsonia florida*), black elderberry (*Sambucus nigra*), and whitethorn acacia (*Vachellia constricta*). Hackberry is variable and may be present in dense, forest-like patches, growing in a more dispersed fashion, or absent.

The subcanopy layer (0.5–2 m) is usually well developed, providing an additional 15–35% cover from lower-growing shrubs and small trees. Catclaw acacia is a common species that may create thickets in the narrow drainages or on terraces in wider channels. Jojoba (*Simmondsia chinensis*) grows on slopes above drainages in thick patches and can grow very tall in some woodlands. Spiny hackberry (*Celtis pallida*) and lotebush (*Ziziphus obtusifolia*) were observed infrequently along the banks and terraces. Several other subcanopy shrubs may be present, though not consistently across all stands of this association. Tarragon (*Artemisia dracunculus*) and burrobush (*Hymenoclea salsola*) occur in the drainage bottoms in trace amounts.

Field-stratum (<0.5 m) cover is sparse, at 1–5%, and generally consists of non-native brome grasses, annual forbs, and a few bunchgrasses, though purple threeawn (*Aristida purpurea*) is a common associate.

This type occurs near and around drainages in the gentle slopes of the alluvial fans of Tonto National Monument and in the wider, drier, northern end of the Cave Spring wash.







Quercus turbinella - Cercocarpus montanus var. *glaber* Shrubland

Sonoran scrub oak - Birchleaf mountain mahogany Shrubland

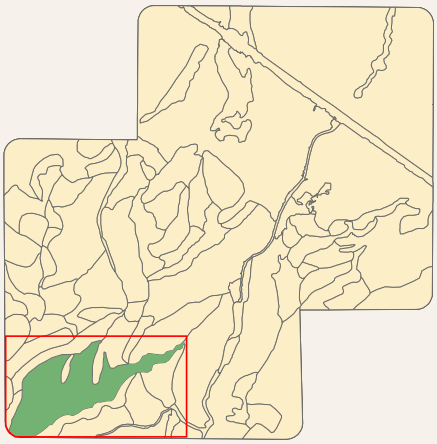
Common species

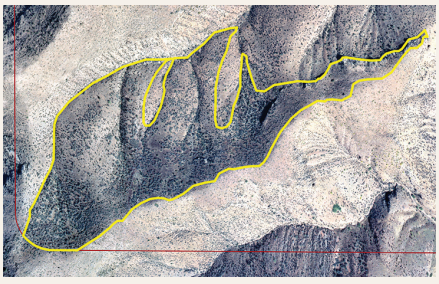
Quercus turbinella
Cercocarpus montanus
Gutierrezia sarothrae
Bouteloua curtipendula
Aristida purpurea

This shrubland association is characterized by the dominance of tall birchleaf mountain mahogany (*Cercocarpus montanus* var. *glaber*) shrubs. These grow densely near the ridge summit but are present throughout the stand, thinning out into the shorter scrub of Sonoran scrub oak (*Quercus turbinella*) on the lower slope and reemerging on the steepening footslope. Total tall-shrub canopy cover was estimated to be approximately 15%, with 6–10% cover of mountain mahogany. The shorter subcanopy is dominated by scrub oak but also has over a dozen other shrub species present, comprising ~35% total cover. The scrub oak forms thick patches throughout the community, especially in areas where birchleaf mountain mahogany is generally tall. Broom snakeweed (*Gutierrezia sarothrae*) is a common associate, appearing as a low-growing shrub, present everywhere but increasing in cover at the mid-slope, where the grade decreases and scrub oak becomes less dense. Singleleaf ash (*Fraxinus anomala*) and sugar sumac (*Rhus ovata*) are present with 1–5% cover. The field stratum (<0.5 m) is sparse, with only 10% total cover, made up of several species of bunchgrass. No single species clearly dominates the stratum. A few scattered juniper (*Juniperus* spp.) trees are present in the stand.

This vegetation type is found on a north- to northwest-facing backslope, crest, and footslope of a mountain, at elevations of 1,000–1,200 meters.







(*Parkinsonia microphylla*) / *Encelia farinosa* Shrubland (P)
(Yellow paloverde) / Brittlebush Shrubland

Common species

Parkinsonia microphylla
Carnegia gigantea
Encelia farinosa
Encelia frutescens
Simmondsia chinensis

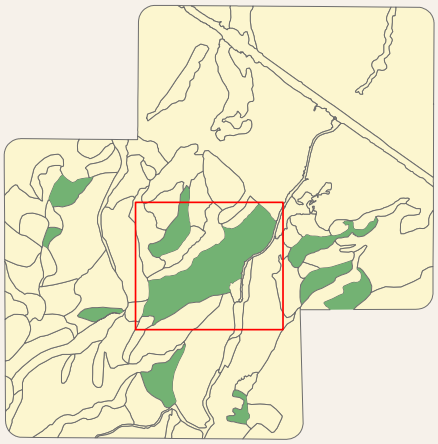
This proposed association is characterized by occasional saguaro (*Carnegia gigantea*) and more frequent yellow paloverde (*Parkinsonia microphylla*) dotting a deep red, rocky landscape dominated by brittlebush (*Encelia farinosa*), usually with 7–10 or more associate shrub species present.

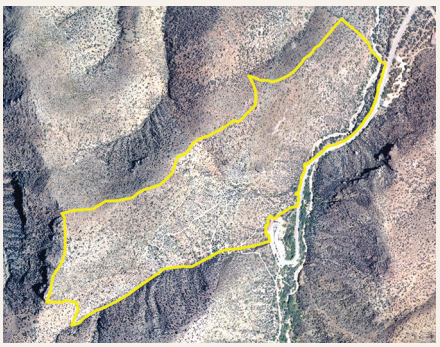
In the subcanopy (0.5–2 m height), total vegetative cover generally ranges from 25 to 35%, but may reach up to 40%. Brittlebush creates the majority of shrub cover, ranging from 11 to 25%, and is a loosely distributed but consistently occurring low shrub. In some areas, it occurs with co-dominants button brittlebush (*E. frutescens*) or jojoba (*Simmondsia chinensis*). A mixed association of shrubs adds to the subcanopy diversity, each with low cover. The most common species include teddy bear cholla (*Opuntia bigelovii*), Fremont's desert-thorn (*Lycium fremontii*), broom snakeweed (*Gutierrezia sarothrae*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), cactus apple (*Opuntia engelmannii*), and sweetbush (*Bebbia juncea*), though only some may occur in a given stand. Seven to ten other shrub species may be present with trace cover. Teddy bear cholla is relatively rare in Tonto NM, and was observed almost exclusively in this association.

The field stratum (below 0.5 m height) is generally sparse, with 1–5% cover. Arizona spikemoss (*Selaginella arizonica*) is a variable dominant in the field layer, in some stands creating 12–20% ground cover, while sparse or absent in others. Common species include purple threeawn (*Aristida purpurea*), Graham's nipple cactus (*Mammillaria grahamii*), Plains blackfoot (*Melampodium leucanthum*), San Felipe dogweed (*Adenophyllum porophylloides*), slender poreleaf (*Porophyllum gracile*), sandmat (*Chamaesyce* sp.), desert wishbone-bush (*Mirabilis laevis*), bluedicks (*Dichelostemma capitatum*), dudleya (*Dudleya* sp.), goldenflower century plant (*Agave chrysantha*), Engelmann's hedgehog cactus (*Echinocereus engelmannii*), and brownplume wirelettuce (*Stephanomeria pauciflora*).

Location of this vegetation type is aspect-determined. It occurs almost exclusively on southeast-facing slopes, rarely on southwest or southern aspects. Elevation generally ranges between 900 and 1,000 meters.







Encelia frutescens - Gutierrezia sarothrae Shrubland (P)

Button brittlebush - Broom snakeweed Shrubland

Common species

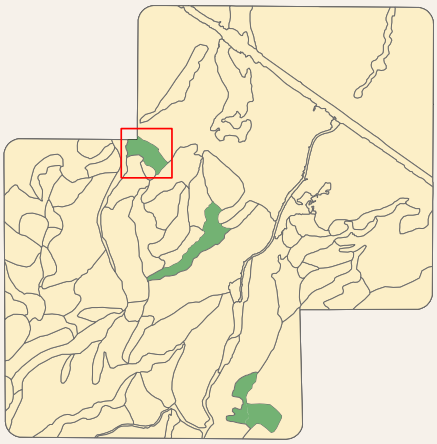
Encelia frutescens
Gutierrezia sarothrae
Prosopis velutina
Dasylirion wheeleri
Eriogonum fasciculatum

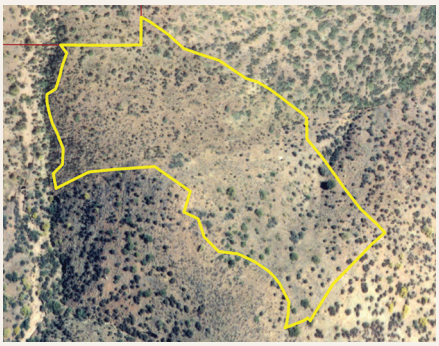
This proposed association is characterized as a low-growing shrubland, with button brittlebush (*Encelia frutescens*) and broom snakeweed (*Gutierrezia sarothrae*) sharing dominance. Button brittlebush and broom snakeweed have consistent cover, in the range of 6–15% each, in all mapped examples of this community. With all species combined, the subcanopy layer (0.5–2 m height) has total cover of around 30%. There are many common associate shrubs, creating high overall diversity, but each species has relatively low cover. Associates with 1–2 (up to 5)% cover usually present include jojoba (*Simmondsia chinensis*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), globemallow (*Sphaeralcea* spp.), sotol (*Dasylirion wheeleri*), cactus apple (*Opuntia engelmannii*), Wright's beebrush (*Aloysia wrightii*), Florida hopbush (*Dodonaea viscosa*), sweetbush (*Bebbia juncea*), crucifixion thorn (*Canotia holacantha*), catclaw acacia (*Senegalia greggii*), yellow paloverde (*Parkinsonia microphylla*), brittlebush (*Encelia farinosa*), Fremont's desert thorn (*Lycium fremontii*), ocotillo (*Fouquieria splendens*), Sonoran scrub oak (*Quercus turbinella*), turpentine bush (*Ericameria laricifolia*), featherplume (*Dalea formosa*), sugar sumac (*Rhus ovata*), goldenflower century plant (*Agave chrysantha*), and others.

Tree cover is low and variable (but not more than 5%) and most consistently provided by velvet mesquite (*Prosopis velutina*). The field stratum (<0.5 m) has generally 2–5% cover, ranging up to 15%, and comprises a diverse mix of grasses and small shrubs, succulents, or herbaceous perennials. Where cover is relatively high (15%), Lehmann's lovegrass (*Eragrostis lehmanniana*; non-native) may be dominant.

This shrubland is located on the upper backslopes, shoulders, and crests of north-trending ridges, at elevations of 800–1,000 meters.







Simmondsia chinensis - Encelia farinosa Shrubland (P)
Jojoba - Brittlebush Shrubland

Common species

Simmondsia chinensis
Encelia farinosa
Fouquieria splendens
Parkinsonia microphylla
Carnegia gigantea
Cylindropuntia bigelovii

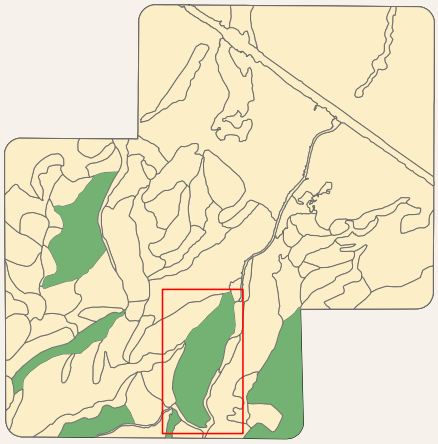
This proposed association is characterized as an open, low-height shrubland dominated by jojoba (*Simmondsia chinensis*) with 11–25% cover and a short shrub layer with brittlebush (*Encelia farinosa*) as the dominant species, providing another 2–10% cover. Jojoba thins out on the south-facing areas, and is denser on north-facing slopes above the minor drainages. From a distance, this repeating pattern is visible: a gradient of jojoba, from more dense to less dense with grasses and subshrubs mixed in, with the light-blue globes of brittlebush emerging in numbers among the dark jojoba. Total cover from all shrubs combined averages ~35%.

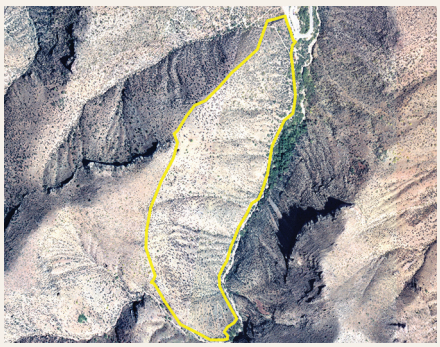
Brittlebush occurs almost exclusively on south- or southeast-facing slopes. In this type, it is densest at the south-facing edges of the many ridges that run downhill. These areas tend to have more visible gravel and loose rock, while the upper sections of the ridges and the north-facing sides are generally higher in associate shrub and herbaceous cover. Annual forb cover is also more abundant in those areas.

Yellow paloverde (*Parkinsonia microphylla*), ocotillo (*Fouquieria splendens*) and saguaro (*Carnegia gigantea*) create a trace canopy (above 2 meters in height) of generally <1% cover in the brittlebush-dominated portions of the mosaic. Teddy bear cholla (*Cylindropuntia bigelovii*) is a sparse associate on the south-facing slope sections. Canopy-height species are rare here overall. Rills and/or gullies occur in all stands.

This shrubland association grows on unstable, east-facing (usually with a southerly component) slopes at Tonto National Monument, above canyon bottom drainages and below sheer rock faces of Dripping Springs quartzite from 850 to 1,100 meters in elevation.







Simmondsia chinensis - Encelia frutescens Shrubland (P)

Jojoba - Button brittlebush Shrubland

Common species

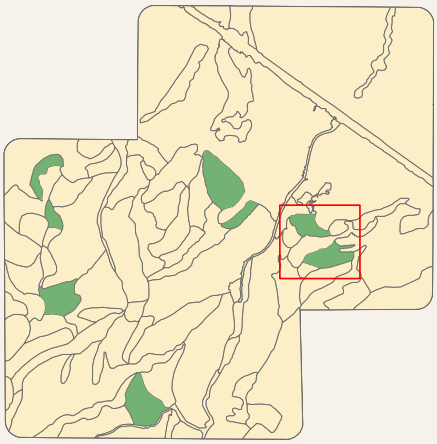
Simmondsia chinensis
Encelia frutescens
Sphaeralcea sp.

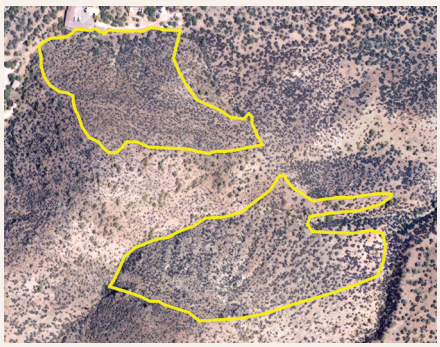
This proposed association is one of the denser shrubland communities at Tonto NM, with overall shrub cover ranging from 30 to 50%. The community is characterized by a subcanopy layer (0.5–2 m) dominated by jojoba (*Simmondsia chinensis*) and button brittlebush (*Encelia frutescens*). Jojoba is typically more abundant than the button brittlebush, comprising 6–10% cover in some stands and up to 26–33% in others, but the two can approach co-dominance in places. Jojoba grows as large, robust individuals on these slightly cooler, north-trending slopes. The button brittlebush is shorter, with flowering height generally less than 0.75 meters. Together, the two create a subcanopy of two heights and densities.

Other species present in this type are diverse. Many shrubs and subshrubs are present in varying abundance and frequency among stands. Associates may include snapdragon penstemon (*Keckiella antirrhinoides*), globemallows (*Sphaeralcea* spp.), buckhorn cholla (*Cylindropuntia acanthocarpa*), broom snakeweed (*Gutierrezia sarothrae*), turpentine bush (*Ericameria laricifolia*), Wright's beebrush (*Aloysia wrightii*), Fremont's desert-thorn (*Lycium fremontii*), catclaw acacia (*Senegalia greggii*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), sotol (*Dasylirion wheeleri*), sugar sumac (*Rhus ovata*), and others. Sparse amounts of bunchgrasses occupy open spaces between shrubs. Bush muhly (*Muhlenbergia porteri*) occurs in most stands, with a mix of less-frequent grass species. Canopy (>2 m) cover is sparse to absent. Occasional ocotillo (*Fouquieria splendens*), yellow paloverde (*Parkinsonia microphylla*), or velvet mesquite (*Prosopis velutina*) are observed in approximately half of the examples of this type. Saguaro cactus (*Carnegia gigantea*) is rare.

This type is found on the upper slopes above Deadman's Canyon in the southern half of the monument, and on upper slopes above the broad alluvial fans in the northern half. Most stands occur on northern-facing slopes (often northwestern or northeastern occurrences) from 700 to 1,150 meters in elevation.







Cylindropuntia acanthocarpa Shrubland (P)
Buckhorn cholla Shrubland

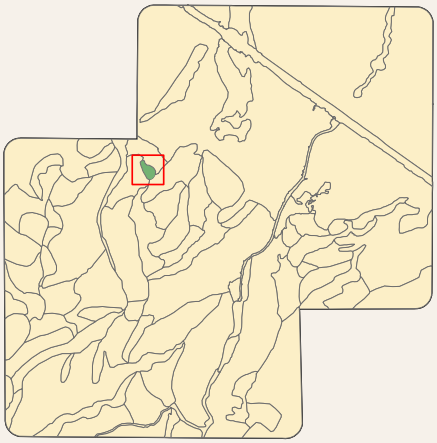
Common species

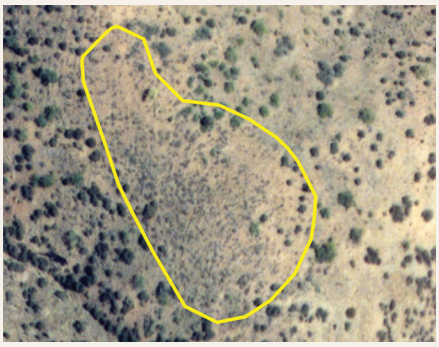
Cylindropuntia acanthocarpa
Eriogonum wrightii
Menodora scabra
Porophyllum gracile
Cuscuta indecora
Aristida purpurea

This proposed association is a unique, small, homogeneous patch of buckhorn cholla (*Cylindropuntia acanthocarpa*) on one of the lower ridges of Tonto NM. The subcanopy cover of 40% is formed, for the most part, by the open architecture of the branches of buckhorn cholla. Subshrubs and grasses grow underneath this open canopy. Canopy-height species (>2 m) are essentially absent, with only one or two ocotillo (*Fouquieria splendens*) present in the entire area. Notably, slender poreleaf (*Porophyllum gracile*) is a relatively large plant here, growing to 0.75 meters in height within the structure of the cholla. Bigseed alfalfa dodder (*Cuscuta indecora*, a parasite) generates little cover, but is noticeable and prefers the rough menodora (*Menodora scabra*)—a common host—and bastardsage (*Eriogonum wrightii*), a less-common host. Bunches of purple threeawn (*Aristida* purpurea) and non-native Lehmann's lovegrass (*Eragrostis lehmanniana*) populate most of the sparse field cover.

This shrubland sits on a south-southwest facing hill with mild slope (15–35%) at around 900 meters in elevation. The soils appear to be compacted, with loose rocks and gravel but predominantly bare ground. Much of the soil was covered with light cyanobacteria (biological soil crust).







Parkinsonia microphylla / Simmondsia chinensis Wooded Shrubland (P)

Paloverde / Jojoba Wooded Shrubland

Common species

Parkinsonia microphylla
Carnegia gigantea
Prosopis velutina
Simmondsia chinensis
Encelia frutescens

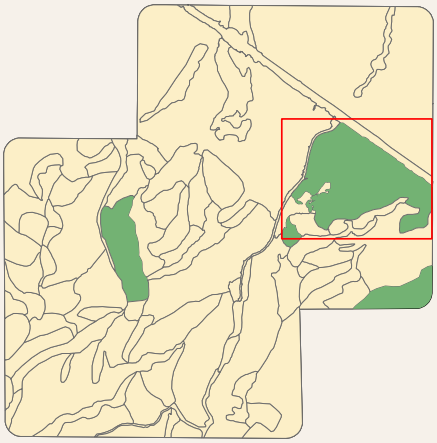
This proposed association is characterized by yellow paloverde trees (*Parkinsonia microphylla*) 2–3 meters tall, over a shorter layer (<2 m) dominated by jojoba (*Simmondsia chinensis*) with various mixed-shrub patches and herbaceous associates. The vegetation has an open, park-like structure, with widely spaced, large, round shrubs (often in patches) and well-spaced trees. The paloverde act as shelter for many other species. The field stratum (<0.5 m) generally has sparse cover or is primarily composed of low-growing seasonal annuals.

Cover of trees 2–5 meters tall generally ranges from 15 to 17%, and is clearly dominated by paloverde (10–15% cover), with velvet mesquite (*Prosopis velutina*) as an associate tree (2–3% cover). Mesquite is irregularly distributed in the upland areas of the fans. It is found more reliably near drainages, where paloverde also becomes denser. Saguaro (*Carnegiea gigantea*) is usually present in small numbers. Catclaw acacia (*Senegalia greggii*) and, occasionally, lotebush (*Ziziphus obtusifolia*) and spiny hackberry (*Celtis ehrenbergiana*) may fill in narrow drainages. Ocotillo (*Fouquieria splendens*) and/or blue paloverde (*Parkinsonia florida*) can be present in low numbers.

Total subcanopy cover (0.5–2 m) is ~35%. Jojoba is the most consistently distributed large shrub species, with cover between 15 and 25%. Other associates vary somewhat depending on aspect shifts and topographic position. Brittlebush (*Encelia farinosa*) is common, generally with 1–10% cover. Fremont's desert-thorn (*Lycium fremontii*) and button brittlebush (*Encelia frutescens*) are both well distributed, albeit with low abundance. Field-stratum cover is very sparse, around 1%, due to the rocky substrate. Purple threeawn (*Aristida purpurea*) is the most common grass species. Seasonal forbs may be present.

This association occurs on the north-facing alluvial fan system that occupies the northern half of the monument.







Parkinsonia microphylla / Simmondsia chinensis - Ericameria laricifolia Wooded Shrubland (P)

Yellow paloverde / Jojoba - Turpentine bush Wooded Shrubland

Common species

Parkinsonia microphylla
Simmondsia chinensis
Ericameria laricifolia
Prosopis velutina
Lycium fremontii
Senegalia greggii

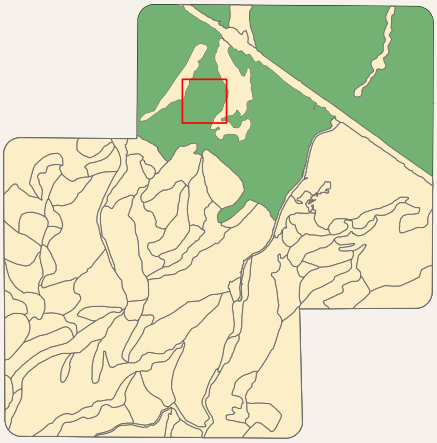
This proposed association is characterized by yellow paloverde trees (*Parkinsonia microphylla*) 2–3 m tall, over a shorter (<2 m) layer dominated by jojoba (*Simmondsia chinensis*), with the consistent common associate shrub turpentine bush (*Ericameria laricifolia*). Other mixed-shrub patches and herbaceous associates are present. The vegetation has an open, park-like structure, with widely spaced, large, round shrubs (often in patches) and well-spaced trees. The yellow paloverde act as shelter for many other species. The field stratum generally has sparse cover or is primarily composed of low-growing seasonal annuals.

Tree cover generally ranges from 15 to 17% in the 2–5 meter canopy. It is clearly dominated by yellow paloverde (10–15% cover), with individual canopies often as broad as (or broader than) the height of the plant. Small shrubs and annuals occur under their canopies. Velvet mesquite (*Prosopis velutina*) is an associate tree (2–3% cover) with irregular distribution.

Total subcanopy (0.5–2 m) cover is ~35%, dominated by jojoba, with consistent distribution and cover between 15 and 25%. Turpentine bush is a characteristic subdominant in this association. As a low shrub, turpentine bush usually generates 6–10% cover (more in one stand) and seems to readily colonize previously disturbed areas, sometimes growing in almost homogeneous patches on old road cuts and along fence lines. Diversity of less-common associate shrubs is generally high, with 10 or more species present, but there may be fewer. Grass species commonly found in the field stratum include purple threeawn (*Aristida purpurea*), sideoats grama (*Bouteloua curtipendula*) and Lehmann's lovegrass (*Eragrostis lehmanniana*; non-native), but none accounts for significant cover. Forb cover and diversity may be substantial in wet seasons.

This association is found across the low portions of the north and northwest-facing alluvial fans that occupy the northern half of the monument.







Parkinsonia microphylla / Eriogonum fasciculatum - Encelia frutescens Wooded Shrubland (P)

Yellow paloverde / Eastern Mojave buckwheat - Button brittlebush Wooded Shrubland

Common species

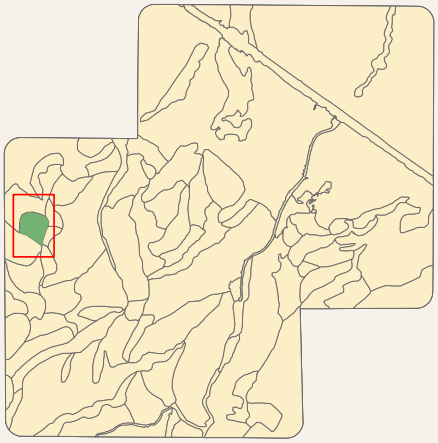
Parkinsonia microphylla
Fouquieria splendens
Eriogonum fasciculatum
Encelia frutescens

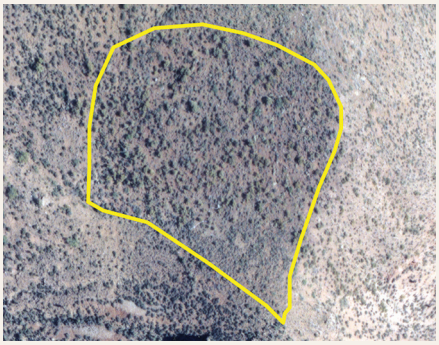
This proposed association is characterized as a mixed-shrub community with significant canopy cover from short trees. The relatively tall yellow paloverde (*Parkinsonia microphylla*) and ocotillo (*Fouquieria splendens*) appear to tower over a low, open subcanopy of spindly button brittlebush (*Encelia frutescens*) and matted eastern Mojave buckwheat (*Eriogonum fasciculatum*).

Yellow paloverde and ocotillo form a prominent canopy (>2 m), with a total cover of about 15%. Yellow paloverde occurs in tree and shrub form, generally about 2.5 meters tall, and is the more abundant of the two. Ocotillo (up to 4 m tall) is estimated to provide less than 5% cover. The subcanopy is composed of a mix of other shrub associates, together having total cover of about 25%. The subcanopy is fairly open, dominated by buckwheat, with button brittlebush clustering around the bases of the paloverde. Jojoba (*Simmondsia chinensis*) and banana yucca (*Yucca baccata*) are common associates, with the yucca sometimes up to one meter tall and visually striking within the community. Other shrub species that may be present, with trace cover, include goldenflower century plant (*Agave chrysantha*), brittlebush (*Encelia farinosa*), cactus apple (*Opuntia engelmannii*), buckhorn cholla (*Cylindropuntia acanthocarpa*), turpentine bush (*Ericameria laricifolia*), starry bedstraw (*Galium stellatum*), catclaw acacia (*Senegalia greggii*), and Wright's beebrush (*Aloysia wrightii*). Field layer (<0.5 m) cover is very low (< 1%), with no dominants recorded.

This shrubland sits on a west-northwest-facing backslope of a mountain, at about 1,000 meters in elevation.







Canotia holacantha Shrubland (P)
Crucifixion thorn Shrubland

Common species

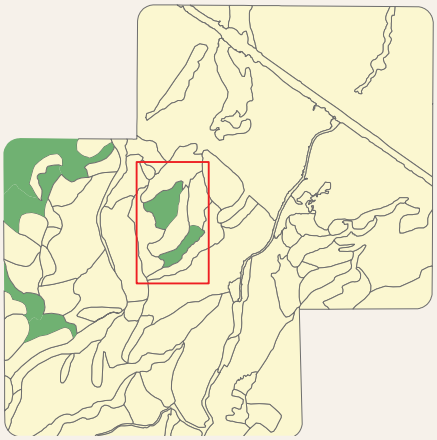
Canotia holacantha
Simmondsia chinensis
Gutierrezia sarothrae
Eriogonum fasciculatum
Opuntia engelmannii

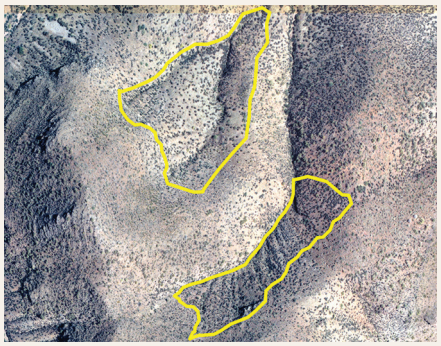
This proposed association is characterized by crucifixion thorn (*Canotia holacantha*) as the dominant subcanopy (0.5–2 m) shrub, generally occurring with 6–10 (up to 15)% cover. It has a shrubby form, growing to about two meters, but some taller individuals with one or a few central trunks and an overall vertical form could be considered trees. Jojoba (*Simmondsia chinensis*), broom snakeweed (*Gutierrezia sarothrae*) and/or eastern Mojave buckwheat (*Eriogonum fasciculatum*) may be co-dominants. Cactus apple (*Opuntia engelmannii*) and Florida hopbush (*Dodonaea viscosa*) are common associates. Shrub diversity is moderately high, with 8–10 additional species generally present. These may include bastardsage (*Eriogonum wrightii*), sotol (*Dasylirion wheeleri*) (occasionally co-dominant in some stands), Fremont's desert-thorn (*Lycium fremontii*), pale wolfberry (*Lycium pallidum*), turpentine bush (*Ericameria laricifolia*), Wright's beebrush (*Aloysia wrightii*), ocotillo (*Fouquieria splendens*), sugar sumac (*Rhus ovata*), catclaw acacia (*Senegalia greggii*), broom snakeweed (*Gutierrezia sarothrae*), banana yucca (*Yucca baccata*), and others.

Plant cover in the field layer is generally 5% or less and is most often a patchy mix of perennial grasses, possibly including desert needlegrass (*Achnatherum speciosum*), sideoats grama (*Bouteloua curtipendula*), purple threeawn (*Aristida purpurea*), cane bluestem (*Bothriochloa barbinodis*), and others. Occasionally, scattered trees, including mesquite (*Prosopis* spp.) and redberry juniper (*Juniperus arizonica,* formerly *J. coahuilensis*) may be present.

This vegetation type is found on the upper slopes, ridges, and crests of north-trending aspects. Elevation ranges from 800 to 1,200 meters. Slope tends to be steep, usually from 35% to more than 50% (up to 90%). Ground cover is generally small rock or coarse sedimentary gravel, with areas of bedrock outcrops, especially at higher elevations. Many of the areas where this alliance is found are cut repeatedly by shallow ravines, especially in backslope areas.







Dodonaea viscosa Shrubland (P)
Florida hopbush Shrubland

Common species

Dodonaea viscosa
Encelia frutescens
Simmondsia chinensis
Achnatherum speciosum
Canotia holacantha
Dasylirion wheeleri

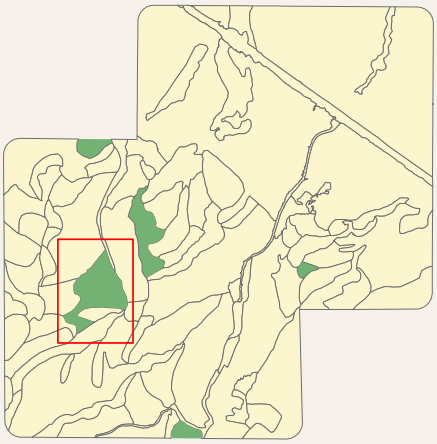
This proposed association is characterized by the presence and dominance of Florida hopbush (*Dodonaea viscosa*) averaging less than two meters tall, accompanied by jojoba (*Simmondsia chinensis*) and button brittlebush (*Encelia frutescens*), which can have enough cover to be considered co-dominant in some stands. Total cover in the subcanopy (0.5–2 m) is 35–40%. Species over two meters tall are sparse and include occasional ocotillo (*Fouquieria splendens*) or sugar sumac (*Rhus ovata*), or short, scrubby trees, such as crucifixion thorn (*Canotia holacantha*) and yellow paloverde (*Parkinsonia microphylla*).

Shrub diversity is high, with several other shrubs commonly present in low numbers, each contributing 1–2% cover. These include sotol (*Dasylirion wheeleri*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), bastardsage (*E. wrightii*), broom snakeweed (*Gutierrezia sarothrae*), goldenflower century plant (*Agave chrysantha*), cactus apple (*Opuntia engelmannii*), buckhorn cholla (*Cylindropuntia acanthocarpa*), featherplume (*Dalea formosa*), globemallow (*Sphaeralcea* sp.), catclaw acacia (*Senegalia greggii*), sweetbush (*Bebbia juncea*), and others. Less-common shrubs that were observed include snapdragon penstemon (*Keckiella antirrhinoides*), Wright's beebrush (*Aloysia wrightii*), and spearleaf brickellbush (*Brickellia atractyloides*).

The field layer (<0.5 m) contains a mix of grasses, small cacti, and herbaceous or woody perennials, with the highest cover generated by the grasses. Across all stands, combined cover averages 3–4%. Desert needlegrass (*Achnatherum speciosum*) is present in most stands, and may dominate. Associate grasses may include spidergrass (*Aristida ternipes* var. *gentilis*), sideoats grama (*Bouteloua curtipendula*), purple threeawn (*Aristida purpurea*), Arizona cottontop (*Digitaria californica*), cane bluestem (*Bothriochloa barbinodis*), and others.

This vegetation type is generally located on north- or northeast-facing backslopes, shoulders, and crests of ridges at 850–1,150 meters in elevation. The surface is covered with a mix of rock, bedrock, and gravel, with gravel being the most common.







Simmondsia chinensis / Eriogonum wrightii Shrubland (P)
Jojoba / Bastardsage Shrubland

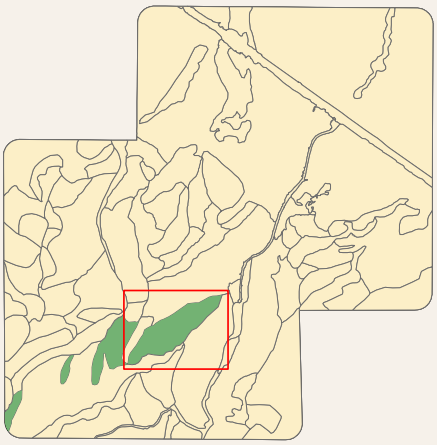
Common species
Simmondsia chinensis
Eriogonum wrightii
Achnatherum speciosum
Canotia holacantha

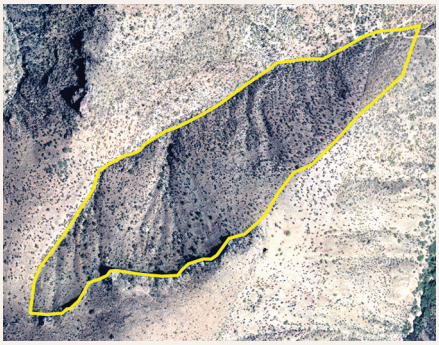
This proposed association is characterized by a subcanopy layer dominated by jojoba (*Simmondsia chinensis*) shrubs with an average of 10% cover (ranging from 6 to 20%), and an understory layer dominated by bastardsage (*Eriogonum wrightii*). There are usually a number of other shrubs present in this height range (0.5–2 m), creating a diverse community with ~25–35% total cover. Individually, each species has only 1–3% cover. Common shrubs include crucifixion thorn (*Canotia holacantha*), sugar sumac (*Rhus ovata*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), turpentine bush (*Ericameria laricifolia*), sotol (*Dasylirion wheeleri*), catclaw acacia (*Senegalia greggii*), cactus apple (*Opuntia engelmannii*), broom snakeweed (*Gutierrezia sarothrae*), banana yucca (*Yucca baccata*), globemallows (*Sphaeralcea* spp.), and goldenflower century plant (*Agave chrysantha*).

The canopy (>2 m in height) is typically sparse (always <10%), if not absent, with the occasional sugar sumac (*Rhus ovata*), crucifixion thorn (*Canotia holacantha*), or birchleaf mountain mahogany (*Cercocarpus montanus*). Yellow paloverde is not a component of this community except where it is accidental and transitional, having crept in from adjacent *Parkinsonia microphylla / Encelia farinosa* communities. The field layer (<0.5 m) is dominated by grasses and, secondarily, by forbs and subshrubs but has fairly low cover, averaging 3–4% (up to 10%), with no species consistently dominant throughout.

This vegetation type is restricted to slopes with northern or northwestern aspects and elevations ranging from 900 to 1,150 meters. The slopes are usually steep and loose, with 35–50% slope or greater, with high rock and gravel cover.







Simmondsia chinensis - Eriogonum fasciculatum Shrubland (P)

Jojoba - Eastern Mojave buckwheat Shrubland

Common species

Simmondsia chinensis
Eriogonum fasciculatum
Encelia frutescens
Achnatherum speciosum

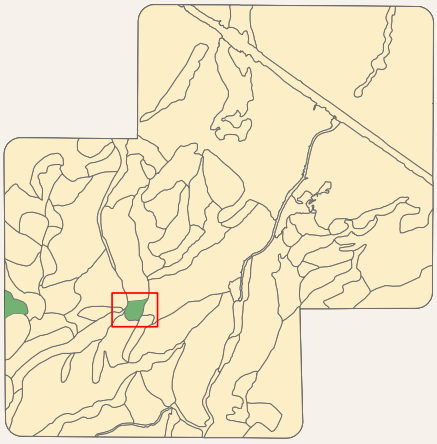
This proposed association is characterized by jojoba (*Simmondsia chinensis*) shrubs providing the dominant cover in the subcanopy (0.5–2 m), with low, sprawling eastern Mojave buckwheat (*Eriogonum fasciculatum*) growing between them.

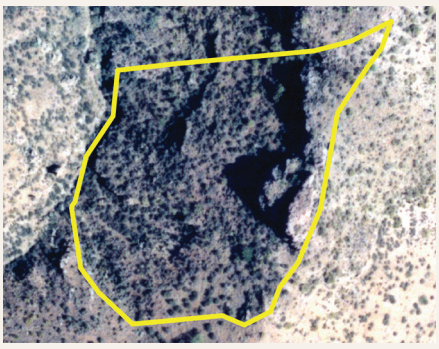
Total shrub cover ranges from 30 to 35%, with jojoba generally providing 11–25% cover and buckwheat shrubs generally at 6–10% cover. Button brittlebush (*Encelia frutescens*) is a common associate, providing an additional 1–3% cover. The rest of the subcanopy layer is composed of a heterogeneous mix of shrub species. These may include globemallow (*Sphaeralcea* spp.), catclaw acacia (*Senegalia greggii*), cactus apple (*Opuntia engelmannii*), Fremont's desert-thorn (*Lycium fremontii*), turpentine bush (*Ericameria laricifolia*), broom snakeweed (*Gutierrezia sarothrae*), sotol (*Dasylirion wheeleri*), sugar sumac (*Rhus ovata*), banana yucca (*Yucca baccata*), goldenflower century plant (*Agave chrysantha*), bastardsage (*Eriogonum wrightii*), or others.

Canopy (>2 m) cover is sparse (<5%) or even absent. When present, it consists of occasional trees, such as velvet mesquite (*Prosopis velutina*), paloverde (*Parkinsonia* spp.), or tall crucifixion thorn (*Canotia holacantha*) and ocotillo (*Fouquieria splendens*). The field stratum (<0.5 m) is also sparse, at <5% total cover, comprising several grass species with no clear dominant. The field species most consistently found across all stands are desert needlegrass (*Achnatherum speciosum*) and purple threeawn (*Aristida purpurea*), both of which are common parkwide, and sideoats grama (*Bouteloua curtipendula*) and Arizona cottontop (*Digitaria californica*).

This association occurs on the steep upper portions of some west-facing slopes above Deadman's Canyon, at 975–1,125 meters.







Simmondsia chinensis - Ericameria laricifolia Shrubland (P)
Jojoba - Turpentine bush Shrubland

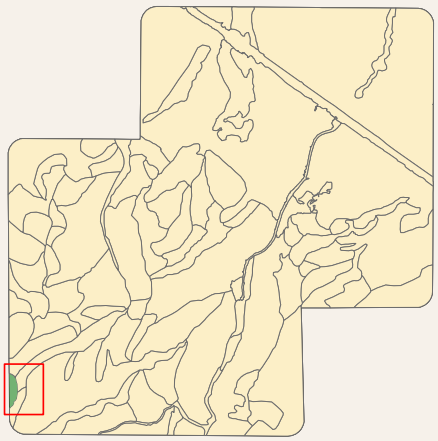
Common species

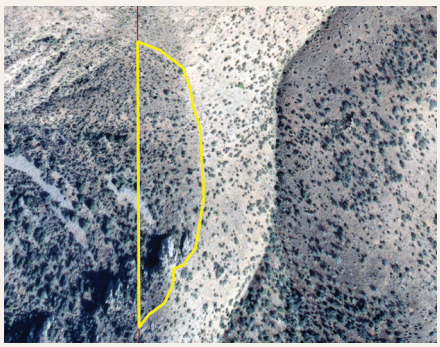
Simmondsia chinensis
Ericameria laricifolia
Opuntia engelmannii
Canotia holacantha

This proposed association is characterized by a subcanopy layer (0.5–2 m height) dominated by jojoba (*Simmondsia chinensis*) at 6–10% cover, with turpentine bush (*Ericameria laricifolia*) as a subdominant associate (1–5% cover). Large cactus apple (*Opuntia engelmannii*) and short-statured crucifixion thorn (*Canotia holacantha*) are the primary common associates. Crucifixion thorn is most abundant at the shoulder of the saddle and the upper portions of the minor drainages that run down the backslope. Other shrubs present in low numbers include goldenflower century plant (*Agave chrysantha*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), broom snakeweed (*Gutierrezia sarothrae*), and buckhorn cholla (*Cylindropuntia acanthocarpa*). A few ocotillos are present. Otherwise, canopy (>2 m) cover is lacking. The field stratum (<0.5 m) cover is sparse, at about 5%, and composed primarily of the grasses, desert needlegrass (*Achnatherum speciosum*), Boer lovegrass (*Eragrostis curvula*; non-native), and Arizona cottontop (*Digitaria californica*).

Only one stand of this proposed association occurs at Tonto National Monument, on the west-facing half of a saddle at about 1,150 meters in elevation.







Simmondsia chinensis / Selaginella arizonica Shrubland (P)
Jojoba / Arizona spikemoss Shrubland

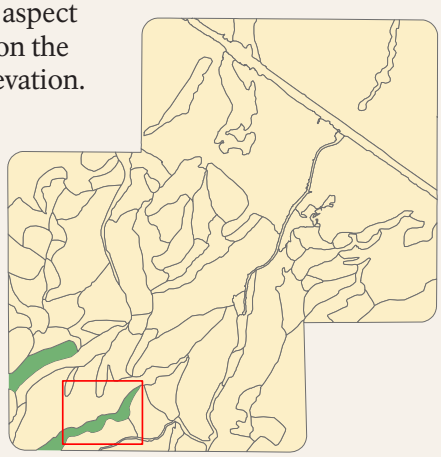
Common species
Simmondsia chinensis
Selaginella arizonica
Opuntia engelmannii
Opuntia phaeacantha
Senegalia greggii

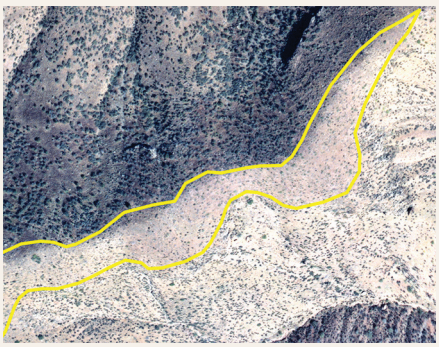
This proposed association is characterized as open and low-growing, with most vegetation at heights less than two meters. The subcanopy (0.5–2 m) is dominated by jojoba (*Simmondsia chinensis*), but a number of other shrub species are also present. Total cover in this stratum is 25–30%, with jojoba contributing ~6–10%. Tulip prickly pear (*Opuntia phaeacantha*), cactus apple (*Opuntia engelmannii*), and catclaw acacia (*Senegalia greggii*) are the three most common associates. Any one may be locally more abundant than the others, with cover of each ranging from 2 to 5%. Other associates may include button brittlebush (*Encelia frutescens*), turpentine bush (*Ericameria laricifolia*), globemallow (*Sphaeralcea* sp.), buckhorn cholla (*Opuntia acanthocarpa*), brittlebush (*Encelia farinosa*), sotol (*Dasylirion wheeleri*), yellow paloverde (*Parkinsonia microphylla*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), featherplume (*Dalea formosa*), sweetbush (*Bebbia juncea*), banana yucca (*Yucca baccata*), crucifixion thorn (*Canotia holacantha*), Fremont's desert-thorn (*Lycium fremontii*), and others.

Arizona spikemoss (*Selaginella arizonica*) creates most of the field-stratum (<0.5 m) cover (10–45%) and lends a characteristic look to this vegetation type. The soil is thin, with bedrock close to the surface. Blocky, large rocks are common. The spikemoss grows into any exposed soil and under the edges of loose rocks to occupy the thin layer of soil below. Several grass species may be present with little cover. Graham's nipple cactus (*Mammillaria grahamii*) and Engelmann's hedgehog cactus (*Echinocereus engelmannii*) are more abundant on these high, rocky slopes than in many other areas of the park. Other uncommon species recorded in this type include Plains blackfoot (*Melampodium leucanthum*), dudleya (*Dudleya* spp.), pinkflower hedgehog cactus (*Echinocereus fendleri*), San Felipe dogweed (*Adenophyllum porophylloides*), tanglehead (*Heteropogon contortus*), green sprangletop (*Leptochloa dubia*), spreading fleabane (*Erigeron divergens*), hackberry beardtongue (*Penstemon subulatus*), rue of the mountains (*Thamnosma texana*), desert marigold (*Baileya multiradiata*), and brownplume wirelettuce (*Stephanomeria pauciflora*).

This shrubland occurs in a small range limited by elevation and southeast aspect and occurs only in the southern half of the monument. Two stands exist, on the southern ends of the tallest ridges in the park, at 1,150–1,220 meters in elevation.







Simmondsia chinensis - Sphaeralcea spp. Shrubland (P)
Jojoba - Globemallow Shrubland

Common species
Simmondsia chinensis
Sphaeralcea rusbyi
Sphaeralcea ambigua
Encelia frutescens
Opuntia engelmannii
Prosopis velutina

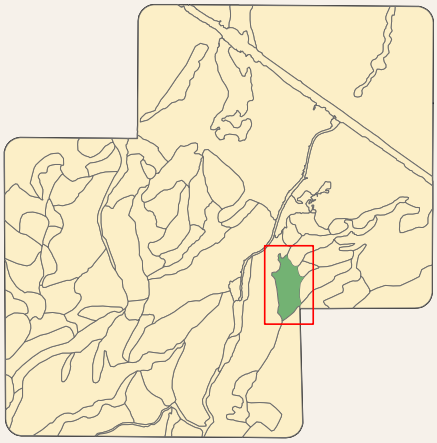
This proposed association is characterized by widely spaced jojoba interspersed with Rusby's globemallow (*Sphaeralcea rusbyi*) and desert globemallow (*Sphaeralcea ambigua*). Overall cover in the subcanopy (0.5–2 m) is ~35%, with jojoba accounting for around two-thirds of the cover and globemallows providing ~8%. The globemallow shrubs are frequent, with large widths (0.5–0.75 m). Subshrubs are infrequently nestled among them. Other common shrubs (at least 1% cover) include button brittlebush (*Encelia frutescens*), cactus apple (*Opuntia engelmannii*), and broom snakeweed (*Gutierrezia sarothrae*). Other associates are buckhorn cholla (*Cylindropuntia acanthocarpa*), spiny hackberry (*Celtis ehrenbergiana*), Gila manroot (*Marah gilensis*), pale wolfberry (*Lycium pallidum*), lotebush (*Ziziphus obtusifolia*), brownfoot (*Acourtia wrightii*), and eastern Mojave buckwheat (*Eriogonum fasciculatum*).

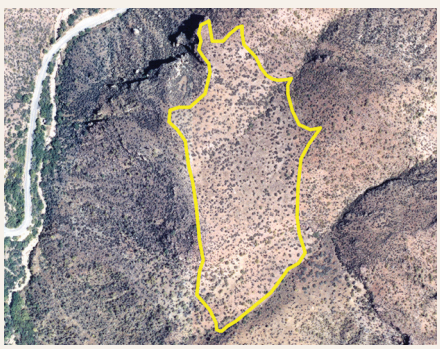
Occasional velvet mesquite (*Prosopis velutina*) and ocotillo (*Fouquieria splendens*) account for the sparse 2% canopy cover above two meters in height. In the field stratum, grasses comprise an estimated 10% total cover, with spidergrass (*Aristida ternipes*), Boer lovegrass (*Eragrostis curvula* var. *confertiflora*; non-native), and purple threeawn (*Aristida purpurea*) the most abundant. In areas with near-surface bedrock, Arizona spikemoss (*Selaginella arizonica*) fills in the open spaces.

This community could be considered to be a sub-association of the *Simmondsia chinensis* Shrubland (see below), differing by having a clear subdominant species and a greater graminoid component. It has a similar lack of tree-canopy cover.

This type is found only in one location, on the northeast side of Honey Butte. Slope gradient is 15–35%, and elevation is 875–950 meters.







Simmondsia chinensis - Opuntia engelmannii Shrubland (P)

Jojoba - Cactus apple Shrubland

Common species

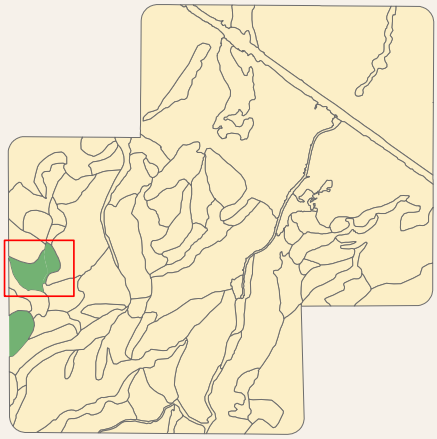
Simmondsia chinensis
Opuntia engelmannii
Rhus ovata
Encelia frutescens
Achnatherum speciosum

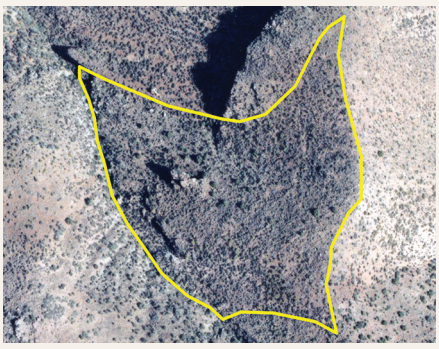
This proposed shrubland association is transitional between the Sonoran Desert uplands and the interior chaparral vegetation types. It is characterized by the predominance of jojoba (*Simmondsia chinensis*) and cactus apple (*Opuntia engelmannii*), joined by a diverse mix of other large shrub species. The majority of cover is in the subcanopy (0.5–2 m). Total combined cover is ~35% across all stands. Jojoba commonly generates 5–15% cover, and can share or trade co-dominance with pricklypear, whose cover varies from 2 to 3%, upward to 8%. In one stand, button brittlebush (*Encelia frutescens*) is a co-dominant.

Canopy cover (>2 m) is sparse to absent, always <10%, and is made up of occasional saguaro (*Carnegiea gigantea*), ocotillo (*Fouquieria splendens*), or yellow paloverde (*Parkinsonia microphylla*). These species, along with the larger shrubs, sugar sumac (*Rhus ovata*) and crucifixion thorn (*Canotia holacantha*), may be visually prominent even if not contributing much cover. However, sugar sumac can be locally dominant and, when present, will be co-dominant with jojoba. In these areas, other species more commonly associated with chaparral, such as banana yucca (*Yucca baccata*), crucifixion thorn, Sonoran scrub oak (*Quercus turbinella*), and buckwheat (*Eriogonum* spp.) also increase in frequency and abundance. Field-stratum (<0.5 m) cover is sparse (between 1–3%). Desert needlegrass (*Achnatherum speciosum*) is commonly present.

This shrubland is found on upper backslopes and crests of mountain slopes with a mostly northwest aspect (on summits, aspect can vary more). These slope positions tend to be more exposed, with several bedrock outcroppings scattered throughout. The slopes are fairly stable, even with 35–50% slope.







Simmondsia chinensis Shrubland (P)
Jojoba Shrubland

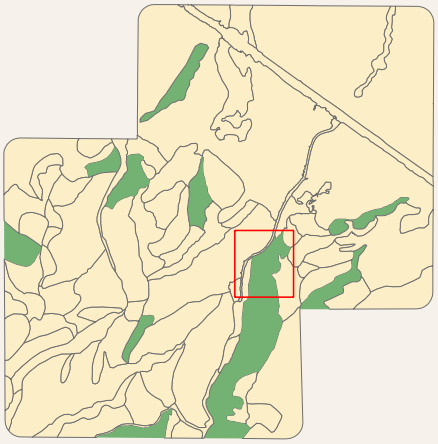
Common species
Simmondsia chinensis
Parkinsonia microphylla
Canotia holacantha
Keckiella antirrhinoides

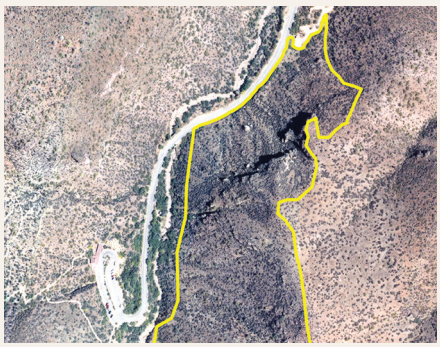
This proposed association is characterized by the clear, sole dominance of jojoba (*Simmondsia chinensis*). Numerous associate shrub species are usually present, but none provides enough cover or consistency to be considered co-dominant. Total subcanopy cover ranges from 25% to 45% (averaging about 35%), with cover of the dominant jojoba ranging from 11 to 45%. Jojoba density increases in drainage depressions and the slopes immediately above drainages. Common associates include Fremont's desert-thorn (*Lycium fremontii*), snapdragon penstemon (*Keckiella antirrhinoides*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), button brittlebush (*Encelia frutescens*), crucifixion thorn (*Canotia holacantha*), globemallow (*Sphaeralcea* spp.), broom snakeweed (*Gutierrezia sarothrae*), and others. Shrub diversity is high, with 10–20 (occasionally more) species present, but even collectively these almost always produce less cover than jojoba alone.

Field-layer (<0.5 m) cover is a trace component of this community, usually 1–2%, rarely up to 10%. One stand contains about 20% cover of the non-native annual grass, wild oats (*Avena fatua*), but population dynamics of annual species can vary widely between years. Along with cover, the number of species found in the field stratum is usually, but not always, low, and none is obviously dominant. Canopy (>2 m) cover is also sparse, usually less than 5%. Tall species that may be present, with little cover, include ocotillo (*Fouquieria splendens*), yellow paloverde (*Parkinsonia microphylla*), blue paloverde (*P. florida*), velvet mesquite (*Prosopis velutina*), saguaro (*Carnegiea gigantea*), and crucifixion thorn.

This type is found throughout the monument, on the mid-to-upper slopes of ridges in the mountainous areas. This association favors north- to west-facing slopes, but occurs also on east and southern aspects, at elevations spanning 750–1,100 meters.







Simmondsia chinensis - Lycium fremontii Shrubland (P)

Jojoba - Fremont's desert-thorn Shrubland

Common species

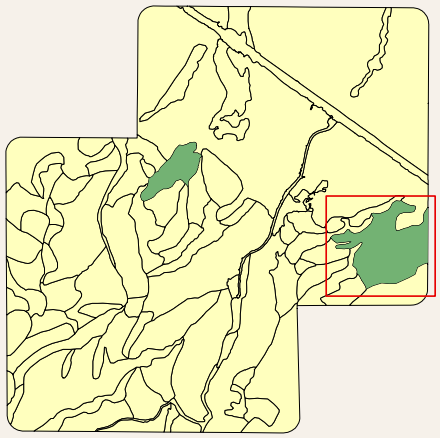
Simmondsia chinensis
Lycium fremontii
Prosopis velutina
Celtis ehrenbergiana
Parkinsonia microphylla
Parkinsonia florida

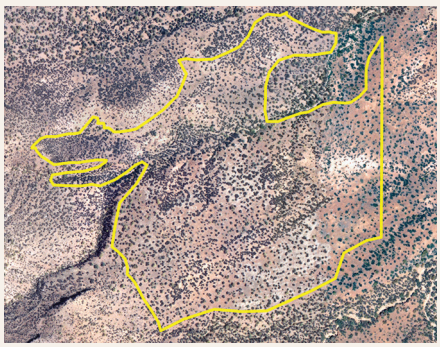
This proposed association is characterized by a moderately dense (15–30% cover) mix of large shrubs, often growing close together or entwined to form large but widely spaced clumps. These clusters of shrubs act almost as small islands, capturing and retaining water and nutrients. The dominant shrub here is jojoba (*Simmondsia chinensis*), followed closely by Fremont's desert-thorn (*Lycium fremontii*), with velvet mesquite (*Prosopis velutina*) and spiny hackberry (*Celtis ehrenbergiana*) as common associates, often seen in low numbers within the clusters. Blue paloverde (*Parkinsonia florida*) is present as a shrubby, short tree with 1–3% cover. The understory of these shrub clusters is inhabited by various subshrubs and herbaceous species. The field layer (<0.5 m) generally has low overall cover of just a few percent.

Yellow paloverde (*Parkinsonia microphylla*) is present in low numbers, averaging 2–3 meters tall, with cover below 1%. This species is more common in neighboring areas and where slope increases into the foothills; abundance increases along these transitions. Saguaro (*Carnegia gigantea*) is rare to absent in this type. Ocotillo (*Fouquieria splendens*), averaging four meters tall, occurs in low numbers throughout. Other species present were predominantly in the subcanopy (0.5–2 m), each with cover ~1%, including brittlebush (*Encelia farinosa*), snapdragon penstemon (*Keckiella antirrhinoides*), catclaw acacia (*Senegalia greggii*), globemallow (*Sphaeralcea* spp.), lotebush (*Ziziphus obtusifolia*), teddy bear cholla (*Cylindropuntia bigelovii*), and Coues' cassia (*Senna covesii*). The field layer has a large annual component. Perennial species were uncommon but included purple threeawn (*Aristida purpurea*), green sprangletop (*Leptochloa dubia*), slimleaf bursage (*Ambrosia confertiflora*), broom snakeweed (*Gutierrezia sarothrae*), and threadleaf snakeweed (*Gutierrezia microcephala*).

This shrubland occurs in Tonto National Monument at low elevations (750–900 m). It is found on north- or northeast-facing slopes of medium grade (15–35% slope), covered largely with loose rock and gravel of mostly sedimentary origin, with some old alluvium near the footslopes and some red, sandy loam soil exposed.







Vachellia constricta - Mixed-shrub Shrubland (PS)

Whitethorn acacia - Mixed-shrub Shrubland

Common species

Vachellia constricta
Aristida purpurea
Parkinsonia microphylla
Sphaeralcea sp.

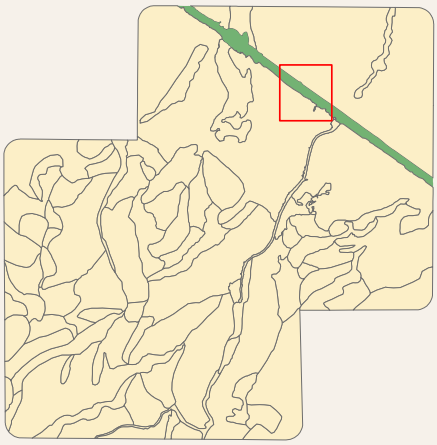
This "park special" association is characterized by a diverse, almost random mix of shrubs and subshrubs. Whitethorn acacia (*Vachellia constricta*) is the most consistently distributed species, with individuals at the edges of the roadside ditches. A few short (to 2.5 m) trees are present: yellow paloverde (*Parkinsonia microphylla*), blue paloverde (*P. florida*), and velvet mesquite (*Prosopis velutina*).

Many of the other species present represent an extremely diverse mix of shrubs, many of which do not occur elsewhere in the park or are rare within its boundaries. This diversity likely resulted from the use of a bulk re-vegetation seed mix at some point in the past. Whitethorn acacia is relatively abundant in the ditches along the roadside, creating 11–25% cover, and also occurs along the sides of the dirt road to the north of the highway. Also common or notable along the highway is a variety of eastern Mojave buckwheat (*Eriogonum fasciculatum*) that is greener, with more red tones, and grows more upright than most of the same species observed in the park. Fourwing saltbush (*Atriplex canescens*) is noticeable and only observed in two other places in the park. Fairy duster (*Calliandra eriophylla*), Parry's penstemon (*Penstemon parryi*) and triangleleaf bursage (*Ambrosia deltoidea*) are all observed here but not observed anywhere else within the park. A decorative plant, desert cassia (*Senna nemophila*), grows in a few places along the road, and is also seen on the leach field in the park.

Purple threeawn (*Aristida purpurea*) is abundant along the edge of the highway, a meter or so deep. It creates the large majority (cover class 11–25%) of the 20% field-stratum (<0.5 m) cover. On the lower, north side of the road, the non-native annuals, mouse barley (*Hordeum murinum*) and red brome (*Bromus rubens*), form patches under shrub and tree canopies.

This type is found only along US Highway 188, the main road that cuts through the northern portion of Tonto National Monument. As such, this community is unique to this area and has been described as a "park special." This shrubland borders the two-lane highway, and occurs within ~20 meters from the road edges.







3 Accuracy Assessment

3.1 Methods

Accuracy assessment (AA) was carried out on 81 mapped areas (polygons) over a two-week period in November 2010. The purpose of the AA is to provide end users of the mapping products with an estimate of the map's accuracy (i.e., to evaluate how well the map represents the reality on the ground). AA data is input into an error matrix that calculates the percentage of correct versus incorrect matches between the map data and the field AA data. The matrix provides a numeric summary of the accuracy, in percent, for each map class, as well as an overall accuracy.

The AA data often identify instances in which two associations are difficult to differentiate in the field. This may indicate that those associations are insufficiently different to justify being mapped as two distinct community types. In these cases, it may be appropriate for the associations to be merged into a single map class that contains both classified communities. When producers respond to AA data by combining map units into map classes, the underlying individual accuracies for each class are pooled to create the new map-class accuracy.

Post-production changes to "fix" or change map attributes based on AA field data are considered a violation of the AA process. The results may help producers to understand mapping errors for improving future projects, but they are not intended to further improve the map being assessed. Legitimate errors (e.g., questionable field calls) are evaluated based on all data available, such as assessor's position and vantage point, AA field notes, and, if necessary, secondary review of field photos and other data.

Current AA guidelines (Lea and Curtis 2010) reflect newer, better practices that were not yet adopted when the AA for this project was completed. These include performing a separate, internal validation that occurs prior to the AA phase. The purpose of this validation phase is to evaluate, calibrate, and validate the map, ecological classifications, and materials, such as the field key. This phase allows for changes and refinements to be made before the formal, external AA is conducted. Because the Tonto NM project was conducted before these guidelines were published or widely practiced, no such internal validation was completed.

Following NPS Vegetation Mapping Program guidelines for small parks (since superseded by Lea and Curtis 2010), and because the park was mapped census-style, we conducted a census-based accuracy assessment, rather than a sample-based one. Each polygon in the map was assessed in its entirety and assigned an association by taking the entire polygon into consideration.

While appropriate to the project, this method can sometimes yield somewhat misleading results. If a user does not consider the total number of polygons in each class when reading the census-based AA contingency table for this project, then the table can appear to substantially over- and under-represent the map's accuracy. For instance, where there were four polygons, two incorrect calls during the AA would equate to 50% accuracy, while a correct call for a type with only one representative polygon would equate to 100% accuracy. For this reason, it is important for readers to note the number (n) of polygons associated with each accuracy value. The number of polygons assessed within each association is noted in the last column of Table 3-1 (below), "row total."

To ensure objectivity, SODN and OALS plant ecologists who were not involved in the original observations conducted the accuracy assessment. The assessors were trained in the classification and mapping methodologies, and on the map classes. A briefing included discussion of plant life-forms, familiarization with the NVC hierarchy and criteria for identifying associations, review of the field key, techniques for estimating species cover classes by stratum, subtleties of visual interpretation of satellite imagery for evaluation of vegetation, use of the GPS-linked handheld computer, and other necessary methods.

The assessors were provided with a GPS unit loaded with map polygon boundaries and with printed map sections that labeled each polygon with a simple ID number. Also provided were a vegetation formation key (Appendix C), a set of map class (association) summary descriptions (abbreviated versions of those in Appendix A), and datasheets (Appendix D) for recording AA data. These datasheets contained a checklist of the Tonto NM map classes and requested some additional descriptive data and identification of dominant species (to guard against erroneously checking the wrong box).

The assessors were assigned to visit each polygon, walk through it to evaluate the lifeform and canopy cover of the dominant species in each stratum, use the key and text descriptions of relevant vegetation types, and then check the best-fitting map-class name for the polygon on the datasheet. The assessor was asked to choose a class name for the polygon as mapped, considering the whole area of the polygon. A rating of the goodness-of-fit (poor, fair, good, or excellent; see below) was also requested, along with any notes or observations that might help the map producers to interpret the assessment data.

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

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

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

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

3.2 Results

Data were compared by doing a simple spatial join of the AA results against the attributed map. This allowed each AA field evaluation to be compared to each map polygon, and the results tabulated. The primary photointerpreter from OALS met with project ecologists to analyze the map errors revealed in the preliminary contingency table. Each point mismatch (i.e., disagreement between AA field call and polygon label) was evaluated for the type of error (true or false). Some examples of "false" error include GPS position error, questionable field determinations, edge error, and inclusions (small patches of vegetation within larger map polygons). In most of these cases, the false errors were corrected, while others were further investigated.

Table 3-1 is an error matrix showing the results of the AA, including user's and producer's accuracy per map class (association type), overall accuracy for all classes (80%), and Kappa (78%), which is a measure of overall accuracy minus chance agreement. Values that occur within shaded cells along the diagonal indicate agreement between the assessor and producer. Values in unshaded cells indicate disagreement. Column totals equal the total number of plots placed within that class by the assessors on the ground. Row totals are the number of plots assigned to that class by the map producer.

Of the 22 associations included in the AA, 11 had 100% producer's accuracy. As explained in Section 3.1, an accuracy of 100% can reflect a single correct AA call (1 out of 1) or could reflect four out of four correct calls, and so it is important to note the total

Table 3-1. Thematic accuracy assessment error matrix.

Type names[1]	PLAWRI - JUGMAJ RF	PROVEL - SENGRE WSc	PROVEL W	QUETUR - CERMON S	(PARMIC) / ENCFAR S	ENCFRU - GUTSAR S	SIMCHI - ENCFAR S	SIMCHI - ENCFRU S	CYLACA S	PARMIC / SIMCHI WS[2]	PARMIC / SIMCHI - ERILAR WS[2]	PARMIC / ERIFAS - ENCFRU WS	CANHOL S	DODVIS S	SIMCHI / ERIWRI S	SIMCHI - ERIFAS S	SIMCHI - ERILAR S	SIMCHI / SELARI S	SIMCHI - SPHAER. SPP. S	SIMCHI - OPUENG S	SIMCHI S[3]	**ROW TOTAL**	Producer's accuracy
PLAWRI - JUGMAJ RF	1																					**1**	100%
PROVEL - SENGRE WSc		2																				**2**	100%
PROVEL W			4																			**4**	100%
QUETUR - CERMON S				1																		**1**	100%
(PARMIC) / ENCFAR S					8					1										1		**10**	80%
ENCFRU - GUTSAR S						3														1		**4**	75%
SIMCHI - ENCFAR S							3	1													2	**6**	50%
SIMCHI - ENCFRU S								5					1						1			**7**	71%
CYLACA S									1													**1**	100%
PARMIC / SIMCHI WS[2]										5	1	1										**7**	71%
PARMIC / ERIFAS - ENCFRU WS												1										**1**	100%
CANHOL S													3						1	1	1	**6**	50%
DODVIS S														5								**5**	100%
SIMCHI / ERIWRI S															4							**4**	100%
SIMCHI - ERIFAS S										1						1						**2**	50%
SIMCHI - ERILAR S																	1					**1**	100%
SIMCHI / SELARI S																		2				**2**	100%
SIMCHI - SPHAER. SPP. S																			1			**1**	100%
SIMCHI - OPUENG S								1												2		**3**	67%
SIMCHI S[3]								1													11	**12**	92%
COLUMN TOTAL	**1**	**2**	**4**	**1**	**8**	**3**	**3**	**8**	**1**	**7**	**1**	**2**	**4**	**5**	**4**	**1**	**1**	**2**	**3**	**5**	**14**	**80**	
User's accuracy	100%	100%	100%	100%	100%	100%	100%	63%	100%	71%	n/a	50%	75%	100%	100%	100%	100%	100%	33%	40%	79%		

Kappa (K): 0.78; n: 80; Observed agreement: 64; Chance agreement: 498

[1] The park special, *Vachellia constricta* - Mixed-shrub Shrubland, was not part of the AA evaluation.

[2] The PARMIC / SIMCHI WS (wooded shrubland) map class includes the *P. microphylla* / *S. chinensis* and *P. microphylla* / *S. chinensis* - *Ericameria laricifolia* associations. The PARMIC / SIMCHI - ERILAR WS was retained as a column header (field data) as one polygon was assigned to this association. See section 3.2.1 for details.

[3] The SIMCHI Shrubland in this table represents a map class at Tonto NM. It was formed to include the *Simmondsia chinensis* - *Lycium fremontii* shrubland in the same map class as the *Simmondsia chinensis* Shrubland association. Data for these map classes are pooled in this table.

number of polygons evaluated in each class. The other 10 associations had producers' accuracies ranging from 0 to 80%. Associations with accuracies below 75% are briefly addressed in Section 3.2.1, below.

3.2.1 Review of disagreements

Each of the mismatches was reviewed to identify the nature of the discrepancy. Most of the mismatched calls were between similar communities that have dominant species in common; few were between drastically different types. At Tonto NM, there are several dominant species with widespread distribution. Differentiating the associations is often more a question of determining relative abundance/relative dominance than of absolute presence/absence. Based on AA datasheets, plot photos, and imagery, it was determined that three field calls were incorrectly assessed (i.e., should have been in agreement with the producers' designation). Specific changes made in response to these evaluations are detailed below.

The AA team placed two *Prosopis velutina* Woodland polygons within the *Prosopis velutina* / *Senegalia greggii* Wooded Shrubland association. Because both of these field calls were determined to be in error for multiple reasons, the error matrix reflects agreement.

One polygon mapped as *Dodonaea viscosa* Shrubland was called *Simmondsia chinensis - Opuntia engelmannii* Shrubland during the AA. The assessors recorded their GPS observation point at the far boundary edge of the mapped area, which is thought to have unduly affected their evaluation (being on the downslope edge and not having sufficiently viewed the interior). This and other considerations led us to call this an error in the interpretation of the materials, and so the matrix shows agreement for this polygon.

We also assessed all mismatches to see if any associations were consistently being mistaken for one another and if they should be merged together into a single map class. We determined that two associations met these criteria. For the first, *Simmondsia chinensis - Lycium fremontii* Shrubland (two polygons), the assessors placed the polygons into the *Simmondsia chinensis* Shrubland. While original classification data showed this to be a separate type, field assessments failed to identify it. For this reason, we combined the former into the latter and pooled the AA data. For the second, *Parkinsonia microphylla* / *S. chinensis - Ericameria laricifolia* Wooded Shrubland, the assessors placed two of three polygons into the similar and adjacent type, *Parkinsonia microphylla* / *S. chinensis* Wooded Shrubland. These were also combined into a single map class.

All other mismatches were taken as normal errors due to imperfection in the classification process, the mapping process or some combination of both. Six associations had producer's accuracies below 75%. Each is briefly addressed below:

***Canotia holocantha* Shrubland.** The mapper and assessor agreed on three of the six polygons (50% producer's accuracy). The assessors placed the other three, one each, in *S. chinensis* Shrubland, *S. chinensis - Opuntia engelmannii* Shrubland, and *S. chinensis - Sphaeralcea* spp. Shrubland. One additional polygon was placed in this type (75% user's accuracy).

***S. chinensis* / *Encelia farinosa* Shrubland.** The mapper and assessor agreed on three of the six polygons (50% producer's accuracy). The assessors placed two of the other three in *S. chinensis* Shrubland, and one in *S. chinensis* / *Encelia frutescens* Shrubland. No additional polygons were placed in this type (100% user's accuracy).

***S. chinensis* / *Encelia frutescens* Shrubland.** The mapper and assessor agreed on five of the seven polygons (71% producer's accuracy). The assessors placed one of the other two in *Canotia holocantha* Shrubland, and one in *S. chinensis - Sphaeralcea* spp. Shrubland. Three additional polygons were placed in this type, indicating that its total area was under-mapped (63% user's accuracy).

***S. chinensis* / *Eriogonum fasciculatum* Shrubland.** The mapper and assessor agreed on one of the two polygons (50% producer's accuracy). The assessors placed the other in the *P. microphylla* / *S. chinensis*

Wooded Shrubland. No additional polygons were placed in this type (100% user's accuracy).

***S. chinensis - Opuntia engelmannii* Shrubland.** The mapper and assessor agreed on two of the three polygons (67% producer's accuracy). The assessors placed the other in the in *S. chinensis* / *Encelia frutescens* Shrubland. Three additional polygons were placed in this type, indicating that its total area was under-mapped (40% user's accuracy).

***S. chinensis - Lycium fremontii* Shrubland.** The mapper and assessor agreed on zero of the two polygons (0% producer's accuracy). The assessors placed both in *S. chinensis* Shrubland. No additional polygons were placed in this type, which was merged into a map class with the *S. chinensis* Shrubland type.

***Parkinsonia microphylla / S. chinensis - Ericameria laricifolia* Shrubland.** The mapper and assessor agreed on one of the three polygons (33% producer's accuracy). The assessors placed the other two in the floristically and structurally similar *Parkinsonia microphylla* / *S. chinensis* Shrubland association. No additional polygons were placed in this type, which was merged into a map class with the *Parkinsonia microphylla* / *S. chinensis* Shrubland type.

4 Discussion

4.1 Vegetation characterization

Overall, the vegetation at Tonto NM can be separated into a few broad categories, from most abundant to least abundant, as follows: transitional Sonoran desert scrub, semi-desert shrublands, montane shrublands, mesquite and acacia washes and woodlands, and riparian forest. The large swaths of lower alluvial fans that flow north toward Roosevelt Lake support a well-defined and consistent community in which yellow paloverde trees join with jojoba to create a wooded shrubland, interspersed only by mesquite-lined washes.

Moving upslope from the valley floor, the vegetation shifts. As the paloverde trees become less common, jojoba, globemallow, brittlebush, grasses, and subshrubs increase, eventually developing into semi-desert shrubland and grassland communities. Also, the mountain-ridge landforms become more defined, with distinct aspect shifts, and species patterns emerge. Most consistently seen is the alternating presence of the yellow paloverde - brittlebush association, embracing the southern slopes and being replaced by jojoba - button brittlebush - broom snakeweed associations on the north- and west-facing slopes.

At the monument's highest elevations—the steep, north-facing drainage slopes of Deadman's Canyon—the final shift in vegetation occurs and influences of the interior chaparral are evident, with mountain mahogany, Sonoran scrub oak, and crucifixion thorn becoming the dominant species. Only one small riparian area exists, in the Cave Canyon drainage. This drainage is primarily a spring-fed system, with limited aboveground flow supplemented by runoff and intermittent flow from rain events and snowmelt higher in the watershed.

Many of the vegetation communities at Tonto NM are dominated by jojoba, with a variety of other shrub species occupying subdominant roles depending on location and landform positions. Where not dominant, jojoba is still often present in lower numbers. Other wide-ranging and characteristic species include brittlebush, yellow paloverde, saguaro, globemallow, velvet mesquite, wolfberry, Engelmann's prickly-pear, whitethorn acacia, snakeweed, desert needlegrass, and purple threeawn.

4.2 National Vegetation Classification System placement

Of the 23 final types, only three were recognized/described within the NVC at time of writing for this report. This is an inevitability of the current NVC being under development and reflects the particular lack of preexisting NVC classes that have been defined for the Sonoran Desert ecoregion. We anticipate that many of the associations we have described for Tonto NM will fit well within the currently identified *Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance. Several others may be incorporated into the NVC group, G293 Sonoran Paloverde - Mixed cacti Desert Scrub.

Once the component associations of these alliances have been described based on additional work within the region, it would be useful to "crosswalk" the local types identified in this report into an updated report reflecting established regional types to facilitate comparisons with other lands in the Sonoran Desert. Future researchers and readers can conduct a search on the usnvc.org site (or its replacement) to ascertain the most recent placement of each association identified in this report—a process that will be ongoing for the next several years as the NVC continues to evolve.

4.3 The flora

4.3.1 Park species list

As a result of the data collection undertaken during this project and subsequent related research, the park's plant species occurrence list has been revised to include 70 families and 450 species (not including another five subspecies and varieties). This list of species is maintained and updated by SODN and available for public viewing on the Southwest Environmental Information Network

(SEINet) data portal, under the Agency Floras tab (http://swbiodiversity.org/seinet/checklists/checklist.php?cl=2543&pid=5). The SEINet list also provides links to herbarium specimens that were collected in the park and accessioned into any of the herbaria that participate in the SEINet. During this inventory effort, a total of 168 species and an additional 7 genera were observed during plot and polygon sampling combined. A full list of species recorded during this project may be found in Appendix E.

4.3.2 Global and state rarity assessment

Based on the rarity ranking system originally developed by The Nature Conservancy but now managed by NatureServe, we evaluated all the plants observed during this effort to see if any were considered rare or imperiled. The "global rank" describes each species' status globally and describes the risk of extinction, with rank G1 being critically imperiled and G5 being secure. State ranks are also on a scale of 1–5, relative to distributions and abundances within state boundaries. Eight species have a rank of G3 (Table 4-1), defined as "Vulnerable – At moderate risk of extinction due to a restricted range, relatively few populations, recent or widespread declines, or other factors" (natureserve.org). Of these, two species also had comparable state rankings of S3. More details on these ranking systems are available from the NatureServe website, http://www.natureserve.org/biodiversity-science/publications/natureserve-conservation-status-assessments-methodology-assigning.

4.4 Final products and geodatabase delivery

Both spatial and tabular data collected during this project were input into a file 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 association descriptions. Each spatial feature in the geodatabase (points and polygons) can be selected such that data listing species and their associated cover classes is displayed. Searches can be performed both forward and backward in this format, so the user can browse data by species and see all the locations, or by location and see all the species. A description of the geodatabase structure and attachment formats is given in Appendix F.

All final products, including this report and the geodatabase, are available for download and viewing from the NPS data store (IRMA link) and the NPS Vegetation Inventory website (http://science.nature.nps.gov/im/inventory/veg/products.cfm). Spatial map data products can also be viewed in Internet Explorer (http://science.nature.nps.gov/im/inventory/veg/mapviewer/mapviewer.html) by searching by park or geographic area. Data can also be requested direct from the SODN offices or accessed via the SODN website under the inventory reports tab (http://science.nature.nps.gov/im/units/sodn/digital_library.cfm).

Table 4-1. Plant species observed during mapping efforts with a global rarity rank of G3 or higher.

Scientific name	Common name	Family	Global rank/State rank
Abutilon parishii	Parish's Indian mallow	Malvaceae	G3/S3
Brickellia floribunda	Chihuahuan brickellbush	Asteraceae	G3/--
Encelia virginensis	Virgin River brittlebush	Asteraceae	G3/--
Ephedra aspera	rough jointfir	Ephedraceae	G3/--
Lycium parishii	Parish's desert-thorn	Solanaceae	G3/S3
Opuntia macrocentra	purple pricklypear	Cactaceae	G3/--
Perityle coronopifolia	crowfoot rockdaisy	Asteraceae	G3/--
Phlox tenuifolia	Santa Catalina Mountain phlox	Polemoniaceae	G3/--

4.5 Updating the map

At the time of publication, no vegetation types similar to those mapped at Tonto NM had been described and formally accepted into the NVCS. In time, however, the data from this project and others will be combined into a larger (national or regional) database and the vegetation types described herein will become "accepted," assigned an NVC code, or, in some cases, may be subsumed or changed once they are viewed within a broader context. While there are no standing expectations that funding will be available to repeat/update these map products in future years, it is recommended that efforts are made to at least update the spatial attributes of polygons to show the final NVC types, once they are available. This should be documented and applied using a simple crosswalk table.

5 Literature Cited

Albrecht, E. W., B. F. Powell, W. L. Halvorson, and C. A. Schmidt. 2007. Vascular plant and vertebrate inventory of Tonto National Monument. OFR 2007-1295. U.S. Geological Survey, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson.

Arizona Cooperative Extension (ACE). 2009. Arizona water map curriculum guide, graphic 2: physiographic provinces. http://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1501b.pdf.

Bray, J. R., and J. T. Curtis. 1957. An ordination of the upland forest communities of Southern Wisconsin. Ecological Monographs 27:325–349.

Brian, N. J. 1991. Resurvey of 1961 line intercept transects at Tonto National Monument, Arizona. Technical Report no. 38. USGS Cooperative Park Studies Unit, School of Renewable Natural Resources, University of Arizona, Tucson.

Brooks, M. L., and J. C. Chambers. 2011. Resistance to invasion and resilience to fire in desert shrublands of North America. Rangeland Ecology and Management 64(5):431–438.

Brown, D. E. 1982. Biotic communities of the American Southwest: United States and Mexico. Desert Plants 4:1–342.

Burgess, R. L. 1965. A checklist of the vascular flora of Tonto National Monument, Arizona. Journal of the Arizona Academy of Science 3:213–223.

Clarke, K. R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18:117–143.

Clarke, K. R., and R. M. Warwick. 2001. Change in marine communities: An approach to statistical analysis and interpretation. Second edition. Plymouth, U.K.: PRIMER-E.

Clarke, K. R., and R. N. Gorley. 2006. PRIMER v6: User manual/Tutorial. Plymouth, U.K.: PRIMER-E.

Comer, P., D. Faber-Langendoen, R. Evens, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J.Teague. 2003. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, Virginia.

Driscoll, R. E., and others. 1984. An ecological land classification framework for the United States. USDA Forest Service, Miscellaneous Publication 1439. U.S. Department of Agriculture, Forest Service, Washington, D.C.

Federal Geographic Data Committee (FGDC). 1997. Vegetation classification standard. http://www.fgdc.gov/ standards/projects/FGDC-standards-projects/vegetation/vegclass.pdf.

——. 2008. National Vegetation Classification Standard, Version 2. Vegetation subcommittee. FGDC Document number FGDC-STD-005-2008. http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation/NVCS_V2_FINAL_2008-02.pdf/.

Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R.Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: Terrestrial vegetation of the United States. Volume I: The National Vegetation Classification Standard. The Nature Conservancy, Arlington, Virginia.

Halvorson, W. L., and P. Guertin. 2003. Weeds in the West: Status of introduced plants in southern Arizona parks. http://sdfsnet.srnr.arizona.edu/index.php?page=datamenu&lib=2&sublib=13. Accessed September 30, 2011.

Hiett, K. L., and W. L. Halvorson. 1999. Inventory and assessment of avifauna and a monitoring protocol proposal for Tonto National Monument, Arizona. Technical Report No. 62. USGS Cooperative Park Studies Unit, School of Renewable Natural Resources, University of Arizona, Tucson.

Hubbard, J. A., C. L. McIntyre, and S. E. Studd. 2013. Status of terrestrial vegeta-

tion and soils at Tonto National Monument, 2009–2010. Natural Resource Technical Report NPS/SODN/NRTR—2013/833. National Park Service, Fort Collins, Colorado.

Ingram, M. 2000. Desert storms. Pages 41–50 *in* S. J. Phillips and P. W. Comus, eds., A natural history of the Sonoran Desert. Tucson: Arizona-Sonora Desert Museum Press.

Jenkins, P., F. Reichenbacher, K. Johnson, and A. Gondor. 1995. Vegetation inventory, classification, and monitoring for Tonto National Monument. Cooperative Park Studies Unit Technical Report 95/50. Biological Resources Division USGS, University of Arizona, Tucson.

Jennings, M. D., D. Faber-Langendoen, O. L. Loucks, R. K. Peet and D. Roberts. 2009. Standards for the associations and alliances of the U.S. National Vegetation Classification. Ecological Monographs 79(2):173–199. http://www.jstor.org/stable/40385204.

Jennings, M. D., D. Faber-Langendoen, R. K. Peet, O. L. Loucks, D. C. Glenn-Lewin, A. Damman, M. G.Barbour, R. Pfister, D. H. Grossman, D. Roberts, D. Tart, M. Walker, S. S. Talbot, J. Walker, G. S Hartshorn, G. Waggoner, M. D. Abrams, , A. Hill, M. Rejmanek. 2006. Description, documentation, and evaluation of associations and alliances within the U.S. National Vegetation Classification, version 4.5. Vegetation Classification Panel, Ecological Society of America, Washington, D.C.

Kartesz, J. T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. First edition. *In:* J. T. Kartesz and C. A. Meacham, Synthesis of the North American flora, Version 1.0. North Carolina Botanical Garden, Chapel Hill, North Carolina.

Lea, C. 2011. Vegetation classification guidelines: National Park Service vegetation inventory, version 2.0. Natural Resource Report NPS/NRPC/NRR—2011/374. National Park Service, Fort Collins, Colorado.

Lea, C., and A. C. Curtis. 2010. Thematic accuracy assessment procedures: National Park Service vegetation inventory, version 2.0. Natural Resource Report NPS/2010/NRR—2010/204. National Park Service, Fort Collins, Colorado.

Lindsay, B. A., D. G. Robinett, and F. R. Toupal. 1994. Soil survey of Tonto National Monument. U.S. Department of Agriculture, Soil Conservation Service, Tucson, Arizona.

McAuliffe, J. R. and T. R. Van Devender. 1998. A 22,000-year record of vegetation change in the north-central Sonoran Desert. Palaeogeography, Palaeoclimatology, Palaeoecology 141:253–275.

National Park Service (NPS). 2005. Sonoran Desert Network vital signs monitoring plan. Technical Report NPS/IMR/SODN-003. National Park Service. Denver, Colorado.

——. 2006. Geologic resource evaluation scoping summary: Tonto National Monument, Arizona. National Park Service, Geologic Resources Division, Denver, Colorado.

——. 2012. National vegetation inventory website. http://science.nature.nps.gov/im/inventory/veg/index.cfm

Phillips, B. G. 1992. Status of non-native plant species, Tonto National Monument, Arizona. Technical report no. 46. USGS Cooperative Park Studies Unit, School of Renewable Natural Resources, University of Arizona, Tucson.

——. 1997. History of fire and fire impacts at Tonto National Monument, Arizona. Technical report no. 59. USGS Cooperative Park Studies Unit, School of Renewable Natural Resources, University of Arizona, Tucson.

Price, P. W., and S. M. Fondriest. 1995. Terrestrial invertebrate survey of Tonto National Monument, Arizona. Department of Biological Sciences, Northern Arizona University, Flagstaff.

Sheppard, P. R., A. C. Comrie, G. D. Packin, K. Angersbach, and M. K. Hughes. 2002. The climate of the U.S. Southwest. Climate Research 21:219–238.

Studd, S. E., T. M. Mau-Crimmins, and J. Welborn. 2011. Invasive plant mapping inventory for Tonto National Monument,

2005. Natural Resource Technical Report NPS/SODN/NRTR—2011/478. National Park Service, Fort Collins, Colorado.

Swann, D. E., C. R. Schwalbe, R. C. Murray, and W. W. Shaw. 1996. An Inventory of the terrestrial vertebrates at Tonto National Monument, Arizona. Cooperative Park Studies Unit, University of Arizona, Tucson.

The Nature Conservancy and Environmental Systems Research Institute (TNC and ESRI). 1994. Standardized national vegetation classification system. Report to U.S. Department of Interior National Biological Survey and National Park Service. http://biology.usgs.gov/npsveg/ classification/index.html.

——. 1996. Methodology for assessing the utility of existing data for vegetation mapping. Report to U.S. Department of Interior, National Biological Survey and National Park Service. http://biology. usgs.gov/npsveg/existdata/index.html.

Theobald, D. M., D. L. Stevens, Jr., D. White, N. S. Urquart, A. R. Olsen, and J. B. Norman. 2007. Using GIS to generate spatially balanced designs for natural resource applications. Environmental Management 40:134–146.

United Nations Educational, Scientific and Cultural Organization (UNESCO). 1973. International classification and mapping of vegetation. UNESCO, Paris, France.

Van West, C. R., and others. 2000. Subsistence and environmental interactions. Pages 27–56 *in:* J. S. Dean, ed., Salado. Albuquerque: University of New Mexico Press.

Waters, M. R. 1998. The effect of landscape and hydrologic variables on the prehistoric Salado: Geoarchaeological Investigations in the Tonto Basin, Arizona. Geoarchaeology 13(2):105–160.

Appendix A: Vegetation Community Type Descriptions

This appendix includes information on the 23 vegetation types that were identified and mapped at Tonto National Monument between 2008 and 2010. All information not identified as specific to Tonto NM was collected from NatureServe Explorer (http://www.natureserve.org/explorer/) or from the U.S. National Vegetation Classification website (http://usnvc.org/). This includes the NatureServe or National Vegetation Classification (NVC) 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 provided in Appendix C. The dichotomous key in Appendix B was created for use in the field to determine the different associations and is based on species composition and cover values.

FOREST AND WOODLAND

Platanus wrightii - Juglans major Riparian Forest
Prosopis velutina Woodland (P)
Prosopis velutina / *Senegalia greggii* Wet Scrub

WOODED SHRUBLAND

Parkinsonia microphylla / *Simmondsia chinensis - Ericameria laricifolia* Wooded Shrubland (P)
Parkinsonia microphylla / *Simmondsia chinensis* Wooded Shrubland (P)

SHRUBLAND

Quercus turbinella / *Cercocarpus montanus* var. *glaber* Shrubland
(*Parkinsonia microphylla*) / *Encelia farinosa* Shrubland (P)
Encelia frutescens - Gutierrieza sarothrae Shrubland (P)
Simmondsia chinensis - Encelia farinosa Shrubland (P)
Simmondsia chinensis - Encelia frutescens Shrubland (P)
Cylindropuntia acanthocarpa Shrubland (P)
Parkinsonia microphylla / *Eriogonum fasciculatum - Encelia frutescens* Shrubland (P)
Canotia holocantha Shrubland (P)
Dodonaea viscosa Shrubland (P)
Simmondsia chinensis - Eriogonum wrightii Shrubland (P)
Simmondsia chinensis - Eriogonum fasciculatum Shrubland (P)
Simmondsia chinensis - Ericameria laricifolia Shrubland (P)
Simmondsia chinensis / *Selaginella arizonica* Shrubland (P)
Simmondsia chinensis - Sphaeralcea spp. Shrubland (P)
Simmondsia chinensis - Opuntia engelmannii Shrubland (P)
Simmondsia chinensis Shrubland (P)
Simmondsia chinensis - Lycium fremontii Shrubland (P)
Vachellia constricta - Mixed Shrub Shrubland (PS)

Platanus wrightii - Juglans major Riparian Forest

Translated name: Arizona sycamore - Arizona Walnut Riparian Forest
NVC name: Platanus wrightii - Juglans major Riparian Forest
Identifier: CEGL00645

NVC CLASSIFICATION

Division	*Populus fremontii - Platanus wrightii - Celtis laevigata* Southwest North American Flooded Forest Division [D013]
Macrogroup	Interior Warm & Cool Desert Riparian Forest Macrogroup [M036]
Group	*Platanus wrightii* Flooded Forest Alliance [A3801]
Association	*Platanus wrightii - Juglans major* Riparian Forest [CEGL00645]

DISTRIBUTION

Tonto National Monument

This association is found in a single spring-fed drainage which runs through Tonto National Monument.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument

The portion of the drainage that holds the riparian forest lies at approximately 1,000 m elevation, and the aspect is generally north-facing. The stream channel is only 1–3 m wide and has incised more than 1 m in depth, exposing gravelly sand in the vertical banks. The channel is covered by gravel, rock, and sand, with a fairly deep litter layer on the adjacent banks.

VEGETATION DESCRIPTION

Tonto National Monument

This riparian forest association is characterized by tall *Juglans major* (Arizona walnut) and *Platanus wrightii* (Arizona sycamore) forming a shady forest canopy over the Cave Canyon spring. *Rubus arizonensis* (Arizona dewberry) forms a thick mat at the base of the many *Celtis laevigata* var. *reticulata* (netleaf hackberry) and *Prosopis velutina* (velvet mesquite) trees growing on the surrounding slopes.

The top canopy is dominated by *Juglans major* and *Platanus wrightii*, which form a mostly closed canopy with occasional open spaces. *J. major* is dominant with an estimated cover class of 34–50%; *P. wrightii* cover is between 26 and 33%, with total estimated cover for this riparian forest stand of 65%. Height for both species averages around 14 m. *J. major* is more abundant immediately adjacent to the drainage, whereas *P. wrightii* occurs most densely at a distance from the water source. There are occasional *C. laevigata* var. *reticulata* individuals within the drainage estimated to be 5 m or taller, but these provide only trace cover in the top canopy.

The drainage edges and banks support a rich lower canopy layer in which *C. laevigata* var. *reticulata* and *P. velutina* are densely mixed as both trees and tall shrubs. Tree life-form is ascribed to individuals with one or a few discernible trunks and a tree-like canopy not reaching the ground. These are not considered to be dominant overall, however, and comprise an estimated total cover of only 5%. These two species are found throughout, well represented in the 0.5–2 m height range, and mix with numerous other shrubs, giving a total combined cover of 35%. *C. laevigata* and *P. velutina* are each estimated to make up 11–25% cover, with *Celtis* just barely dominant over *Prosopis*. Notable associates in the subcanopy are *Lycium fremontii*, *Ziziphus obtusifolia, Simmondsia chinensis*, and *Rubus arizonensis*, which are counted in both the field and the subcanopy strata depending on height, as *R. arizonensis* will grow as a vine covering existing shrubs or as a low, shrubby ground cover in thick patches along the banks.

Total field-stratum cover is about 30%, with much of this composed of *Bromus diandrus* and a number of annuals that contribute to a thick field layer beneath the canopies on either side of the bank. *R. arizonensis* and *Elymus glauca* each contribute between 1 and 5% of the total cover, but are not considered dominants.

GLOBAL TYPE CONCEPT DESCRIPTION

This riparian forest is found along perennial and seasonally intermittent streams in the foothills zone of isolated desert mountain ranges in southeastern Arizona and southwestern New Mexico. Stands occur in narrow stream valleys and on gently sloping alluvial terraces. Elevations range from 1,240 to – 1,700 m. This association requires reliable surface flow during the winter-spring months, is periodically inundated during spring runoff, and generally occurs along small, perennial streams. The Gray Ranch stand, in southwestern New Mexico, occurs on gravelly alluvium deposited among boulders derived from rhyolite alluvium parent material. These depositional soils are silty loam in texture. The tree canopy is co-dominated by the broad-leaved trees *Platanus wrightii* and *Juglans major*. Total canopy cover is over 70%, and is usually composed of a few large *Platanus wrightii* dominating the stand, with larger numbers of smaller *Juglans major* trees. Height of the canopy is typically 18–23 m. Other broad-leaved deciduous trees that may be present in some stands include *Fraxinus velutina*, *Populus angustifolia*, and *Alnus oblongifolia*. The understory has a sparse shrubby layer, with less than 10% total cover composed of saplings of *Platanus* and *Juglans* spp., and a highly variable mix of shrub species that may include *Baccharis salicifolia*, *Rhus microphylla*, and *Chilopsis linearis*. The sparse-to-moderately dense herbaceous layer may have high species diversity. At Gray Ranch, NM, the most abundant herbaceous species are the perennial grasses *Bouteloua curtipendula* (15% cover) and *Setaria grisebachii* (10% cover). Other grasses that may occur include *Leptochloa dubia, Muhlenbergia* spp., *Elymus elymoides*, and *Elymus glaucus*. Forbs are sparse, with less than 5% cover.

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	*Juglans major, Platanus wrightii*
Canopy (2–5 m)	*C. laevigata* var. *reticulata, Prosopis velutina*
Subcanopy (0.5–2 m)	*C. laevigata* var. *reticulata, Prosopis velutina*
Field (0–0.5 m)	*Bromus diandrus*, annuals

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Lycium fremontii, Ziziphus obtusifolia, Simmondsia chinensis, Rubus arizonensis*
Field (0–0.5 m)	*Rubus arizonensis, Elymus glauca*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Sambucus nigra, Mara gilensis, Gutierrezia sarothrae, Sphaeralcea* spp., *Artemisia dracunculus, Rhus trilobata, Ambrosia psilostachya*
Field (0–0.5 m)	*Erigeron divergens, Nicotiana obtusifolia, Senecio lemmonii, Stephanomeria pauciflora, Sonchus oleraceus*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from two classification plots and one mapped polygon.

Global

This association has been described from data collected in New Mexico and Arizona.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP203, IP 204
Tonto National Monument Polygons: F02
Local description authors: L. Crumbacher, S. Drake

Prosopis velutina Woodland (P)

Translated name: Velvet mesquite woodland
NVC name: N/A
Identifier: NPSSODN069

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Alliance	Mesquite Riparian Forest, Woodland and Shrubland [A.3877]
Association	*Prosopis velutina* Woodland (P)

DISTRIBUTION

Tonto National Monument

This type occurs near and around drainages in the gentle slopes of the alluvial fans of Tonto National Monument and in the wider, drier, northern end of the Cave Spring wash.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument

These woodlands occur mostly in drainages where the channels vary from ≤1 to 5 m in width; narrower drainages have more sand and gravel than rock in their channels, while wider ones are usually rockier. Gila conglomerate forms some of the walls and some Barnes conglomerate is present as large rocks in the channels. In the fans, the woodland often encompasses upland areas between two drainages.

VEGETATION DESCRIPTION

Tonto National Monument

This woodland association is characterized by a canopy dominated by *Prosopis velutina* (velvet mesquite) with common associates *Celtis reticulata, Senegalia greggii* and occasional tree-like *Parkinsonia microphylla*. Total tree cover in the 2–5 m height range is between 30 and 55% across all stands. *Prosopis velutina* always creates the majority of the cover but with a broad range (11–25% cover class to 34–50% cover class). Its height varies from 3 to 4.5 meters. *P. velutina* occupies the banks, terraces, and upland areas near drainages. Other associates have relatively low cover, (1–2%) and are not always consistent across the type. These include *Parkinsonia microphylla* and *P. florida*, *Sambucus nigra,* and *Vachellia constricta*. *Celtis laevigata* var. *reticulata* may be present in dense, forest-like patches or growing in a more dispersed fashion or it may be absent.

The subcanopy layer is usually well developed, providing an additional 15–35% cover from lower-growing shrubs and small trees (0.5–2 m tall). *Senegalia greggii* is a common species that may create thickets in the narrow drainages or on terraces in wider channels. In one stand it is a subcanopy dominant; in others just a minor associate. *Simmondsia chinensis* may be found on slopes above drainages in thick patches—and can grow very tall in some woodlands. *Celtis pallida* and *Ziziphus obtusifolia* are observed infrequently along the banks and terraces. Several other subcanopy shrubs may be present, though not consistently across all stands of this association. These include *Lycium fremontii*, *Encelia frutescens, E. farinosa, Isocoma acradenia, Baccharis sarothroides, B. salicifolia, Ericameria laricifolia, Porophyllum gracile,* and others. *Artemisia dracunculus* and *Hymenoclea salsola* may be found in the drainage bottoms in usually trace amounts.

Field-stratum cover is sparse, at 1–5%, and generally consists of non-native grasses, annual forbs, and a few bunchgrasses, though *Aristida purpurea* is a common associate. *Bromus rubens* and *Bromus diandrus* are found near the drainages; *B. diandrus* especially common on the shaded terraces and uplands.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Prosopis velutina, Parkinsonia microphylla*
Subcanopy (0.5–2 m)	*Senegalia greggii, Hymenoclea salsola, Simmondsia chinensis, Celtis laevigata* var. *reticulata*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Parkinsonia florida, Acacia constricta, Celtis laevigata* var. *reticulata, Sambucus nigra*
Subcanopy (0.5–2 m)	*Ziziphus obtusifolia, Lycium fremontii, Acacia greggii, Baccharis sarothroides, Hymenoclea salsola, Simmondsia chinensis, Artemisia dracunculus, Marah gilensis*
Field (0–0.5 m)	*Bromus rubens, Bromus diandrus, Aristida purpurea, Elymus glaucus, Eragrostis curvula* var. *confertiflora*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Juniperus monosperma, Phoradendron* sp.
Subcanopy (0.5–2 m)	*Atriplex canescens, Artemisia ludoviciana, Bebbia juncea, Brickellia coulteri, Eriogonum fasciculatum, Ericameria laricifolia, Encelia farinosa, Encelia frutescens, Isocoma acradenia, Porophyllum gracile, Galium stellatum, Stephanomeria pauciflora, Sphaeralcea ambigua,*
Field (0–0.5 m)	*Dichelostemma capitatum, Cynodon dactylon, Achnatherum speciosum, Gutierrezia sarothrae, Chamaesyce* sp.

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from two classification plots and four field-mapped polygons.

Global

At the time of writing, the alliance concepts within the USNVC program and available via the usnvc.org website are in flux. Most are underdeveloped and many are acting as placeholders and do not have detailed descriptions nor have associations under them. It is unclear where the herein-described mesquite woodland could or should best be placed within the current structure. A.3877, Mesquite Riparian Forest, Woodland and Shrubland alliance, falls within the North American Warm Desert Riparian Low Bosque and Shrubland Group [G533], which includes areas with riparian influences from perennial or intermittent streams and would fit with the stands mapped at Tonto even though dominant species listed do not match well other than the *P. velutina*. This alliance is listed as the best fit and it is anticipated that as more data are incorporated into the NVC hierarchy, the descriptions will be

expanded to better represent this park's vegetation. The description of vegetation is described entirely from data observations made at the monument.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP085, IP099
Tonto National Monument Polygons: W03, W05, W06, W07
Local description authors: B. Fallon, S. Studd

Prosopis velutina - Senegalia greggii Wet Scrub

Translated name: Velvet mesquite - Catclaw acacia Wet Scrub
NVC name: *Prosopis velutina - Senegalia greggii* Wet Scrub
Identifier: CEGL005340

NVC CLASSIFICATION

Division	*Prosopis glandulosa / Typha domingensis - Schoenoplectus pungens* Southwestern North American Warm Desert Freshwater Marsh & Bosque Division [D032]
Macrogroup	Warm Desert Lowland Freshwater Marsh, Wet Meadow & Shrubland [M076]
Group	*Prosopis glandulosa - Prosopis velutina - Baccharis* spp. North American Warm Desert Riparian Low Bosque & Shrubland Group [G533]
Alliance	*Prosopis glandulosa - Prosopis velutina - Prosopis pubescens* Wet Scrub Alliance [A3877]
Association	*Prosopis velutina - Senegalia greggii* Wet Scrub [CEGL005340]

DISTRIBUTION

Tonto National Monument
This type is found in both of the main drainages at Tonto NM (Deadman's Canyon and Cave Canyon).

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This vegetation association occurs in the narrow, rocky-bottomed, open channels of drainages in the canyons of Tonto National Monument. The drainages are sometimes only a few meters wide, with the slopes of high ridges ascending above. In some areas, the canyons are bordered by sheer walls cut into the conglomerate. In other areas, the surrounding mountainsides slope more gently into the channel. Surface cover is a mixture of sand, gravel, and rock, with some bedrock exposures. The association occurs at 670–900 meters in elevation.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized by low-growing and wide-spreading *Prosopis velutina* (velvet mesquite) across open drainage bottoms dominated by rock and sand. The surrounding high-cut terraces and walls host a mixed community of shrubs, including *Senegalia greggii* (catclaw acacia). Tree cover is low in these exposed canyon bottoms, generally 10–15% total. *Prosopis velutina* comprises 6–10% cover and is 2.5–3 meters tall. *Parkinsonia microphylla* (foothill or littleleaf paloverde) may be a co-dominant tree. Other tree species possibly present include *Parkinsonia florida* (blue paloverde), *Celtis laevigata* var. *reticulata* (netleaf hackberry) and *Sambucus nigra* (black elderberry). The trees occur primarily on the terraces or rocky islands sitting above the bottom of the drainages, and are generally well-spaced.

Subcanopy cover is about 20%. Species composition varies as a reflection of the surrounding slopes. *Senegalia greggii* is prevalent, but only generates 1–10% cover. *Simmondsia chinensis* may provide about as much cover as *Senegalia*, particularly on the steep walls and terraces. *Bebbia juncea* commonly grows in the drainage bottoms, while *Brickellia atractyloides* prefers the rocky sides. A variety of other shrub species may be present, again reflective of the adjacent communities.

Some perennial forbs, subshrubs, and vines occur on the rocky channel floors. Bunchgrasses, such as *Bouteloua curtipendula*, *Eragrostis lehmanniana* (NN), and *Eragrostis curvula* var. *confertiflora* (NN) grow in the rocky islands that are present in wider areas of the drainages.

Global Description (Data are only from one other location in AZ).

This riparian woodland is described from southern Arizona. Plot data from Buenos Aires National Wildlife Refuge (NWR) indicate an elevational range of 970–1,030 m (3,200–3,700 feet) where it is found on gentle slopes along drainages and in floodplains on valley floors. The alluvial soils are variable and range from sand to clay textures. The vegetation is characterized by a moderately dense to dense tree canopy co-dominated by *Prosopis velutina* and *Senegalia greggii*. Scattered short shrubs may be present but are generally not dense enough to form strata. Common shrubs may include *Baccharis emoryi*, *Baccharis sarothroides*, *Calliandra eriophylla*, *Celtis pallida*, *Lycium andersonii, Mimosa aculeaticarpa* var. *biuncifera (= Mimosa biuncifera)*, *Mimosa dysocarpa*, and *Opuntia spinosior*. The open to dense (20–80% cover) herbaceous layer is dominated by a mixture of grasses and forbs. The native annual forb *Amaranthus palmeri* may be present but does not co-dominate the herbaceous layer. Associated herbaceous species include *Aristida ternipes*, *Boerhavia* spp., *Bouteloua aristidoides*, *Bouteloua curtipendula*, *Chloris virgata*, *Digitaria californica*, *Ipomoea hederacea*, *Kallstroemia grandiflora*, *Panicum hirticaule*, *Proboscidea parviflora*, and *Tidestromia lanuginosa*. If present, *Eragrostis lehmanniana* cover is low, with less than 25% cover and less than a third of the total perennial graminoid cover.

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Prosopis velutina, Parkinsonia microphylla*
Subcanopy (0.5–2 m)	*Senegalia greggii, Simmondsia chinensis*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Lycium fremontii, Bebbia juncea, Brickellia atractyloides, Phoradendron californicum, Gutierrezia sarothrae, Encelia frutescens, Artemisia ludoviciana, Aloysia wrightii*
Field (0–0.5 m)	*Bouteloua curtipendula, Aristida purpurea*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Nicotiana obtusifolia, Baccharis sarothroides, Ambrosia salsola, Encelia farinosa, Artemisia dracunculus, Brickellia californica, Brickellia coulteri, Dodonaea viscosa, Keckiella antirrhinoides, Lotus rigidus*
Field (0–0.5 m)	*Maurandella antirrhinflora, Muhlenbergia porteri, Aristida ternipes, Bothriochloa barbinodis, Bromus diandrus, Eragrostis lehmanniana, Eragrostis curvula* var. *confertiflora, Funastrum cyanchoides, Erigeron divergens, Convolvulus equitans, Mirabilis laevis, Linanthus bigelovii, Stephanomeria pauciflora, Erysimum capitatum, Glandularia bipinnatifida, Ephedra aspera, Bromus diandrus* (NN), *Eragrostis lehmanniana* (NN), *Eragrostis curvula* var. *confertiflora* (NN)

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from two field-mapped polygons.

Global

This type is considered to be very similar to CEGL005340, *Prosopis velutina* / *Senegalia greggii* Wet Scrub, as described from Buenos Aires NWR, but also drawing on descriptions from other mapping projects completed in low desert areas of southwestern Arizona. As such, this description does not match entirely with the data from Tonto NM but bears enough ecological similarity to be thought the same, pending revision of the NVC type with new influxes of data. The NVC types are still undergoing development, and revision will continue for many years. Several NVC types are currently only described from one area and, therefore, do not actually represent the vegetation as it occurs across its entire range.

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

ELEMENT SOURCES

Tonto National Monument Plots: None
Tonto National Monument Polygons: WS14, WS15
Local description authors: B. Fallon, S. Studd

Parkinsonia microphylla / Simmondsia chinensis - Ericameria laricifolia Wooded Shrubland (P)

Translated name: Yellow paloverde / Jojoba - Turpentine bush Wooded Shrubland
NVC name: N/A
Identifier: NPSSODN085

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Parkinsonia microphylla / Simmondsia chinensis - Ericameria laricifolia* Wooded Shrubland (P)

DISTRIBUTION

Tonto National Monument

This type is found in the northern half of the monument, and covers large swaths of alluvial fan landforms. These map units are bisected by the highway.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This association occurs on the alluvial fan system. The slope position varies from foot to toeslope with approximately 6–16% grade. The alluvial slopes have moderate to high gravel and rock cover, and the rocks are angular in nature. These slopes have an overall northern aspect, but with northwestern trending portions. Minor drainages cut north–south through stands of this type, draining toward Roosevelt Lake.

VEGETATION DESCRIPTION

Tonto National Monument

This wooded shrubland association cover is characterized by 2–3 m tall *Parkinsonia microphylla* trees (yellow paloverde), over a shorter layer (<2 m) dominated by *Simmondsia chinensis* (jojoba) with the consistent common associate shrub *Ericameria laricifolia* (turpentine bush). Other various mixed-shrub patches and herbaceous associates are present. The vegetation has an open, park-like structure, with widely spaced, large and round shrubs (often in patches) and well-spaced trees. The *P. microphylla* act as shelter for many other species, with the field stratum in general having sparse cover or mostly composed of low-growing seasonal annuals.

Tree cover generally ranges from 15 to 17% in the 2–5 meter canopy, clearly dominated by *Parkinsonia microphylla* (10–15% cover), with individual canopies often as broad as, or broader than, the height of the plant. For these individuals, canopy base height is often 0.75 m or more. Small shrubs and annuals occur under their canopies. *Prosopis velutina* is an associate tree (2–3% cover) with an irregular distribution in the upland areas of the fans, being found more reliably near drainages, where *P. microphylla* also becomes denser. *Carnegiea gigantea* is usually present in small numbers. *Senegalia greggii*, and occasionally *Ziziphus obtusifolia* (lotebush) and *Celtis ehrenbergiana* (spiny hackberry), may fill in narrow drainages. *Parkinsonia florida* (blue paloverde) can be present in low numbers.

Total subcanopy cover (0.5–2 m) is about 35%, dominated by *Simmondsia chinensis* with consistent distribution and cover between 15 and 25%. *S. chinensis* here is a relatively large shrub, to 2 m or more in height and width. Other associates vary somewhat depending on aspect shifts and topographic position. This association is most often seen where the fans tend to the northwest (generally west of the bottom section of Cave Canyon drainage), where the slopes become less steep and are described as the lower alluvial outflow sections of the fan. *Ericameria laricifolia* (turpentine bush) is a characteristic sub-dominant in this association. As a low shrub, *E. laricifolia* usually generates 6–10% cover (more in one stand) and seems to readily colonize old disturbed areas, sometimes growing in almost homogeneous patches on old road cuts and along fence lines.

Diversity of less-common associate shrubs is generally high, with 10 or more species present, but there may be fewer. These can include *Lycium fremontii, L. pallidum, Krameria grayi, Opuntia engelmannii, Ferocactus wislizeni, Encelia farinosa, E. frutescens, Eriogonum wrightii, Larrea tridentata, Ziziphus obtusifolia, Cylindropuntia fulgida, Brickellia coulteri* and others.

Grass species commonly found in the field stratum include *Aristida purpurea*, *Bouteloua curtipendula*, and *Eragrostis lehmanniana*, but none accounts for significant cover. Forb cover and diversity may be substantial in wet seasons.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Parkinsonia microphylla*
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Ericameria laricifolia*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Prosopis velutina*
Subcanopy (0.5–2 m)	*Lycium fremontii, L. pallidum, Senegalia greggii, Encelia frutescens, Krameria grayii, Encelia farinosa, Celtis pallida, Ziziphus obtusifolia, Opuntia engelmannii, Opuntia acanthocarpa, Marah gilensis, Sphaeralcea* sp.*, Ferocactus wislezenii, Gutierrezia sarothrae*
Field (0–0.5 m)	*Aristida purpurea, Porophyllum gracile, Senna covesii, Adenophyllum porophylloides, Chamaesyce* sp.*, Dichelostemma capitatum*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	*Carnegia gigantea*
Canopy (2–5 m)	*Acacia constricta, Juniperus coahuilensis, Ziziphus obtusifolia, Parkinsonia florida, Carnegia gigantea*
Subcanopy (0.5–2 m)	*Opuntia phaeacantha, Vachellia constricta, Encelia virginensis, Larrea tridentata, Cylindropuntia fulgida, Brickellia coulteri, Eriogonum fasciculatum, Eriogonum wrightii, Cuscuta indecora, Opuntia leptocaulis*
Field (0–0.5 m)	*Eragrostis curvula* var. *confertiflora, Bouteloua curtipendula, Eragrostis lehmanniana, Bromus rubens, Echinocereus fendleri, Echinocereus engelmannii, Janusia gracilis, Krameria erecta, Krameria grayi*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from one classification plot and three mapped polygons. This association was merged into a map class with the very similar *Parkinsonia microphylla* / *Simmondsia chinensis* Wooded Shrubland association. This association differs from that one in having the common associate *Ericameria laricifolia* and in the composition of some of the other species present, but the dominant shrubs and trees are very similar.

Global

More classification is needed to fully describe this type globally.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP080
Tonto National Monument Polygons: WS02, WS04, WS05
Local description authors: S. Studd

Parkinsonia microphylla / Simmondsia chinensis Wooded Shrubland (P)

Translated name: Paloverde - Jojoba Wooded Shrubland
NVC name: N/A
Identifier: NPSSODN075

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Parkinsonia microphylla / Simmondsia chinensis* Wooded Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type, found in the northern half of the monument, covers large swaths of alluvial fan landforms. These map units are bisected by the highway.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This association occurs on the alluvial fan system that occupies the northern half of the monument. The slope position varies from foot to toeslope, with approximately 6–16% grade. The alluvial slopes have moderate to high gravel and rock cover, and are angular in nature. These slopes have an overall northern aspect, but with northeastern-trending portions. Minor drainages cut north–south through stands of this type, draining toward Roosevelt Lake.

VEGETATION DESCRIPTION

Tonto National Monument
This widespread wooded shrubland association is characterized by 2–3 m tall *Parkinsonia microphylla* trees, over a shorter layer (<2 m) dominated by *Simmondsia chinensis* with various mixed-shrub patches and herbaceous associates. The vegetation has an open, park-like structure, with widely spaced, large and round shrubs (often in patches) and well-spaced trees. The *P. microphylla* act as shelter for many other species, with the field stratum in general having sparse cover or being composed mostly of low-growing seasonal annuals.

Tree cover generally ranges from 15 to 17% in the 2–5-meter canopy, clearly dominated by *Parkinsonia microphylla* (10–15% cover) with individual canopies often as broad as, or broader than, the height of the plant. For these individuals, canopy base height is often 0.75 m or more. Small shrubs and annuals occur under their canopies. *Prosopis velutina* is an associate tree (2–3% cover) with an irregular distribution in the upland areas of the fans, being found more reliably near drainages, where *P. microphylla* also becomes denser. *Carnegiea gigantea* is usually present in small numbers. *Senegalia greggii*, and occasionally *Ziziphus obtusifolia* (lotebush) and *Celtis ehrenbergiana* (spiny hackberry) may fill in narrow drainages. *Fouquieria splendens* and/or *Parkinsonia florida* can be present in low numbers.

Total subcanopy cover (0.5–2 m) is about 35%, dominated by *Simmondsia chinensis* with consistent distribution and cover between 15 and 25%. *S. chinensis* here is a relatively large shrub, to 2 m or more in height and width. Other associates vary somewhat depending on aspect shifts and topographic position. On these higher-elevation portions of the alluvial fan (east of both the entrance road and the main drainage), the low shrub, *Encelia farinosa*, is the most common associate, generally with 1–10% cover. *Lycium fremontii* and *Encelia frutescens* are both fairly well distributed, albeit with low abundance. Less-common associate shrubs can include *Encelia frutescens, Opuntia engelmannii, O. bigelovii, O. acanthocarpa, Eriogonum fasciculatum, Larrea tridentata, Ericameria laricifolia, Canotia holacantha, Fouquieria splendens, Keckiella antirrhinoides, Mirabilis bigelovii*, or others. Field-stratum cover is very sparse, around 1%, due to the rocky substrate. *Aristida purpurea* is the most common grass species; seasonal forbs may be present. **Note:** In one area with a series of low hills and shallow drainages, *P. microphylla*

cover is reduced to ~3% and *Lycium fremontii* becomes the sub-dominant species, occurring frequently and consistently alongside the *S. chinensis*.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Parkinsonia microphylla*
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Encelia farinosa*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	*Carnegia gigantea*
Canopy (2–5 m)	*Prosopis velutina, Fouquieria splendens*
Subcanopy (0.5–2 m)	*Eriogonum fasciculatum, Cylindropuntia acanthocarpa, Cylindropuntia bigelovii, Lycium fremontii, Senegalia greggii, Celtis ehrenbergiana, Sphaeralcea* spp.*, Mirabilis laevis, Ericameria laricifolia*
Field (0–0.5 m)	*Aristida purpurea, Porophyllum gracile, Senna covesii, Dichelostemma capitatum*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Dodonaea viscosa, Canotia holocantha*
Subcanopy (0.5–2 m)	*Larrea tridentata, Opuntia engelmannii, Parkinsonia florida, Marah gilensis, Keckiella antirrhinoides, Encelia frutescens, Ephedra aspera, Ziziphus obtusifolia, Stephanomeria pauciflora, Ferocactus cylindraceus, Carnegia gigantea*
Field (0–0.5 m)	*Acourtia wrightii*, *Eragrostis curvula* var. *confertiflora, Bouteloua curtipendula, Eragrostis lehmanniana, Bromus rubens, Echinocereus fendleri, Echinocereus engelmannii, Janusia gracilis, Krameria erecta, Krameria grayi*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from two classification plots and four field-mapped polygons.

Global
The USNVC currently has a placeholder association *Simmondsia chinensis - Parkinsonia microphylla* Shrubland, but it does not include any description and is pending more data to expand it.

The association as described solely from data collected at Tonto NM may eventually be placed within this section of the hierarchy that falls under Group 293, *Carnegiea gigantea - Parkinsonia microphylla - Ambrosia deltoidea* Mixed Cacti Desert Scrub Group. More classification is needed to fully describe this type.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP028, IP090
Tonto National Monument Polygons: WS06, WS07, WS08, S89
Local description authors: L. Crumbacher, S. Studd

Quercus turbinella - Cercocarpus montanus var. *glaber* Shrubland

Translated name: Sonoran scrub oak - Birchleaf mountain mahogany Shrubland
NVC name: *Quercus turbinella - Cercocarpus montanus* Shrubland
Identifier: CEGL000979

NVC CLASSIFICATION

Division	Western North American Interior Chaparral Division [2.B.2.Nd]
Macrogroup	Warm Interior Chaparral Macrogroup [M091]
Group	*Quercus turbinella - Ceanothus greggii - Arctostaphylos pungens* Chaparral Group [G281]
Alliance	*Quercus turbinella* Alliance [A0793]
Association	*Quercus turbinella - Cercocarpus montanus* var. *glaber* Shrubland (CEGL000979)

DISTRIBUTION

Tonto National Monument

This type is found in one stand at Tonto National Monument, located along the ridge above the upper ruins, in the southwest corner of the monument.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument

This vegetation type is found on a north- to northwest-facing backslope, crest, and footslope of a mountain between 1,000 and 1,200 m in elevation. The ground cover is primarily rock of 0.2–0.4 meters in diameter.

VEGETATION DESCRIPTION

Tonto National Monument

This shrubland association is characterized by dominance of tall *Cercocarpus montanus* var. *glaber* shrubs. These grow densely near the ridge summit but are present throughout the stand, thinning out into the shorter scrub of *Quercus turbinella* on the lower slope and reemerging on the steepening footslope. Total tall-shrub canopy cover is estimated to be approximately 15%, with 6–10% cover of *C. montanus* var. *glaber*. The shorter subcanopy, dominated by *Q. turbinella* but with over a dozen other shrub species present, comprises 35% total cover. *Q. turbinella* forms thick patches throughout the community, especially in the areas where *C. montanus* is generally tall. *Gutierrezia sarothrae* is a common associate, appearing as a low-growing shrub, present everywhere, but increasing in cover at the mid-slope, where the grade decreases and *Q. turbinella* becomes less dense. *Fraxinus anomala* and *Rhus ovata* are present with 1–5% cover.

Other common associates in the subcanopy are *Canotia holacantha, Eriogonum wrightii,* and *Simmondsia chinensis*, each with an estimated 1–5% cover. The field stratum is sparse, with only 10% total cover, made up of several species of bunchgrass; no species clearly dominates the stratum. *Bouteloua curtipendula, Aristida purpurea, Eragrostis secundiflora* var. *oxylepis*, and *Achnatherum speciosum* are estimated to each contribute 1–5% cover. A few scattered *Juniperus coahuilensis* and *J. monosperma* trees are present in the stand.

Global

While the *Quercus turbinella - Cercocarpus montanus* Shrubland association (CEGL000989) is accepted within the USNVC, there is no currently available written description. However, its presence within the central highlands transition zone province is considered certain. The USNVC Group detail report is available for the *Quercus turbinella - Ceanothus greggii - Arctostaphylos pungens* Chaparral Group (G281) and *Quercus turbinella* Chaparral Alliance (A0793); both are directly cited below.

(G281): This upland shrubland group is characterized by Sierra Madre Occidentale evergreen sclerophyllous indicator species that may be present to dominant. These diagnostic species include evergreen shrubby oaks, such as *Quercus turbinella, Quercus toumeyi,* and, in western Mojave stands, *Quercus cornelius-mulleri* and *Quercus john-tuckeri*, as well as many other diagnostic species, including *Arctostaphylos glauca, Arctostaphylos pringlei,*

Cercocarpus montanus var. *glaber (= Cercocarpus betuloides)*, *Cercocarpus montanus* var. *paucidentatus*, *Ceanothus greggii, Garrya flavescens, Garrya wrightii*, and *Rhus ovata*. Additional characteristic species include *Arctostaphylos patula, Juniperus californica, Nolina parryi*, and *Rhus trilobata*.

(A0793): This alliance includes evergreen shrublands dominated or co-dominated by *Quercus turbinella* that typically forms thickets with other shrubs. Important shrub associates can include *Arctostaphylos* spp., *Ceanothus greggii, Cercocarpus montanus, Coleogyne ramosissima, Ephedra viridis*, *Fraxinus greggii, Garrya wrightii, Juniperus osteosperma, Rhus virens, Rhus trilobata, Rhus microphylla*, and a shrub form of *Quercus grisea*. Ground cover is typically sparse, with scattered grasses, forbs, and ferns. Some typical herbaceous components include *Aristida* spp., *Astrolepis sinuata (= Notholaena sinuata)*, *Bouteloua curtipendula*, *Bouteloua eriopoda*, 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 in limestone canyons, in the mountains of Nevada, Arizona, New Mexico, and western Texas.

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Stratum	Species
Canopy (> 5 m)	Canopy > 5m	--
Canopy (2–5 m)	Canopy 2 -5 m	*Cercocarpus montanus*
Subcanopy (0.5–2 m)	Subcanopy 0.5 – 2 m	*Quercus turbinella, Gutierrezia sarothrae*
Field (0–0.5 m)	Field 0 – 0.5m	*Bouteloua curtipendula, Aristida purpurea*

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Fraxinus anomala, Rhus ovata, Juniperus monosperma, Juniperus coahuilensis*
Subcanopy (0.5–2 m)	*Arenaria masalcradenia, Canotia holacantha, Ceanothus greggii, Dasylirion wheeleri, Eriogonum fasciculatum, Ericameria laricifolia*
	Eriogonum wrightii, Lycium fremontii, Lycium pallidum, Nolina microcarpa, Rhamnus ilicifolia, Rhus trilobata, Salvia pinguifolia, Simmondsia chinensis
Field (0–0.5 m)	*Achnatherum speciosum*, *Aristida ternipes, Bothriochloa barbinodis, Eragrostis lehmanniana (NN), Eragrostis secundiflora* var. *oxylepis (NN), Erysimum capitatum, Muhlenbergia porteri, Leptochloa dubia*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Salvia pinguifolia*
Field (0–0.5 m)	*Ambrosia psilostachya*, *Agave chrysantha, Bromus rubens* (NN), *Corydalis aurea, Erigeron divergens, Leptochloa dubia, Melampodium leucanthum, Muhlenbergia emersleyi, Pellaea* spp., *Selaginella arizonica*

CLASSIFICATION COMMENTS

Tonto National Monument

This local description is based solely on data collected during this inventory project. It is based on data from two classification plots and one ground-mapped polygon.

Global

This association is thought to fall under A0793, *Quercus turbinella* Shrubland Alliance. At this time, there are no described associations under this alliance. However, the geographic references match, as do the dominant species.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP20, IP22
Tonto National Monument Polygons: S58
Local description authors: L. Crumbacher, S. Drake, S. Studd

(*Parkinsonia microphylla*) / *Encelia farinosa* Shrubland (P)

Translated name: (Yellow paloverde) / Brittlebush Shrubland
NVC name: N/A
Identifier: NPSSODN072

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	(*Parkinsonia microphylla*) / *Encelia farinosa* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This is a common and widely distributed vegetation type at Tonto National Monument. This type is found in the southern half of the monument, across broad swaths of steep slope in the mountain areas.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
Location of this vegetation type within Tonto NM is apparently aspect-determined; it occurs almost exclusively on southeast-facing slopes, rarely on southwest or southern aspects below elevations of 1,200 meters, generally between 900 and 1,000 m. Exposed rock and gravel comprise the majority of surface cover. The loose substrate is generally colluvially deposited and of sedimentary origin. Stromatolites may be common. Slope varies greatly. It is always greater than 15% but may be greater than 50%.

VEGETATION DESCRIPTION

Tonto National Monument
This proposed shrubland association is characterized by occasional *Carnegia gigantea* and more frequent *Parkinsonia microphylla* dotting a deep red, rocky landscape dominated by *Encelia farinosa*, usually with 7–10 or more associate shrub species present.

Over all stands of this association, *Parkinsonia microphylla* comprises 2–12% canopy cover (average 7%) at a scrubby height of 2–3 m. *P. microphylla* can take the habit of a tree or a shrub, often both in the same area. Tree-form *P. microphylla* has one to several trunks, splitting at or near ground level, and a canopy often as broad as, or broader than, the height of the plant. For these tree forms, the canopy base height is often 0.75 m or more. Shrub-by *P. microphylla* is usually shorter than its tree-form counterpart and has a very low (or no) canopy base height, with branches touching to the ground. *Carnegia gigantea* and *Fouquieria splendens* occurrence is most common in conjunction with *P. microphylla*, but their density is low.

In the subcanopy (0.5–2 m height), the dominant stratum, total vegetative cover generally ranges from 25 to 35%, but may reach up to 40%. *Encelia farinosa* creates the majority of shrub cover, ranging from 11 to 25%. *E. farinosa* occurs as a loosely distributed but consistently occurring low shrub. In some areas, *E. farinosa* occurs with co-dominants *E. frutescens* or *Simmondsia chinensis*. In these areas, *E. farinosa* cover may be limited to 6–10%. A very mixed association of shrubs adds to the subcanopy diversity, but only a few add a significant amount to the total cover. The most common associate species include *Opuntia bigelovii*, *Lycium fremontii*, *Gutierrezia sarothrae*, *Eriogonum fasciculatum*, lower-growing *Parkinsonia microphylla*, *Opuntia engelmannii*, and *Bebbia juncea*, though only some may occur in a given stand. Seven to ten or more other shrub species may be present with trace cover. *O. bigelovii* occurrence in Tonto NM is nearly unique to this vegetation type and the closely related *Simmondsia chinensis - Encelia farinosa* shrubland association.

Selaginella arizonica is a variable dominant in the field layer, in some stands creating 12–20% ground cover, while sparse or absent in others. It is most abundant in areas of higher elevation. Apart from *Selaginella*, the field

stratum is sparse, with 1–5% cover. Common species include *Aristida*, *purpurea*, *Mammillaria grahamii*, *Melampodium leucanthum*, *Adenophyllum porophylloides*, *Porophyllum gracile*, *Chaemaesyce* sp., *Mirabilis laevis*, *Dichelostemma capitatum*, *Dudleya* sp., *Agave chrysantha*, *Echinocereus engelmannii*, and *Stephanomeria pauciflora*.

This vegetation association resembles the *Simmondsia chinensis* / *Encelia farinosa* shrubland association. It differs in having the consistent *Parkinsonia microphylla* component (even when it has low cover, it is present locally), giving these stands a more wooded shrubland structure, greater diversity, and a stronger succulent presence.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Parkinsonia microphylla*
Subcanopy (0.5–2 m)	*Encelia farinosa, Simmondsia chinensis, Encelia frutescens*
Field (0–0.5 m)	*Selaginella arizonica*

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	*Carnegia gigantea*
Canopy (2–5 m)	*Carnegia gigantea, Fouquieria splendens, Prosopis velutina*
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Opuntia bigelovii, Encelia frutescens, Sphaeralcea* sp., *Opuntia acanthocarpa, Eriogonum fasciculatum, Galium stellatum, Janusia gracilis, Opuntia engelmannii, Acacia greggii, Bebbia juncea, Ferocactus wislizeni, Lycium fremontii*
Field (0–0.5 m)	*Aristida, purpurea, Mammillaria grahamii, Melampodium leucanthum, Adenophyllum porophylloides, Porophyllum gracile, Chamaesyce* sp., *Mirabilis laevis, Dichelostemma capitatum, Dudleya* sp., *Agave chrysantha, Echinocereus engelmannii, Stephanomeria pauciflora*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Parkinsonia florida*
Subcanopy (0.5–2 m)	*Matelea parvifolia, Yucca baccata, Brickellia coulteri, Aloysia wrightii, Dodonaea viscosa, Berberis fremontii, Dasylirion wheeleri, Hyptis emoryi*
Field (0–0.5 m)	

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from six classification plots and ten mapped polygons.

Global

This association is not currently represented within the USNVC system. However, it is thought that eventually, with more data, it would likely be incorporated under the *Encelia farinosa* Shrubland Alliance (A4215), which is under the Mojave - Sonoran Bajada and Valley Desert Scrub Group (G295). Due to the position of Tonto at the edge of the Sonoran Desert influence and lower edge of the interior chaparral influence, it could also be seated within the Sonoran - Paloverde - Mixed Cacti Desert Scrub Group (G293). More classification is needed to fully describe this type.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP005, IP016, IP048, IP066, IP096, IP222
Tonto National Monument Polygons: S11, S20, S31, S33, S42, S45, S50, S69, S77, S81
Local description authors: S. Studd, B. Fallon

Encelia frutescens - Gutierrezia sarothrae Shrubland (P)

Translated name: Button brittlebush - Broom snakeweed Shrubland
NVC name: N/A
Identifier: NPSSODN071

NVC CLASSIFICATION

Division --
Macrogroup --
Group --
Association *Encelia frutescens - Gutierrezia sarothrae* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found in the southeast corner and central portions of the monument.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland is located on the upper backslopes, shoulders, and crests of north-trending ridges, at elevations of 800–1,000 m. Slope ranges from 15% to more than 50%. Ground cover is a mix of rock, bedrock, and gravel, with rock and gravel commonly the most prominent cover.

VEGETATION DESCRIPTION

Tonto National Monument
This proposed shrubland association is characterized as an *Encelia frutescens - Gutierrezia sarothrae* low-growing shrubland, with many common associate shrubs creating high overall diversity but each species having relatively low cover. *Encelia frutescens* and *Gutierrezia sarothrae* have consistent cover, in the range of 6–15% each, in all mapped examples of this community. With all species combined, the subcanopy layer (0.5–2 m height) has total cover of around 30%. There are multiple common associates with 1–2 (up to 5)% cover usually present, including *Simmondsia chinensis*, *Eriogonum fasciculatum*, *Sphaeralcea* spp., *Dasylirion wheeleri*, *Opuntia engelmannii, Aloysia wrightii, Dodonaea viscosa, Bebbia juncea, Canotia holacantha, Senegalia greggii, Parkinsonia microphylla, Encelia farinosa, Lycium fremontii, Fouquieria splendens, Quercus turbinella, Ericameria laricifolia, Dalea formosa, Rhus ovata, Agave chrysantha,* and others.

Tree cover is low and variable, but not more than 5% and most consistently provided by *Prosopis velutina* (velvet mesquite). Occasional *Canotia holacantha, Parkinsonia microphylla,* or *Senegalia greggii* are recorded. The field stratum (<0.5 m tall), is generally 2–5% cover, ranging up to15%, and comprises a diverse mix of grasses and small shrubs, succulents, or herbaceous perennials. Here again, the species list is diverse, with no single species appearing consistently dominant in the field stratum. Where cover is relatively high (15%), *Eragrostis lehmanniana* may be dominant.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Encelia frutescens, Gutierrezia sarothrae*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Prosopis velutina*
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Eriogonum fasciculatum, Lycium fremontii, Sphaeralcea* spp.*, Dasylirion wheeleri, Dodonaea viscosa, Aloysia wrightii, Bebbia juncea, Sphaeralcea rusbyi, Senecio flaccidus*
Field (0–0.5 m)	*Eragrostis lehmanniana, Aristida purpurea, Bouteloua curtipendula*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	*Carnegiea gigantea*
Canopy (2–5 m)	*Canotia holacantha, Parkinsonia microphylla, Senegalia greggii, Phoradendron californicum, Juniperus coahuilensis, Fouquieria splendens*
Subcanopy (0.5–2 m)	*Acourtia wrightii, Opuntia chlorotica, Cylindropuntia acanthocarpa, Opuntia phaeacantha, Opuntia engelmannii, Sphaeralcea* spp.*, Acacia greggii, Yucca baccata, Ericameria laricifolia, Rhus ovata, Agave chrysantha, Encelia farinosa, Canotia holacantha, Dalea formosa, Keckiella antirrhinoides, Lotus rigens, Quercus turbinella, Galium stellatum*
Field (0–0.5 m)	*Melampodium leucanthum, Eragrostis curvula,* var. *conferta, Agave chrysantha, Dudleya* sp.*, Heteropogon contortus, Dichelostemma capitatum, Castilleja* sp.*, Mirabilis laevis, Echinocereus fendleri, Poa fendleriana, Ambrosia confertiflora, Echinocereus engelmannii*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from one classification plot and four mapped polygons.

Global

More classification is needed to fully describe this type.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP034
Tonto National Monument Polygons: S40, S41, S44, S52
Local description authors: L. Crumbacher, S. Drake

Simmondsia chinensis - Encelia farinosa Shrubland (P)

Translated name: Jojoba - Brittlebush shrubland
NVC name: N/A
Identifier: NPSSODN073

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Simmondsia chinensis - Encelia farinosa* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found in the southern half of the monument, across broad swaths of steep slope in the mountain areas.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland association grows on unstable, east-facing (usually with a southerly component) slopes at Tonto National Monument, above canyon-bottom drainages and below Dripping Springs quartzite sheer rock faces, from 850 to 1,100 meters in elevation. The grades vary from 15% at footslopes to greater than 50% on backslopes. These mid- to lower-mountain slopes feature an undulating pattern, parallel to the slope, of colluvially created ridges and steep-walled minor drainages. Ground cover is generally an almost equal mix of sedimentary gravel and rock, with rare exposed bare soil, and sparse amounts of bedrock outcrop.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized as an open, low-height shrubland dominated by *Simmondsia chinensis* (jojoba) in the subcanopy stratum (0.5–2 m), with 11–25% cover, and a short shrub layer with *Encelia farinosa* (brittlebush) as the dominant species providing another 2–10% cover. The vegetation follows the repeating landform pattern; *S. chinensis* thins out on the south-facing areas and is denser on north-facing slopes above the minor drainages. From a distance, a repeating pattern is visible: a gradient of *Simmondsia chinensis*, from more dense to less dense with grasses and subshrubs mixed in; then, the light-blue globes of *Encelia farinosa* emerge in numbers among the dark jojoba. Total cover from all shrubs combined averages ~35%.

E. farinosa occurs almost exclusively on south- or southeast-facing slopes. In this type, it is densest at the south-facing edges of the many ridges that run downhill. These areas tend to have more visible gravel and loose rock, while the upper sections of the ridges and the north-facing sides are generally higher in associate shrub and herbaceous cover, featuring common associates *Canotia holacantha*, *Encelia frutescens*, *Lycium fremontii*, *Sphaeralcea* sp., and *Dodonaea viscosa* in the subcanopy, and field-stratum associates *Achnatherum speciosum*, *Heteropogon contortus*, *Aristida purpurea*, and *Ambrosia confertiflora*. Annual forb cover is also more abundant in those areas.

Parkinsonia microphylla, *Fouquieria splendens*, and *Carnegia gigantea* create a trace canopy of generally <1% cover above 2 m in height in the *E. farinosa*-dominated portions of the mosaic. *Cylindropuntia bigelovii* is a sparse associate on the south-facing slope sections. The canopy height species are overall rare here. All of the stands of this type were burned in the 1964 Schultz Fire within the monument. This may explain why the *C. gigantea* and other cacti are less dense than on similar slopes of similar aspect that feature the similar (*Parkinsonia microphylla*) / *Encelia farinosa* shrubland association. Rills and/or gullies occur in all stands.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Encelia farinosa*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Fouquieria splendens, Parkinsonia microphylla, Carnegia gigantea*
Subcanopy (0.5–2 m)	*Canotia holacantha, Cylindropuntia bigelovii, Sphaeralcea* sp., *Parkinsonia microphylla, Encelia frutescens, Dodonaea viscosa, Lycium fremontii, Gutierrezia sarothrae, Opuntia phaeacantha, Cylindropuntia acanthocarpa, Opuntia engelmannii, Eriogonum fasciculatum*
Field (0–0.5 m)	*Selaginella arizonica, Achnatherum speciosum, Mammillaria grahamii, Heteropogon contortus, Aristida purpurea, Eragrostis lehmanniana*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Juniperus monosperma*
Subcanopy (0.5–2 m)	*Prosopis velutina, Carnegia gigantea, Acacia greggii, Keckiella antirrhinoides, Eriogonum wrightii, Bebbia juncea, Ferocactus wislizeni, Agave chrysantha, Phoradendron californicum, Brickellia atractyloides, Senecio flaccidus, Opuntia chlorotica, Dasylirion wheeleri, Janusia gracilis, Yucca baccata, Galium stellatum, Marah gilensis, Lotus rigidus, Aloysia wrightii*
Field (0–0.5 m)	*Avena fatua, Adenophyllum porophylloides, Ayenia filiformis, Echinocereus engelmannii, Perityle coronopifolia, Baileya multiradiata, Muhlenbergia porteri, Porophyllum gracile, Poa fendleriana, Digitaria californica, Carnegia gigantea, Mirabilis laevis, Ambrosia confertiflora, Acourtia nana, Eragrostis curvula* var. *contortus, Erigeron divergens, Agave chrysantha, Aristida ternipes* var. *gentilis, Leptochloa dubia*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from three classification plots and six field-mapped polygons. This type is closely related to the (*Parkinsonia microphylla*) / *Encelia farinosa* Shrubland, differing primarily by virtue of having far less *Parkinsonia* and an increased dominance (abundance) of *Simmondsia chinensis*.

Global

This association doesn't have a corollary within the USNVC at this time but is anticipated to eventually fall under the *Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance [A3283].

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

ELEMENT SOURCES

Tonto National Monument Plots: IP018, IP019, IP091
Tonto National Monument Polygons: S15, S39, S51, S84, S85, S87
Local description authors: B. Fallon, S. Studd

Simmondsia chinensis - Encelia frutescens Shrubland (P)

Translated name: Jojoba - Button brittlebush Shrubland
NVC name: N/A
Identifier: NPSSODN079

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Simmondsia chinensis - Encelia frutescens* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found in the southern half of the monument, on the upper slopes above Deadman's Canyon, and in the northern half of the park, on upper slopes above the broad alluvial fans.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
All stands except one occur on northern-facing slopes (with either west or east modifiers); the exception occurs on an east-southeast aspect. This association inhabits a large elevation range, from 700 to 1,150 meters. All slopes are greater than 15% and range up to areas steeper than 50%. Most stands are limited to the backslopes and shoulders of high hills or mountains. The substrates are generally sedimentary in origin. Rock and gravel are usually the dominant ground cover with roughly equal proportions. The soil is rarely exposed, and there may be bedrock outcrops generating cover greater than 15%.

VEGETATION DESCRIPTION

Tonto National Monument
This proposed shrubland association is one of the denser shrubland communities at Tonto NM, with overall shrub cover ranging from 30 to 50%. The community is characterized by a subcanopy layer (0.5–2 m) dominated by *Simmondsia chinensis* (jojoba) and *Encelia frutescens* (button brittlebush). *S. chinensis* is typically more abundant than the *Encelia frutescens*, comprising 6–10% cover in some stands and up to 26–33% in others, but the two can approach co-dominance in places (*E. frutescens* generally provides 6–10% cover, but may be as much as 11–25%). *S. chinensis* is the larger of the two species, ~0.75 m or greater tall. It grows as large, robust individuals on slightly cooler, north-trending slopes. *E. frutescens* is shorter, with flowering height generally less than 0.75 m and with a leaf density and plant width that are both much less than those of *S. chinensis*. The mix of the two dominants creates a subcanopy of two heights and densities.

The species present in this type are very diverse, with many shrubs and subshrubs possibly present in varying abundance and frequency among stands. Associates may include *Keckiella antirrhinoides*, *Sphaeralcea* spp., *Cylindropuntia acanthocarpa, Gutierrezia sarothrae, Ericameria laricifolia, Aloysia wrightii, Lycium fremontii, Senegalia greggii, Eriogonum fasciculatum, Dasylirion wheeleri, Rhus ovata* (less often) and others. Sparse amounts of bunchgrasses occupy open space between shrubs. *Muhlenbergia porteri* occurs in most stands, with a mix of less-frequent grass species.

Canopy cover over 2 m in height is sparse to absent. Occasional *Fouquieria splendens*, *Parkinsonia microphylla*, or *Prosopis velutina* are observed in approximately half of the examples of this type. *Carnegia gigantea* is rare.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Encelia frutescens, Sphaeralcea* sp.
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Fouquieria splendens, Prosopis velutina, Parkinsonia microphylla*
Subcanopy (0.5–2 m)	*Lycium fremontii, Keckiella antirrhinoides, Sphaeralcea ambigua, Sphaeralcea rusbyi, Opuntia acanthocarpa, Eriogonum fasciculatum, Dasylirion wheeleri, Yucca baccata, Gutierrezia sarothrae, Canotia holocantha, Dodonaea viscosa, Acacia greggii, Sphaeralcea* sp.*, Artemisia ludoviciana, Ericameria laricifolia, Aloysia wrightii, Opuntia engelmannii, Opuntia phaeacantha, Marah gilensis, Ferocactus cylindraceus, Ferocactus wislizeni, Galium stellatum*
Field (0–0.5 m)	*Mammillaria grahamii, Muhlenbergia porteri, Dudleya collomiae, Aristida ternipes, Bouteloua curtipendula, Achnatherum speciosum, Porophyllum gracile, Echinocereus engelmannii*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	*Carnegiea gigantea*
Canopy (2–5 m)	*Juniperus monosperma, Parkinsonia florida, Juniperus coahuilensis*
Subcanopy (0.5–2 m)	*Mirabilis laevis, Brickellia coulteri, Acacia constricta, Juniperus monosperma, Opuntia macrocentra, Eriogonum wrightii, Senecio flaccidus, Quercus turbinella, Rhus trilobata, Brickellia atractyloides, Celtis laevigata* var. *reticulata, Agave chrysantha, Encelia virginensis, Porophyllum gracile, Bebbia juncea, Larrea tridentate, Heterotheca villosa*
Field (0–0.5 m)	*Eragrostis curvula, Heteropogon contortus, Perityle coronopifolia, Krameria grayi, Leptochloa dubia, Dichelostemma capitatum, Xanthisma spinulosum, Eragrostis lehmanniana, Aristida purpurea, Castilleja applegatei*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from two classification plots and eight field-mapped polygons.

Global
This type has no corollary in the current iteration of described NVC types. More classification is needed to fully describe this type.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP068, IP213
Tonto National Monument Polygons: S27, S32, S34, S43, S67, S73, S79, S80
Local description authors: B. Fallon, S. Drake

Cylindropuntia acanthocarpa Shrubland (P)

Translated name: Buckhorn cholla Shrubland
NVC name:
Identifier: NPSSODN070

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Cylindropuntia acanthocarpa* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found on a single, small hillslope in the western part of the monument.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland sits on a south–southwest facing hill with mild slope (15–35%) at around 900 m elevation. The soils appears to be compacted, with loose rocks and gravel but predominantly bare ground. Much of the soil is covered with light cyanobacteria.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland is a unique, small (0.61 ha), homogeneous patch of *Cylindropuntia acanthocarpa* on one of the lower ridges of Tonto National Monument. The subcanopy cover of 40% is formed, for the most part, by the open architecture of the branches of *Cylindropuntia acanthocarpa*. Subshrubs and grasses grow underneath this open canopy. Canopy height species (>2 m) are essentially absent, with only one or two *Fouquieria splendens* present in the entire area. Notably, *Porophyllum gracile* is a relatively large plant here, growing to 0.75 meters in height within the structure of the *C. acanthocarpa*. The parasite, *Cuscuta indecora* (bigseed alfalfa dodder), generates little cover, but is noticeable and prefers the *Menodora scabra*—a common victim—and *Eriogonum wrightii* (bastardsage), a less common host. Bunches of *Aristida purpurea* and non-native *Eragrostis lehmanniana* (Lehmann's lovegrass) populate most of the sparse field cover.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Cylindropuntia acanthocarpa*
Field (0–0.5 m)	*Aristida purpurea, Eragrostis lehmanniana*

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Eriogonum wrightii*, *Menodora scabra, Porophyllum gracile*
Field (0–0.5 m)	*Cuscuta indecora*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Fouquieria splendens*
Subcanopy (0.5–2 m)	*Gutierrezia sarothrae, Simmondsia chinensis, Opuntia engelmannii, Opuntia phaeacantha, Prosopis velutina, Sphaeralcea ambigua*
Field (0–0.5 m)	*Achnatherum speciosum, Echinocereus fendleri, Krameria grayi, Chamaesyce* sp., *Senna covesii*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from one mapped polygon).

Global

N/A

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

ELEMENT SOURCES

Tonto National Monument Plots: None
Tonto National Monument Polygons: S53
Local description authors: B. Fallon

Parkinsonia microphylla / Eriogonum fasciculatum - Encelia frutescens Wooded Shrubland (P)

Translated name: Yellow paloverde / Eastern Mojave buckwheat - Button brittlebush Wooded Shrubland
NVC name: N/A
Identifier: NPSSODN081

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Parkinsonia microphylla / Eriogonum fasciculatum - Encelia frutescens* Wooded Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found in one location along the western boundary of the monument.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland sits on a west–northwest facing backslope of a mountain, at about 1,000 m elevation. Slope is 15–35%, and the surface cover is a roughly even mix of gravel, rock, and bedrock.

VEGETATION DESCRIPTION

Tonto National Monument
This wooded shrubland association is characterized as a mixed shrub community with significant canopy cover from short trees. The relatively tall *Parkinsonia microphylla* (yellow paloverde) and *Fouquieria splendens* (ocotillo) appear to tower over a low, open subcanopy of spindly *Encelia frutescens* (button brittlebush) and matted *Eriogonum fasciculatum* (eastern Mojave buckwheat).

Parkinsonia microphylla and *Fouquieria splendens* form a prominent canopy, with a total cover of about 15%. *P. microphylla* occurs as both a tree and a shrub, generally about 2.5 m tall. *F. splendens* (to 4 m tall) is estimated to provide less than 5% cover. The subcanopy is composed of the co-dominants which, together with a mix of other shrub associates, provide a total cover of about 25%. The subcanopy is fairly open, dominated by E. *fasciculatum*, with *E. frutescens* clustering around the bases of the *P. microphylla*. *Simmondsia chinensis* and *Yucca baccata* are common associates, with the yucca sometimes up to 1 m tall and visually striking within the community. Other shrub species that may be present, with trace cover, include *Agave chrysantha, Encelia farinosa, Opuntia engelmannii, Cylindropuntia acanthocarpa, Ericameria laricifolia, Galium stellatum, Senegalia greggii* and *Aloysia wrightii.*

Field-stratum cover is very low (< 1%), with no dominants recorded. Species observed include *Achnatherum speciosum, Aristida purpurea, Dudleya* sp., *Mirabilis laevigata, Carnegia gigantea, Cirsium neomexicana, Adenophyllum porophylloides, Selaginella arizonica,* and *Mammillaria grahamii.*

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Parkinsonia microphylla, Fouquieria splendens*
Subcanopy (0.5–2 m)	*Eriogonum fasciculatum, Encelia frutescens*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Yucca baccata*
Field (0–0.5 m)	--

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Acacia greggii, Carnegiea gigantea, Juniperus coahuilensis*
Subcanopy (0.5–2 m)	*Agave chrysantha, Encelia farinosa, Opuntia engelmannii, Cylindropuntia acanthocarpa, Ericameria laricifolia, Galium stellatum, Aloysia wrightii*
Field (0–0.5 m)	*Achnatherum speciosum, Aristida purpurea Dudleya* sp., *Mirabilis laevigata, Carnegia gigantea, Cirsium neomexicana, Adenophyllum porophylloides, Selaginella arizonica, Mammillaria grahamii*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from one classification plot and one mapped polygon).

Global

The USNVC lists a *Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance [A3283] that broadly fits this type as seen at Tonto NM. However, insufficient data exist to describe the associations within the alliance at this time, and more work is needed. Therefore, this association has been described solely from Tonto NM data.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP012
Tonto National Monument Polygons: S74
Local description authors: S. Studd

Canotia holacantha Shrubland (P)

Translated name: Crucifixion thorn Shrubland
NVC name: N/A
Identifier: NPSSODN066

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Canotia holacantha* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is observed in the northwest corner of the monument, predominantly on the west side of Deadman's Canyon. It also occurs in transitional areas on the steep north slopes of the eastern range above Deadman's Canyon.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This vegetation type is found on the upper slopes, shoulders, ridges, and crests of north-trending aspects. Elevation ranges from 800 to 1,200 m. Slope tends to be steep, usually from 35% to more than 50% (up to 90%), with only one stand of this vegetation type found in an area of 15–35% slope. Ground cover is generally small rock or coarse sedimentary gravel with areas of bedrock outcrops, especially at higher elevations. Many of the areas where this type is found are cut repeatedly by shallow ravines, especially in backslope areas.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized by *Canotia holacantha* as the dominant subcanopy (0.5–2 m) shrub, generally occurring with 6–10 (up to 15)% cover. It generally has a shrubby form, growing to about 2 m, but some taller individuals with one or a few central trunks and an overall vertical form could be considered trees. *Simmondsia chinensis*, *Gutierrezia sarothrae,* and/or *Eriogonum fasciculatum* may be co-dominants. *Opuntia engelmannii* and *Dodonaea viscosa* are common associates. Shrub diversity in the subcanopy is moderately high, with 8–10 additional species generally present. These may include *Eriogonum wrightii, Dasylirion wheeleri* (occasionally co-dominant in some stands), *Lycium fremontii, Lycium pallidum, Ericameria laricifolia, Aloysia wrightii, Fouquieria splendens, Rhus ovata, Senegalia greggii, Gutierrezia sarothrae, Yucca baccata,* and others.

Field-stratum cover is generally 5% or less and is most often a mix of patchy perennial grasses, possibly including *Achnatherum speciosum*, *Bouteloua curtipendula*, *Aristida purpurea*, *Bothriochloa barbinodis,* and other species. Occasionally scattered trees (*Prosopis velutina, Juniperus coahuilensis*) may be present.

Global
Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Canotia holacantha*
Subcanopy (0.5–2 m)	*Canotia holacantha, Simmondsia chinensis, Gutierrezia sarothrae, Eriogonum fasciculatum, Dodonaea viscosa*
Field (0–0.5m)	*Achnatherum speciosum*, *Bouteloua curtipendula, Aristida purpurea, Muhlenbergia porteri, Leptochloa dubia*

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Prosopis velutina, Juniperus coahuilensis, Fouquieria splendens, Senegalia greggii*
Subcanopy (0.5–2 m)	*Dasylirion wheeleri, Rhus ovata, Ericameria laricifolia, Encelia frutescens, Eriogonum wrightii, Sphaeralcea ambigua, Keckiella antirrhinoides, Aloysia wrightii, Lycium fremontii*
Field (0–0.5m)	--

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Ericameria laricifolia, Parkinsonia florida, Prosopis velutina, Artemisia ludoviciana, Cylindropuntia acanthocarpa, Galium stellatum, Ziziphus obtusifolia, Marah giliensis, Sphaeralcea* spp.*, Menodora scabra, Agave chrysantha, Cercocarpus montanus, Lycium pallidum, Baccharis sarothroides, Opuntia chlorotica, Senecio flaccidus, Quercus turbinella, Krameria grayi, Rhus trilobata, Juniperus monosperma*
Field (0–0.5m)	*Bothriochloa barbinodis, Cheilanthes* spp. *Adenophyllum porophylloides, Pleuraphis mutica, Poa fendleriana, Senecio lemmonii, Aristida ternipes, Dichelostemma capitatum*

CLASSIFICATION COMMENTS

Tonto National Monument

This association may eventually be placed under the *Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance, A3283. That alliance is reported from California and Arizona, along the lower slopes of the Mogollon Rim/Central Highlands regions. As of this writing, no associations are listed that match this vegetation. This association type is therefore based solely on data from Tonto NM (three classification plots and six field-mapped polygons.

This type bears similarity to the *Juniperus coahuilensis* / *Canotia holacantha* Woodland association, CEGL000701, but lacks the developed, juniper-dominant tree canopy. This is likely because elevation in the monument barely reaches levels to support these more montane communities.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available

Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Tonto National Monument Plots: IP051, IP202, IP221
Tonto National Monument Polygons: S47, S65, S66, S76, S78, S86
Local description authors: E. Fallon, S. Drake, S. Studd

Dodonaea viscosa Shrubland (P)

Translated name: Hopbush Shrubland
NVC name: N/A
Identifier: NPSSODN067

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Dodonaea viscosa* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is primarily found on the high north- and east-trending slopes in the north-central portion of the park, surrounding Deadman's Canyon. One stand is located on the low hills east of the entrance road.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This vegetation type is generally located on the backslopes, shoulders, and crests of ridges at 850–1,150 m elevation. The surface is covered with a mix of rock, bedrock, and gravel, with gravel being the most common. Bedrock and generally rocky ground cover are present in all stands and seem to be an important characteristic of this vegetation community. Aspect is generally north- or northeast-facing.

VEGETATION DESCRIPTION

Tonto National Monument
This proposed shrubland association is characterized by a the presence and dominance of *Dodonaea viscosa* (hopbush) averaging less than 2 m tall, accompanied by *Simmondsia chinensis* and *Encelia frutescens*, which can have enough cover to be considered co-dominant in some stands. Total cover in the subcanopy (0.5–2 m) is 35–40%. The canopy layer over 2 m is sparse and only occupied by occasional *Fouquieria splendens* or *Rhus ovata* and occasional trees, such as *Canotia holacantha* and *Parkinsonia microphylla*.

Shrub diversity is high, with several other shrubs commonly present in low numbers each contributing 1 or 2% cover. These include *Dasylirion wheeleri, Eriogonum fasciculatum, E. wrightii, Gutierrezia sarothrae, Agave chrysantha, Opuntia engelmannii, O. acanthocarpa, Dalea formosa, Sphaeralcea* sp., *Lycium fremontii, Acacia greggii, Bebbia juncea*, and others. Less-common shrubs observed include *Keckiella antirrhinoides*, *Aloysia wrightii,* and *Brickellia atractyloides*.

The field stratum (<0.5 m) contains a mix of grasses, small cacti, and herbaceous or woody perennials, with the highest cover generated by the grasses. Across all examples, cover averaged 3–4%. *Achnatherum speciosum* is present in most stands, and may dominate the field stratum. Associate grasses may include *Aristida ternipes* var. *gentilis*, *Bouteloua curtipendula*, *Aristida purpurea, Digitaria californica, Bothriochloa barbinodis,* and others. Common associates included *Porophyllum gracile, Castilleja* sp., *Dudleya* sp., *Echinocereus fendleri, Mammillaria viridiflora, Senna covesii, Mammillaria grahamii, Stephanomeria pauciflora, Echinocereus engelmannii, Chamaesyce* sp., *Agave chrysantha,* and *Acourtia wrightii*.

Note: One stand that fell within (but mostly outside) the park boundary differed by having a field layer entirely dominated by the non-native grass, *Eragrostis curvula* var. *confertiflora,* at 26–33% cover. Annual forbs are also abundant. Outside the park boundary, this area has burned in at least five major fires in the last 70 years (Philips 1997; USGS Tech. Report No. 59). There are three major gullies in the stand. The fires, and probably the resulting advanced erosion, may explain the abundance of grass in this area, which might otherwise have shrub-dominated uplands, with sparse woodlands/wooded shrublands in the drainages.

Global
Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Dodonaea viscosa, Encelia frutescens, Simmondsia chinensis*
Field (0–0.5 m)	*Achnatherum speciosum*

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Canotia holacantha, Fouquieria splendens*
Subcanopy (0.5–2 m)	*Eriogonum fasciculatum, Sphaeralcea ambigua, Dasylirion wheeleri, Sphaeralcea* sp., *Gutierrezia sarothrae*
Field (0–0.5 m)	*Bouteloua curtipendula, Aristida ternipes* var. *gentilis, Aristida purpurea*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Parkinsonia microphylla, Rhus ovata*
Subcanopy (0.5–2 m)	*Eriogonum wrightii, Acacia greggii, Sphaeralcea ambigua, Opuntia engelmannii, Opuntia acanthocarpa, Bebbia juncea, Agave chrysantha, Galium stellatum, Lycium fremontii, Encelia virginensis, Keckiella antirrhinoides, Aloysia wrightii, Opuntia chlorotica, Dalea formosa, Brickellia atractyloides, Sphaeralcea rusbyi*
Field (0–0.5 m)	*Porophyllum gracile, Castilleja* sp., *Dudleya* sp., *Echinocereus fendleri, Mammillaria viridiflora, Senna covesii, Mammillaria grahamii, Stephanomeria pauciflora, Echinocereus engelmannii, Digitaria californica, Bothriochloa barbinodis, Chamaesyce* sp., *Agave chrysantha, Acourtia wrightii*

CLASSIFICATION COMMENTS

Tonto National Monument
This description is based solely on data collected during this inventory project. It is based on data from four classification plots and four field-mapped polygons.

Global
There are currently no accepted NVC types that describe this vegetation.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available

Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Tonto National Monument Plots: IP032, IP086, IP200, IP201
Tonto National Monument Polygons: S035, S048, S071, S088, SS02
Local description authors: S. Studd, B. Fallon

Simmondsia chinensis - Eriogonum wrightii Shrubland (P)

Translated name: Jojoba - Bastardsage Shrubland
NVC name: N/A
Identifier: NPSSODN068

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Simmondsia chinensis - Eriogonum wrightii* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found in mostly in the western portion of the monument, at higher elevations above Deadman's Canyon.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This vegetation type is restricted to slopes with northern or northwestern aspects and reported elevations ranging from 900 to 1,150 meters. The slopes are usually steep (≥35–50%) and loose, with high rock and gravel cover. These communities will sometimes reach the crest of the hill but are usually on the upper backslope positions. Some stands have somewhat stabilized colluvial talus present, with small perennial forbs and ferns growing among the rocks and lichen covering the stones.

VEGETATION DESCRIPTION

Tonto National Monument
This proposed shrubland association is characterized by a dominant subcanopy layer with *Simmondsia chinensis* shrubs averaging 10% cover (ranging from 6–20%) and an understory layer dominated by *Eriogonum wrightii*. There are usually a number of other shrubs present in this height range (0.5–2 m), creating a diverse community mix and together providing 25–35% cover. However, each species individually has only 1–3% cover. Common shrubs include *Canotia holacantha*, *Rhus ovata, Eriogonum fasciculatum, Ericameria laricifolia, Dasylirion wheeleri, Senegalia greggii, Opuntia engelmannii, Lycium fremontii, Encelia frutescens, Gutierrezia sarothrae, Yucca baccata, Sphaeralcea* spp. and *Agave chrysantha*.

The canopy above 2 m in height is typically sparse (always <10%), if not absent, with the occasional *Rhus ovata, Canotia holacantha,* or *Cercocarpus montanus*. *Parkinsonia microphylla* is not a component of this community other than where it is accidental and transitional, having crept in from adjacent *Parkinsonia microphylla / Encelia farinosa* communities.

The field layer below 0.5 m is dominated by grasses and, secondarily, by forbs and subshrubs, but has fairly low overall cover, averaging 3–4% (up to 10%), with no single species clearly dominant throughout. In places, *Achnatherum speciosum* and *Bouteloua curtipendula* may be dominant. Other common associates include *Bothriochloa barbinodis, Aristida ternipes,* and *Digitaria californica*.

Global
Data not available. See classification comments.

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Eriogonum wrightii*
Field (0–0.5 m)	*Achnatherum speciosum*, *Bouteloua curtipendula*

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Canotia holacantha, Rhus ovata*
Subcanopy (0.5–2 m)	*Ericameria laricifolia, Galium stellatum, Gutierrezia sarothrae, Dasylirion wheeleri, Opuntia acanthocarpa, Dodonaea viscosa, Keckiella antirrhinoides, Rhus ovata, Eriogonum fasciculatum, Encelia frutescens, Sphaeralcea* sp., *Opuntia chlorotica, Aloysia wrightii*
Field (0–0.5 m)	*Bothriochloa barbinodis, Artemisia ludoviciana, Aristida purpurea*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Cercocarpus montanus, Prosopis velutina, Carnegia gigantea, Parkinsonia microphylla, Fouquieria splendens*
Subcanopy (0.5–2 m)	*Rhamnus crocea, Menodora scabra, Sphaeralcea rusbyi, Marah gilensis, Opuntia engelmannii, Opuntia phaeacantha, Quercus turbinella, Bebbia juncea, Lotus rigidus, Ziziphus obtusifolia, Yucca baccata, Agave chrysantha*
Field (0–0.5 m)	*Adenophyllum porophylloides, Agave chrysantha, Aristida ternipes, Bromus rubens, Cheilanthes fendleri, Digitaria californica, Eragrostis curvula* var. *confertiflora, Eragrostis lehmanniana, Erigeron divergens, Erysimum capitatum, Glandularia bipinnatifida, Heteropogon contortus, Leptochloa dubia, Muhlenbergia microsperma, Melampodium leucanthum, Porophyllum gracile, Selaginella arizonica, Stephanomeria pauciflora*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from three classification plots and four field-mapped polygons.

Global

The USNVC lists a *Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance [A3283] that broadly fits this type as seen at Tonto NM. However, insufficient data exist to describe the associations within the alliance at this time, and more work is needed. Therefore, this association has been described solely from Tonto NM data.

Classification confidence: Low
NatureServe conservation status: Data not available
Global status: Data not available

Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Tonto National Monument Plots: IP027, IP067, IP074,
Tonto National Monument Polygons: S49, S55, S59, S61
Local description authors: B. Fallon, S. Studd

Simmondsia chinensis - Eriogonum fasciculatum Shrubland (P)

Translated name: Jojoba / Eastern Mojave buckwheat Shrubland
NVC name: N/A
Identifier: NPSSODN083

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Simmondsia chinensis - Eriogonum fasciculatum* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found in the southern half of the monument, on the upper slopes above Deadman's Canyon.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland association is uncommon in Tonto National Monument, occurring on the steep upper portions of some west-facing slopes at 975–1,125 meters that feature some very steep components (>50% slope). Rock and small, unevenly-sized gravel create similar ground cover amounts, together forming the dominant ground cover.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized by *Simmondsia chinensis* (jojoba) shrubs providing the dominant cover in the 0.5–2 m height range, with low, sprawling *Eriogonum fasciculatum* (eastern Mojave buckwheat) growing between them.

Total subcanopy cover ranges from 30 to 35%, with *Simmondsia chinensis* generally providing 11–25% cover and *Eriogonum fasciculatum* generally at 6–10% cover. *Encelia frutescens* is a common associate providing an additional 1–3%. The rest of the subcanopy layer is composed of a heterogeneous mix of shrub species. These may include *Sphaeralcea* spp., *Senegalia greggii, Opuntia engelmannii, Lycium fremontii, Ericameria laricifolia, Encelia frutescens, Gutierrezia sarothrae, Dasylirion wheeleri, Rhus ovata, Yucca baccata, Agave chrysantha, Eriogonum wrightii*, or others.

The canopy cover above 2 m in height consists of occasional trees, such as *Prosopis velutina* and *Parkinsonia microphylla,* or tall shrubs, such as *Canotia holacantha* and *Fouquieria splendens,* but is sparse (<5%) or even absent. The field stratum is also sparse, at <5% total cover, made up of several grass species with no clear dominant. The most consistently recorded field species across all stands are *Achnatherum speciosum, Aristida purpurea* (both common park-wide), *Bouteloua curtipendula,* and *Digitaria californica*.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Eriogonum fasciculatum, Encelia frutescens*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Prosopis velutina*
Subcanopy (0.5–2 m)	*Lycium fremontii, Sphaeralcea* sp.*, Ericameria laricifolia, Gutierrezia sarothrae, Acacia greggii, Encelia frutescens*
Field (0–0.5 m)	*Achnatherum speciosum, Bouteloua curtipendula, Poa fendleriana*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Carnegia gigantea, Parkinsonia microphylla, Fouquieria splendens*
Subcanopy (0.5–2 m)	*Dodonaea viscosa, Ferocactus wislizeni, Opuntia engelmannii, Opuntia chlorotica, Opuntia acanthocarpa, Dasylirion wheeleri, Rhus ovata, Yucca baccata, Agave chrysantha, Aloysia wrightii, Eriogonum wrightii, Galium stellatum*
Field (0–0.5 m)	*Dichelostemma capitatum, Dudleya* sp.*, Leptochloa dubia, Aristida purpurea, Digitaria californica, Stephanomeria pauciflora*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from two classification plots and two field-mapped polygons.

Global

The USNVC lists a *Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance [A3283] that broadly fits this type as seen at Tonto NM. However, insufficient data exist to describe the associations within the alliance at this time, and more work is needed. Therefore, this association has been described solely from Tonto NM data.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP211, IP212
Tonto National Monument Polygons: S56, S68
Local description authors: B. Fallon, S. Studd

Simmondsia chinensis - Ericameria laricifolia Shrubland (P)

Translated name: Jojoba - Turpentine bush Shrubland
NVC name: N/A
Identifier: NPSSODN084

NVC CLASSIFICATION

Division --
Macrogroup --
Group --
Association *Simmondsia chinensis - Ericameria laricifolia* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found in one location in the southwest corner of the project area.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
Only one stand of this proposed association occurs at Tonto NM, on the west-facing half of a saddle at about 1,150 meters elevation. Loose, sedimentary rock creates the majority of the surface cover.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized by a subcanopy layer (0.5–2 m height) dominated by *Simmondsia chinensis* (jojoba) with 6–10% cover and *Ericameria laricifolia* (turpentine bush) as a sub-dominant associate (1–5% cover). Large *Opuntia engelmannii* and short-statured *Canotia holacantha* are the primary common associates. *C. holacantha* is most abundant at the shoulder of the saddle and the upper portions of the minor drainages that run down the backslope. Other shrubs present in low numbers include *Agave chrysantha*, *Eriogonum fasciculatum*, *Gutierrezia sarothrae*, and *Cylindropuntia acanthocarpa*. A few *Fouquieria splendens* are present but otherwise, canopy cover over 2 m in height is lacking. The field-stratum cover is sparse, at about 5%, and composed primarily of the grasses, *Achnatherum speciosum*, *Eragrostis curvula*, and *Digitaria californica*.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Ericameria laricifolia*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Fouquieria splendens*
Subcanopy (0.5–2 m)	*Sphaeralcea* sp., *Opuntia engelmannii, Canotia holacantha, Gutierrezia sarothrae, Agave chrysantha, Eriogonum fasciculatum, Cylindropuntia acanthocarpa, Prosopis velutina*
Field (0–0.5 m)	*Achnatherum speciosum, Eragrostis curvula* var. *confertiflora, Digitaria californica*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	--
Field (0–0.5 m)	--

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from one mapped polygon). This distinct community occupies a very small area on the monument's boundary. It is unclear how widespread this community is in the greater local area.

Global

The USNVC lists a *Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance [A3283] that broadly fits this type as seen at Tonto NM. However, insufficient data exist to describe the associations within the alliance at this time, and more work is needed. Therefore, this association has been described solely from Tonto NM data.

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

ELEMENT SOURCES

Tonto National Monument Plots: N/A
Tonto National Monument Polygons: S62
Local description authors: B. Fallon

Simmondsia chinensis / Selaginella arizonica Shrubland (P)

Translated name: Jojoba / Arizona spikemoss Shrubland
NVC name: N/A
Identifier: NPSSODN078

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Simmondsia chinensis / Selaginella arizonica* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This shrubland occurs in a small range limited by elevation and aspect in the southern half of the monument. Two stands exist, on the southern ends of the tallest ridges in the park, at 1,150–1,220 meters elevation.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland occurs on the southeast-facing shoulder and crest of the ridge, above a sheer rock face composed of Dripping Springs quartzite. Sedimentary rock tops the ridges. Bedrock outcrops of less than one meter in height and usually near to flush with the ground and featuring some stromatolites, create about one-third of the ground cover. Rocks and gravel make up the rest of the unvegetated surface.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized as open and low-growing, with vegetation over 2 m absent or nearly so.

The subcanopy (0.5–2 m) is dominated by *Simmondsia chinensis* (jojoba), with a number of other shrub species also present. Total cover in this stratum is 25–30%, with *S. chinensis* contributing 6–10%. *Opuntia phaeacantha, Opuntia engelmannii,* and *Senegalia greggii* (catclaw acacia) are the three most common associates. Any one of the three may be locally more abundant than the others, with cover of each ranging from 2 to 5%. Other associates may include *Encelia frutescens, Encelia virginensis, Ericameria laricifolia, Sphaeralcea* sp., *Opuntia acanthocarpa, Encelia farinosa, Dasylirion wheeleri, Parkinsonia microphylla, Eriogonum fasciculatum, Dalea formosa, Bebbia juncea, Yucca baccata, Canotia holacantha, Lycium fremontii,* and others.

Selaginella arizonica (Arizona spikemoss) creates most of the field-stratum cover and lends a characteristic look to this vegetation type. The soil is very thin, with bedrock close to the surface, and blocky large rocks common. The spikemoss grows into any exposed soil and under the edges of loose rocks to occupy the thin layer of soil below. Because of the rocky surface and dominant cover (10–45%) of *S. arizonica* on the sparse soil, few annuals grow here, making the slopes look brown while surrounding areas are green with spring annuals. Several grass species may be present with little cover. *Mammillaria grahamii* and *Echinocereus engelmannii* are more abundant on these high, rocky slopes than in many other areas of the park. Other uncommon species recorded include *Melampodium leucanthum* (Plains blackfoot), *Dudleya* spp., *Echinocereus fendleri*, *Achnatherum speciosum, Adenophyllum porophylloides*, *Heteropogon contortus*, *Leptochloa dubia*, *Aristida purpurea*, *Eragrostis lehmanniana*, *Erigeron divergens, Penstemon subulatus, Thamnosma texana, Baileya multiradiata, Stephanomeria pauciflora,* and *Echinocereus engelmannii*.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Opuntia phaeacantha, Opuntia engelmannii, Senegalia greggii*
Field (0–0.5 m)	*Selaginella arizonica*

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Encelia farinosa, Encelia frutescens, Encelia virginensis, Bebbia juncea, Opuntia acanthocarpa, Sphaeralcea* sp., *Eriogonum fasciculatum, Dalea formosa*
Field (0–0.5 m)	*Melampodium leucanthum, Stephanomeria pauciflora, Echinocereus engelmannii, Mammillaria grahamii*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Aloysia wrightii*, *Dasylirion wheeleri, Yucca baccata, Mirabilis laevis, Phoradendron californicum, Gutierrezia sarothrae, Galium stellatum, Lycium fremontii, Canotia holacantha, Krameria grayi, Parkinsonia microphylla, Senna covesii*
Field (0–0.5 m)	*Achnatherum speciosum, Adenophyllum porophylloides, Agave chrysantha, Aristida purpurea, Baileya multiradiata, Dudleya* spp., *Eragrostis lehmanniana, Erigeron divergens, Heteropogon contortus, Leptochloa dubia, Muhlenbergia porteri, Penstemon subulatus, Thamnosma texana, Sporobolus cryptandrus*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from two classification plots and two field-mapped polygons.

Global

None; more classification is needed to fully describe this type.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP208, IP220
Tonto National Monument Polygons: S60, S63
Local description authors: B. Fallon, S. Studd

Simmondsia chinensis - Sphaeralcea spp. Shrubland (P)

Translated name: Jojoba - Globemallow Shrubland
NVC name: N/A
Identifier: NPSSODN080

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Simmondsia chinensis - Sphaeralcea* spp. Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found only in one location on the north east side of Honey Butte.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland is represented by a single stand located on the northeast-facing upper slopes of a ridge. Slope gradient is 15–35%, and elevation is 875–950 meters. The predominant surface cover is gravel, rock, and low bedrock outcrops.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized by widely spaced *Simmondsia chinensis* interspersed with *Sphaeralcea rusbyi* and *Sphaeralcea ambigua*. Overall cover in the subcanopy (0.5–2 m height) is ~35%, with *S. chinensis* accounting for about two-thirds of the cover and *Sphaeralcea* spp. providing ~8%. The *Sphaeralcea* shrubs are frequent, with widths of 0.5–0.75 m and subshrubs infrequently nestled among them. Other common shrubs with at least 1% cover include *Encelia frutescens, Opuntia engelmannii,* and *Gutierrezia sarothrae*. Other associates observed are *Cylindropuntia acanthocarpa, Celtis ehrenbergiana, Marah gilensis, Lycium pallidum, Ziziphus obtusifolia, Acourtia wrightii,* and *Eriogonum fasciculatum*.

Occasional *Prosopis velutina* and *Fouquieria splendens* account for sparse (2%) canopy cover above 2 m in height. In the field stratum, grasses comprise an estimated 10% total cover, with *Aristida ternipes, Eragrostis curvula* var. *confertiflora,* and *Aristida purpurea* the most abundant. In areas with near-surface bedrock, *Selaginella arizonica* fills in the open spaces.

This community could be considered to be a sub-association of the *Simmondsia chinensis* Shrubland, differing by having a clear sub-dominant species and a greater graminoid component—but a similar lack of tree canopy cover.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Sphaeralcea rusbyi, Sphaeralcea ambigua*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Prosopis velutina*
Subcanopy (0.5–2 m)	*Encelia frutescens, Opuntia engelmannii, Gutierrezia sarothrae*
Field (0–0.5 m)	*Aristida ternipes, Eragrostis curvula ver. Confertiflora, Aristida purpurea*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Cylindropuntia acanthocarpa, Celtis ehrenbergiana, Marah gilensis, Lycium pallidum, Ziziphus obtusifolia, Acourtia wrightii, Eriogonum fasciculatum*
Field (0–0.5 m)	*Eragrostis lehmanniana, Bothriochloa barbinodis, Bouteloua curtipendula, Bromus rubens*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from one classification plot and a single field-mapped polygon).

Global

More classification is needed to determine if this is an association that repeats in other similar localities.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP046
Tonto National Monument Polygons: S36
Local description authors: L. Crumbacher

Simmondsia chinensis - Opuntia engelmannii Shrubland (P)

Translated name: Jojoba - Engelmann's pricklypear Shrubland
NVC name: N/A
Identifier: NPSSODN074

NVC CLASSIFICATION

Division --
Macrogroup --
Group --
Association *Simmondsia chinensis - Opuntia engelmannii* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found in the uppermost elevations of the southern boundary area of the monument, in a few small, localized areas.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland is found on upper backslopes and crests of mountain slopes with a mostly northwest aspect. On summits, aspect can very more. These slope positions tend to be more exposed, with several bedrock outcroppings scattered throughout. The slopes are fairly stable, even with 35–50% slope. Bare ground is sparse due to the high gravel and rock cover. Little to no erosional features are recorded.

VEGETATION DESCRIPTION

Tonto National Monument
This proposed shrubland association is transitional between the Sonoran Desert uplands and the interior chaparral vegetation types. It is characterized by the predominance of sclerophyllous *Simmondsia chinensis* (Jojoba) and succulent *Opuntia engelmannii* (Engelmann's prickly pear), joined by a diverse mix of other large shrub species. The majority of cover is in the subcanopy (0.5–2 m) height range, with a total combined cover of ~35% across all stands. *S. chinensis* commonly generates 5–15% cover, and can share or trade co-dominance with *O. engelmannii,* whose cover estimates varied from 2 to 3%, upward to 8%. In one stand, *Encelia frutescens* is a co-dominant.

Canopy cover over 2 m in height is sparse to absent, always <10%, and is made up of occasional *Carnegiea gigantea*, *Fouquieria splendens,* or *Parkinsonia microphylla*. These species, along with the larger shrubs, *Rhus ovata* and *Canotia holacantha*, may be visually prominent even though they don't contribute much cover. However, *Rhus ovata* can be locally dominant and, when present, will be co-dominant with *S. chinensis*. In these areas, other species more commonly associated with chaparral, such as *Yucca baccata, Canotia holocantha, Quercus turbinella,* and *Eriogonum* spp., also increase in frequency and abundance.

Ten to 15 or more associate shrub species may be present, commonly including *Rhus ovata, Canotia holacantha, Eriogonum fasciculatum, Eriogonum wrightii, Sphaeralcea* spp., *Encelia frutescens, Aloysia wrightii, Galium stellatum, Agave chrysantha,* and others. Field-stratum cover is sparse, between 1 and 3%; *Achnatherum speciosum* is commonly present.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Opuntia engelmannii*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Rhus ovata, Encelia frutescens, Aloysia wrightii, Canotia holacantha, Eriogonum fasciculatum, Eriogonum wrightii, Sphaeralcea* spp.*, Galium stellatum, Ericameria laricifolia, Acacia greggii, Gutierrezia sarothrae*
Field (0–0.5 m)	*Achnatherum speciosum*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	*Carnegiea gigantea*
Canopy (2–5 m)	*Parkinsonia microphylla, Fouquieria splendens*
Subcanopy (0.5–2 m)	*Encelia virginensis, Dasylirion wheeleri, Phoradendron californicum, Acourtia wrightii, Dodonaea viscosa, Agave chrysantha, Opuntia phaeacantha, Yucca baccata, Cylindropuntia acanthocarpa, Sphaeralcea rusbyi, Dalea formosa, Penstemon subulatus Echinocereus fendleri, Rhus trilobata*
Field (0–0.5 m)	*Leptochloa dubia, Bouteloua curtipendula, Dudleya* spp.

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from 3 classification plots and three mapped polygons.

Global

No described association or alliance description exists for this community at this time. More classification work is needed to fully describe this vegetation.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP052, IP205, IP206
Tonto National Monument Polygons: S64, S70, S75
Local description authors: S. Studd, L. Crumbacher

Simmondsia chinensis Shrubland (P)

Translated name: Jojoba Shrubland
NVC name: N/A
Identifier: NPSSODN082

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Simmondsia chinensis* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This shrubland is the most widespread vegetation community at Tonto National Monument, with the most stands, although it is not the largest in area. This type is found throughout the monument, on the mid-to-upper slopes of ridges in the mountainous areas.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This association favors north- to west-facing slopes but also occurs on east and southern aspects at elevations spanning the 750–1,100 meter range within the monument, and on slopes with a gentle grade to over 50%. Surface cover is generally the rock-gravel mix typical at Tonto.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized by the clear, sole dominance of *Simmondsia chinensis* (jojoba). Numerous associate shrub species are usually present, but none provides enough cover or consistency to be considered co-dominant. Total subcanopy cover ranges from 25 to 45% (averaging about 35%), with cover of the dominant *S. chinensis* ranging from 11 to 45%. Density of *S. chinensis* increases in drainage depressions and the slopes immediately above drainages. Common associates include *Lycium fremontii, Keckiella antirrhinoides, Eriogonum fasciculatum, Encelia frutescens, Canotia holacantha, Sphaeralcea* spp., *Gutierrezia sarothrae,* and others. Shrub diversity is high, with 10–20 (occasionally more) species present—but even collectively, these almost always produce less cover than *S. chinensis* alone.

Field-stratum cover is a trace component of this community, usually 1–2%, rarely up to 10%. One stand contains about 20% cover of the non-native annual grass *Avena fatua* (wild oats), but population dynamics of annual species can vary widely between years. Along with cover, the number of species found in the field stratum is usually, but not always, low. None is obviously dominant.

Canopy cover over 2 m in height is sparse, usually less than 5%. Tall species that may be present, with little cover, include *Fouquieria splendens, Parkinsonia microphylla, P. florida, Prosopis velutina, Carnegiea gigantean,* and *Canotia holacantha*.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Parkinsonia microphylla, Canotia holacantha*
Subcanopy (0.5–2 m)	*Lycium fremontii, Sphaeralcea* sp., *Encelia frutescens, Gutierrezia sarothrae, Eriogonum fasciculatum, Artemisia ludoviciana, Aloysia wrightii, Keckiella antirrhinoides, Encelia farinosa, Eriogonum wrightii, Galium stellatum, Prosopis velutina*
Field (0–0.5 m)	*Muhlenbergia porteri, Achnatherum speciosum, Aristida ternipes, Bouteloua curtipendula, Aristida purpurea, Senecio lemmonii*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	*Carnegia gigantea*
Canopy (2–5 m)	*Fouquieria splendens, Prosopis velutina, Carnegia gigantea*
Subcanopy (0.5–2 m)	*Opuntia engelmannii, Opuntia acanthocarpa, Ferocactus cylindraceus, Mirabilis laevis, Acacia greggii, Larrea tridentata, Marah gilensis, Ferocactus wislizeni, Baccharis sarothroides, Agave chrysantha, Ziziphus obtusifolia, Opuntia bigelovii, Ephedra aspera, Celtis ehrenbergiana, Stephanomeria pauciflora, Brickellia coulteri, Dodonaea viscosa, Opuntia chlorotica, Janusia gracilis, Yucca baccata, Rumex* sp., *Parkinsonia florida*
Field (0–0.5 m)	*Dichelostemma capitatum, Dudleya* sp., *Muhlenbergia microsperma, Eragrostis lehmanniana, Ambrosia confertiflora, Echinocereus engelmannii, Dasyochloa pulchella, Chamaesyce* sp., *Mammillaria grahamii, Adenophyllum porophylloides, Digitaria californica, Pleuraphis mutica, Erigeron divergens, Melampodium leucanthum, Menodora scabra, Eriogonum inflatum*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from four classification plots and 10 field-mapped polygons.

Global

The USNVC currently has a placeholder association, *Simmondsia chinensis - Parkinsonia microphylla* Shrubland (CEGL000983), but it does not include any description and is pending more data to expand it. That association falls under the *Simmondsia chinensis - Canotia holacantha - Eriogonum fasciculatum* Desert Scrub Alliance (A.3283), which seems to be an appropriate level under which to describe the *Simmondsia chinensis* association as found at Tonto NM. However, this description is also likely to undergo more development with additional data inputs.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP008, IP038, IP057, IP088
Tonto National Monument Polygons: S08, S09, S14, S28, S29, S37, S38, S54, S72, S74, S82
Local description authors: B. Fallon, S. Studd

Simmondsia chinensis - Lycium fremontii Shrubland (P)

Translated name: Jojoba - Fremont's desert-thorn Shrubland
NVC name: N/A
Identifier: NPSSODN076

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Simmondsia chinensis - Lycium fremontii* Shrubland (P)

DISTRIBUTION

Tonto National Monument
This type is found only in the northern, alluvial-fan segments of the monument.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland occurs in Tonto National Monument on low-elevation (750–900 m), north- or northeast-facing slopes of medium grade (15–35% slope), covered largely with loose rock and gravel of mostly sedimentary origin, with some old alluvium near the footslopes and some red sandy loam soil exposed.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized by a moderately dense (15–30% cover) mix of large shrubs, often growing close together or entwined to form large but widely spaced clumps. These clusters of shrubs act almost as small islands, perhaps providing shelter or microclimate protection for other species to capture and retain water and nutrients, and germinate. The dominant shrub here is *Simmondsia chinensis* (jojoba) followed closely by *Lycium fremontii* (Fremont's desert-thorn), with *Prosopis velutina* (velvet mesquite) and *Celtis ehrenbergiana* (spiny hackberry) as common associates, often seen in low numbers within the clusters. *Parkinsonia florida* (blue paloverde) is recorded as a shrubby, short tree, with 1–3% cover. The understory of these shrub clusters is inhabited by various subshrubs and herbaceous species, but the field layer in general has low overall cover of just a few percent.

Parkinsonia microphylla (yellow paloverde) is present but in very low numbers, averaging 2–3 m tall, with cover below 1%. This species is more common in neighboring areas and where slope increases into the foothills. Abundance increases along these transitions. *Carnegia gigantea* (saguaro) is rare to absent in this type.

Fouquieria splendens (ocotillo) averaging four meters tall occurs in low numbers throughout.

Other species present are predominantly in the 0.5–2 m height range, with cover ~1%. These include: *Encelia farinosa, Keckiella antirrhinoides, Senegalia greggii* (catclaw acacia), *Sphaeralcea* spp. (globemallows), *Ziziphus obtusifolia* (lotebush), *Cylindropuntia bigelovii* (teddybear cholla), and *Senna covesii* (Coues' cassia). The field layer has a larger annual component, and perennial species are uncommon. Perennials include *Aristida purpurea* (purple threeawn), *Leptochloa dubia* (green sprangletop), *Ambrosia confertiflora* (slimleaf bursage), *Gutierrezia sarothrae* (broom snakeweed), and *Gutierrezia microcephala* (threadleaf snakeweed).

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Simmondsia chinensis, Lycium fremontii*
Field (0–0.5 m)	--

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Prosopis velutina*, *Parkinsonia florida, Fouquieria splendens*
Subcanopy (0.5–2 m)	*Celtis ehrenbergiana, Encelia farinosa, Keckiella antirrhinoides*
Field (0–0.5 m)	*Aristida purpurea, Leptochloa dubia, Senna covesii*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	*Carnegia gigantea*
Canopy (2–5 m)	*Parkinsonia microphylla*
Subcanopy (0.5–2 m)	*Abutilon incanum*, *Bouteloua curtipendula, Cylindropuntia acanthocarpa, Cylindropuntia bigelovii, Encelia frutescens, Larrea tridentata, Lycium pallidum, Opuntia engelmannii, Senegalia greggii, Sphaeralcea ambigua, Sphaeralcea rusbyi*
Field (0–0.5 m)	*Avena fatua, Bromus rubens, Ambrosia confertiflora, Dichelostemma capitatum* subsp. *Capitatum, Gutierrezia sarothrae, Gutierrezia microcephala*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from five classification plots and two field-mapped polygons.

Global

This association will likely fall under A3283, Jojoba - Crucifixion-thorn - Eastern Mojave buckwheat Desert Scrub Association or another, as yet undescribed alliance under the Sonoran paloverde - Mixed cacti Desert Scrub Group (G293). More data need to be gathered and evaluated before these sections of the NVC are fully described.

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

ELEMENT SOURCES

Tonto National Monument Plots: IP09, IP13, IP72, IP94, IP98
Tonto National Monument Polygons: S30, S46
Local description authors: S. Studd

Vachellia constricta - Mixed Shrub Shrubland (PS)

Translated name: Whitethorn acacia - mixed-shrub Shrubland
NVC name: N/A
Identifier: NPSSODN077

NVC CLASSIFICATION

Division	--
Macrogroup	--
Group	--
Association	*Vachellia constricta* - Mixed Shrub Shrubland (PS)

DISTRIBUTION

Tonto National Monument
This type is found only along Highway 188, the main road that crosses the northern portion of Tonto National Monument.

ENVIRONMENTAL DESCRIPTION

Tonto National Monument
This shrubland is heavily influenced by frequent disturbance, increased runoff from the road surface, invasive species invasions due to the road vector, and other seed introductions from road-related erosion-control projects. As such, this community is unique to this area and has been described as a "park special." This shrubland borders the two-lane highway and occurs within ~20 m of the road edges. Much of the substrate is foreign gravel, with some of Tonto's own gravel and loose rock of sedimentary or old alluvial origin. Erosion bars are in place in some areas.

VEGETATION DESCRIPTION

Tonto National Monument
This shrubland association is characterized by a very diverse, almost random mix of shrubs and subshrubs. *Vachellia constricta* is the most consistently distributed plant, with individuals at the edges of the roadside ditches. A few short (to 2.5 m) trees are present: *Parkinsonia microphylla, P. florida,* and *Prosopis velutina*.

Many of the other species present represent an extremely diverse mix of shrubs, many of which do not occur elsewhere in the monument or are rare within its boundaries. The diversity is most likely the result of the use of a bulk revegetation seed mix. *Vachellia constricta* is relatively abundant in the ditches along the roadside, creating 11–25% cover, It also occurs along the sides of the dirt road to the north of the highway. Also common or notable along the highway is a variety of *Eriogonum fasciculatum* that is greener, with more red tones, and grows more upright than most of the same species observed in the monument. *Atriplex canescens* is noticeable along the roadsides, but is only observed in two other places in the monument: on a disturbed saddle and in one of the mesquite woodlands. *Calliandra eriophylla* is planted here, but is not observed anywhere within the park. *Penstemon parryi* (Parry's penstemon) is only present here on the roadside, as is *Ambrosia deltoidea* (triangleleaf bursage). A decorative plant, *Senna nemophila* (desert cassia), grows in a few places along the road, and is also seen on the leach field in the park.

Aristida purpurea is very abundant along the very edge of the highway, a meter or so deep, and creates the large majority (cover class 11–25%) of the 20% field-stratum cover. On the lower, north side of the road, *Hordeum murinum* (mouse barley; non-native annual) and *Bromus rubens* (red brome; non-native annual) form patches under shrub and tree canopies.

Common park shrubs and trees are also present in the transportation corridor. *Ericameria laricifolia* (turpentine bush) fills in open areas along the highway, as it does on recovered roadways in the surrounding wooded shrubland. It is most abundant on the western half of the road, where there is a slight incline toward the west. *Encelia*

farinosa (brittlebush) is quite abundant on the roadsides where the incline is to the east. This *Ericameria* / *Encelia* pattern is consistent with what is observed in the surrounding wooded shrublands. *Simmondsia chinensis* (jojoba) is present, but does not create large amounts of cover. *Parkinsonia microphylla* (yellow paloverde) is encroaching from the surrounding community and *Prosopis velutina* (velvet mesquite) and *Parkinsonia florida* (blue paloverde) are taking advantage of the ditches where roadside water runoff can accumulate. Past the park fences bounding the highway, the vegetation abruptly gives way to *Parkinsonia microphylla* / *Simmondsia chinensis* wooded shrubland.

Certain sections of this roadway shrubland have been historically subject to invasion by multiple non-native species. Due to the vector nature of the road, and the frequent disturbance as the Department of Transportation has moved the immediate road edges, the community is likely to continue being invaded. Of special concern is a small patch of *Cenchrus ciliaris* (buffelgrass) that occurs almost directly across from the park entrance. This has been actively managed for several years and is currently thought to be under control.

GLOBAL TYPE CONCEPT DESCRIPTION

Data not available

MOST ABUNDANT SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	--
Subcanopy (0.5–2 m)	*Vachellia constricta*
Field (0–0.5 m)	*Aristida purpurea*

COMMON ASSOCIATE SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Parkinsonia microphylla*
Subcanopy (0.5–2 m)	*Sphaeralcea* sp., *Ericameria laricifolia, Eriogonum fasciculatum, Encelia farinosa, Simmondsia chinensis*
Field (0–0.5 m)	*Avena fatua, Bromus rubens*

UNCOMMON SPECIES

Tonto National Monument

Stratum	Species
Canopy (> 5 m)	--
Canopy (2–5 m)	*Prosopis velutina, Parkinsonia florida*
Subcanopy (0.5–2 m)	*Conyza canadensis, Prosopis velutina, Acacia greggii, Bailey multiradiata, Senna covesii, Celtis ehrenbergiana, Baccharis sarothroides, Senna nemophila, Calliandra eriophylla, Atriplex canescens, Ambrosia deltoidea*
Field (0–0.5 m)	*Bouteloua curtipendula, Eragrostis lehmanniana, Hordeum murinum, Penstemon parryi*

CLASSIFICATION COMMENTS

Tonto National Monument

This description is based solely on data collected during this inventory project. It is based on data from one mapped polygon. It is described as a "park special," indicating that it is not thought to be a natural or recurring community, but rather one dependent on the particular environment and disturbance regime it has here.

Global

Classification confidence: n/a
NatureServe conservation status: Data not available
Global status: Data not available
Rounded global status: Data not available
Global range: Data not available
Reasons:

ELEMENT SOURCES

Tonto National Monument Plots: None
Tonto National Monument Polygons: T01
Local description authors: B. Fallon, S. Studd

Appendix B: Dichotomous Key to Mapped Vegetation Types at Tonto National Monument

This key was used during the accuracy assessment phase of the vegetation inventory for the 22 associations assessed. The "park special" *Vachellia constricta* - Mixed Shrub Shrubland along the transportation corridor was not included. Some of the association names changed slightly between initial writing of this key and final reporting.

1a Top canopy dominated by *Juglans major* and *Platanus wrightii*, with tree cover >60% (i.e., a forest formation).
***Platanus wrightii - Juglans major* Riparian Forest Association**

1b Vegetation not as above. **(2)**

2a Woodland formation, with trees the dominant lifeform and *Prosopis velutina* the dominant tree species.
***Prosopis velutina* Woodland Association**

2b Not a woodland; community is dominated by shrubs and herbaceous vegetation, with or without significant tree cover. **(3)**

3a Community dominated by shrubs, but with tree cover >10% (i.e., a wooded shrubland formation). **(4)**

3b Community dominated by shrubs, with tree cover <10% (i.e., a shrubland formation). **(6)**

4a Wooded shrubland dominated by *Prosopis velutina* and *Acacia greggii*.
***Prosopis velutina* / *Acacia greggii* Wooded Shrubland Association** (became Wet Scrub association within the NVCS)

4b Vegetation not as above. **(5)**

5a Wooded shrubland dominated by *Parkinsonia microphylla* and *Simmondsia chinensis*, with <=5% *Ericameria laricifolia*.
***Parkinsonia microphylla* / *Simmondsia chinensis* Wooded Shrubland Association**

5b Wooded shrubland dominated by *Parkinsonia microphylla* and *Simmondsia chinensis*, with >=6% *Ericameria laricifolia*.
***Parkinsonia microphylla* / *Simmondsia chinensis* – *Ericameria laricifolia* Wooded Shrubland Association**

6a Shrubland dominated by a species other than *Simmondsia chinensis*. **(7)**

6b Shrubland dominated by *Simmondsia chinensis*. **(15)**

7a Shrubland dominated by *Canotia holacantha*.
***Canotia holacantha* Shrubland Association**

7b Vegetation not as above. **(8)**

8a Shrubland dominated by *Cercocarpus montanus* and *Quercus turbinella*.
***Cercocarpus montanus* – *Quercus turbinella* Shrubland Association**

8b Vegetation not as above. **(9)**

9a Shrubland dominated by *Dodonaea viscosa*.
***Dodonaea viscosa* Shrubland Association**

9b Vegetation not as above. **(10)**

10a Shrubland dominated by *Encelia frutescens* and *Gutierrezia sarothrae*.
***Encelia frutescens – Gutierrezia sarothrae* Shrubland Association**

10b Vegetation not as above. **(11)**

11a Shrubland dominated by *Opuntia acanthocarpa*.
***Opuntia acanthocarpa* Shrubland Association**

11b Vegetation not as above. **(12)**

12a Shrubland dominated by *Encelia farinosa*, with *Parkinsonia microphylla* (trees or shrubs) present as a sub-dominant. In some stands *Encelia frutescens* and/or *Simmondsia chinensis* may be co-dominant or nearly so.
***(Parkinsonia microphylla) / Encelia farinosa* Shrubland Association**

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

13a Shrubland dominated by *Parkinsonia microphylla* and *Eriogonum fasciculatum*, with *Encelia frutescens* as a sub-dominant. N.B.: if the *P. microphylla* considered trees provide >10% cover, this should be a wooded shrubland.
***Parkinsonia microphylla / Eriogonum fasciculatum – Encelia frutescens* Shrubland Association**

13b Vegetation not as above. **(14)**

14a Shrubland clearly dominated by *Simmondsia chinensis*, without any close sub-dominant among the many other shrub species present with very low cover, generally not exceeding 5%.
***Simmondsia chinensis* Shrubland Association**

14b Shrubland dominated by *Simmondsia chinensis*, but with at least one co-dominant or close sub-dominant shrub species. **(15)**

15a Shrubland dominated by *Simmondsia chinensis* and *Encelia farinosa*.
***Simmondsia chinensis – Encelia farinosa* Shrubland Association**

15b Vegetation not as above. **(16)**

16a Shrubland dominated by *Simmondsia chinensis* and *Encelia frutescens*.
***Simmondsia chinensis – Encelia frutescens* Shrubland Association**

16b Vegetation not as above. **(17)**

17a Shrubland dominated by *Simmondsia chinensis* and *Ericameria laricifolia*.
***Simmondsia chinensis – Ericameria laricifolia* Shrubland Association**

17b Vegetation not as above. **(18)**

18a Shrubland dominated by *Simmondsia chinensis* and *Eriogonum fasciculatum*.
***Simmondsia chinensis – Eriogonum fasciculatum* Shrubland Association**

18b Vegetation not as above. **(19)**

19a Shrubland dominated by *Simmondsia chinensis* and *Eriogonum wrightii*.
***Simmondsia chinensis – Eriogonum wrightii* Shrubland Association**

19b Vegetation not as above. **(20)**

20a Shrubland dominated by *Simmondsia chinensis* and *Lycium fremontii*.
***Simmondsia chinensis – Lycium fremontii* Shrubland Association**

20b Vegetation not as above. **(21)**

21a Shrubland dominated by *Simmondsia chinensis* (rarely also *Rhus ovata*) and *Opuntia engelmannii*.
***Simmondsia chinensis – Opuntia engelmannii* Shrubland Association**

21b Vegetation not as above. **(22)**

22a Shrubland dominated by *Simmondsia chinensis* and *Sphaeralcea spp.*
***Simmondsia chinensis – Sphaeralcea spp.* Shrubland Association**

22b Shrubland dominated by *Simmondsia chinensis*, *Opuntia spp.* and *Acacia greggii*, with *Selaginella arizonica* dominating the field stratum, though its cover is only about 10%. Note that some other types may have more absolute *Selaginella* cover, and it may even dominate the field layer, but without imparting the "characteristic look" that this type has.
***Simmondsia chinensis – Opuntia spp. / Selaginella arizonica* Shrubland Association**

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)

Appendix D: Example Datasheets

TONTO NM 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: TONT
Approximate polygon center (UTM NAD83):			
Keyed Formation:			

In table below list the top three dominant species (by cover) for each stratum. Write 'NONE" if none present for a stratum. Use additional spaces and notes section to record other species that are characteristic or diagnostic of a vegetation community, but that may not be dominant in cover. Write a brief descriptive sentence describing the floristic and structural characteristics of the polygon.

R	Top Canopy >5m	R	Canopy 2-5m	R	Sub-Canopy 0.5m – 2m	R	Field 0 -0.5m
1		1		1		1	
2		2		2		2	
3		3		3		3	

Record any notes pertinent to your assessment of this polygon. Note additional characteristic &/or diagnostic species. Write a brief community description. 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.

TONT_AA_Datasheet.ppt

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

Polygon ID:

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

	Juglans major – Platanus wrightii semi permanently flooded forest association
	Prosopis velutina woodland alliance
	Prosopis velutina / Acacia greggii wooded shrubland association
	Parkinsonia microphylla / Simmondsia chinensis wooded shrubland alliance
	Parkinsonia microphylla / Simmondsia chinensis – Ericameria laricifolia wooded shrubland association

	Canotia holacantha shrubland alliance
	Cercocarpus montanus var. glaber / Quercus turbinella shrubland association
	Dodonaea viscosa shrubland alliance
	Encelia frutescens – Gutierrezia sarothrae shrubland association
	Cylindropuntia acanthocarpa shrubland alliance
	(*Parkinsonia microphylla*) / *Encelia farinosa* shrubland association
	Parkinsonia microphylla / Eriogonum fasciculatum – Encelia frutescens shrubland association
	Simmondsia chinensis shrubland alliance
	Simmondsia chinensis – Encelia farinosa shrubland association
	Simmondsia chinensis – Encelia frutescens shrubland association
	Simmondsia chinensis – Ericameria laricifolia shrubland association
	Simmondsia chinensis – Eriogonum fasciculatum shrubland association
	Simmondsia chinensis – Eriogonum wrightii shrubland association
	Simmondsia chinensis – Lycium fremontii shrubland association
	Simmondsia chinensis – Opuntia engelmannii shrubland association
	Simmondsia chinensis – Opuntia spp. / Selaginella arizonica shrubland association
	Simmondsia chinensis – Sphaeralcea spp. Shrubland association

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 list below)

Page ____ of ____

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

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

Park:	Sub-Map #:	Date (mm/dd/yyyy):	
Poly ID(s):		Field Poly ID:	
Observer(s):	Recorder:	Tentative Formation:	Keyed Formation:
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

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

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

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: 0.05.4

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

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

Soil/Landscape Parameters

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

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

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

Aspect (circle dominant aspect)

N NE E SE
S SW W NW

Area Surface Cover (circle one class per feature)

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

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

Erosion Features (circle one class per feature)

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

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

Page ____ of ____

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

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

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

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

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

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

List other common associates

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

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

Sonoran Desert Network
Inventory and Monitoring Program

National Park Service
U.S. Department of the Interior

Page ____ of ____

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

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

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

Soil/Landscape Parameters

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

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

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

Aspect (circle dominant aspect)

N NE E SE

S SW W NW

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

Area Surface Cover (circle one class per feature)

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

Erosion Features (circle one class per feature)

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

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

Appendix E: Plant Species Lists Based on Observations During the Inventory

List of all plant species observed during classification plot data collection and polygon-scale data collection at Tonto NM, 2008–2010.

Table E-1. Plant species observed during mapping at Tonto National Monument, 2008–2010.

Family	Scientific name	Common name	Nativity	Duration
Adoxaceae	*Sambucus nigra*	black elderberry	Non-Native	Perennial
Adoxaceae	*Sambucus nigra* ssp. *canadensis*	American black elderberry	Non-Native	Perennial
Amaranthaceae	*Atriplex canescens*	fourwing saltbush	Native	Perennial
Anacardiaceae	*Rhus ovata*	sugar sumac	Native	Perennial
Anacardiaceae	*Rhus trilobata*	skunkbush sumac	Native	Perennial
Apiaceae	*Lomatium nevadense*	Nevada biscuitroot	Native	Perennial
Apocynaceae	*Funastrum cynanchoides* ssp. *heterophyllum*	Hartweg's twinevine	Native	Perennial
Apocynaceae	*Matelea parvifolia*	spearleaf	Native	Perennial
Asparagaceae	*Agave chrysantha*	goldenflower century plant	Native	Perennial
Asparagaceae	*Dasylirion wheeleri*	common sotol	Native	Perennial
Asparagaceae	*Dichelostemma capitatum*	bluedicks	Native	Perennial
Asparagaceae	*Nolina microcarpa*	sacahuista	Native	Perennial
Asparagaceae	*Yucca baccata*	banana yucca	Native	Perennial
Asteraceae	*Acourtia nana*	dwarf desertpeony	Native	Perennial
Asteraceae	*Acourtia wrightii*	brownfoot	Native	Perennial
Asteraceae	*Adenophyllum porophylloides*	San Felipe dogweed	Native	Perennial
Asteraceae	*Ambrosia confertiflora*	weakleaf bur ragweed	Native	Perennial
Asteraceae	*Ambrosia deltoidea*	triangle bur ragweed	Native	Perennial
Asteraceae	*Ambrosia psilostachya*	Cuman ragweed	Native	Perennial
Asteraceae	*Artemisia dracunculus*	tarragon	Native	Perennial
Asteraceae	*Artemisia ludoviciana*	white sagebrush	Native	Perennial
Asteraceae	*Baccharis salicifolia*	mule-fat	Native	Perennial
Asteraceae	*Baccharis sarothroides*	desertbroom	Native	Perennial
Asteraceae	*Baileya multiradiata*	desert marigold	Native	Perennial
Asteraceae	*Bebbia juncea*	sweetbush	Native	Perennial
Asteraceae	*Brickellia atractyloides*	spearleaf brickellbush	Native	Perennial
Asteraceae	*Brickellia coulteri* var. *coulteri*	Coulter's brickellbush	Native	Perennial
Asteraceae	*Brickellia floribunda*	Chihuahuan brickellbush	Native	Perennial
Asteraceae	*Cirsium neomexicanum*	New Mexico thistle	Native	Perennial
Asteraceae	*Coleosanthus californicus*	California brickellbush	Native	Perennial
Asteraceae	*Conyza canadensis*	Canadian horseweed	Native	Annual
Asteraceae	*Encelia farinosa*	brittlebush	Native	Perennial
Asteraceae	*Encelia frutescens*	button brittlebush	Native	Perennial
Asteraceae	*Encelia virginensis*	Virgin River brittlebush	Native	Perennial
Asteraceae	*Ericameria laricifolia*	turpentine bush	Native	Perennial
Asteraceae	*Erigeron divergens*	spreading fleabane	Native	Biennial
Asteraceae	*Gutierrezia microcephala*	threadleaf snakeweed	Native	Perennial
Asteraceae	*Gutierrezia sarothrae*	broom snakeweed	Native	Perennial
Asteraceae	*Heterotheca villosa*	hairy false goldenaster	Native	Perennial
Asteraceae	*Hymenoclea monogyra*	singlewhorl burrobrush	Native	Perennial

Table E-1. Plant species observed during mapping at Tonto National Monument, 2008–2010, cont.

Family	Scientific name	Common name	Nativity	Duration
Asteraceae	*Isocoma acradenia*	alkali goldenbush	Native	Perennial
Asteraceae	*Melampodium leucanthum*	plains blackfoot	Native	Perennial
Asteraceae	*Perityle coronopifolia*	crowfoot rockdaisy	Native	Perennial
Asteraceae	*Porophyllum gracile*	slender poreleaf	Native	Perennial
Asteraceae	*Senecio flaccidus*	threadleaf ragwort	Native	Perennial
Asteraceae	*Senecio lemmonii*	Lemmon's ragwort	Native	Perennial
Asteraceae	*Sonchus oleraceus*	common sowthistle	Non-Native	Annual
Asteraceae	*Stephanomeria pauciflora*	brownplume wirelettuce	Native	Perennial
Asteraceae	*Trixis californica*	American threefold	Native	Perennial
Asteraceae	*Xanthisma* sp.	sleepydaisy	Native	Perennial
Berberidaceae	*Berberis fremontii*	Fremont's mahonia	Native	Perennial
Brassicaceae	*Erysimum capitatum*	sanddune wallflower	Native	Perennial
Cactaceae	*Carnegiea gigantea*	saguaro	Native	Perennial
Cactaceae	*Cylindropuntia acanthocarpa*	buck-horn cholla	Native	Perennial
Cactaceae	*Cylindropuntia bigelovii*	teddybear cholla	Native	Perennial
Cactaceae	*Cylindropuntia fulgida*	jumping cholla	Native	Perennial
Cactaceae	*Cylindropuntia leptocaulis*	Christmas cactus	Native	Perennial
Cactaceae	*Echinocereus engelmannii*	Engelmann's hedgehog cactus	Native	Perennial
Cactaceae	*Echinocereus fendleri*	pinkflower hedgehog cactus	Native	Perennial
Cactaceae	*Ferocactus cylindraceus*	California barrel cactus	Native	Perennial
Cactaceae	*Ferocactus wislizeni*	candy barrelcactus	Native	Perennial
Cactaceae	*Mammillaria barbata*	greenflower nipple cactus	Native	Perennial
Cactaceae	*Mammillaria grahamii*	Graham's nipple cactus	Native	Perennial
Cactaceae	*Opuntia chlorotica*	dollarjoint pricklypear	Native	Perennial
Cactaceae	*Opuntia engelmannii*	cactus apple	Native	Perennial
Cactaceae	*Opuntia macrocentra*	purple pricklypear	Native	Perennial
Cactaceae	*Opuntia phaeacantha*	tulip pricklypear	Native	Perennial
Cannabaceae	*Celtis ehrenbergiana*	spiny hackberry	Native	Perennial
Cannabaceae	*Celtis laevigata* var. *reticulata*	netleaf hackberry	Native	Perennial
Caryophyllaceae	*Arenaria macradenia*	Mojave sandwort	Native	Perennial
Celastraceae	*Canotia holacantha*	crucifixion thorn	Native	Perennial
Commelinaceae	*Tradescantia occidentalis*	prairie spiderwort	Native	Perennial
Convolvulaceae	*Convolvulus equitans*	Texas bindweed	Native	Perennial
Convolvulaceae	*Cuscuta indecora*	bigseed alfalfa dodder	Native	Perennial
Crassulaceae	*Dudleya collomiae*	Gila County liveforever	Native	Perennial
Cucurbitaceae	*Marah gilensis*	Gila manroot	Native	Perennial
Cupressaceae	*Juniperus coahuilensis*	redberry juniper	Native	Perennial
Cupressaceae	*Juniperus monosperma*	oneseed juniper	Native	Perennial
Ephedraceae	*Ephedra aspera*	rough jointfir	Native	Perennial
Euphorbiaceae	*Argythamnia neomexicana*	New Mexico silverbush	Native	Perennial
Euphorbiaceae	*Chamaesyce* sp.	sandmat	N/A	N/A
Fabaceae	*Calliandra eriophylla*	fairyduster	Native	Perennial
Fabaceae	*Dalea formosa*	featherplume	Native	Perennial
Fabaceae	*Lotus rigidus*	shrubby deervetch	Native	Perennial
Fabaceae	*Lupinus* sp.	lupine	Native	N/A
Fabaceae	*Parkinsonia florida*	blue paloverde	Native	Perennial

Table E-1. Plant species observed during mapping at Tonto National Monument, 2008–2010, cont.

Family	Scientific name	Common name	Nativity	Duration
Fabaceae	*Parkinsonia microphylla*	yellow paloverde	Native	Perennial
Fabaceae	*Prosopis velutina*	velvet mesquite	Native	Perennial
Fabaceae	*Senegalia greggii*	catclaw acacia	Native	Perennial
Fabaceae	*Senna covesii*	Coues' cassia	Native	Perennial
Fabaceae	*Vachellia constricta*	whitethorn acacia	Native	Perennial
Fabaceae	*Vicia ludoviciana*	Louisiana vetch	Native	Annual
Fagaceae	*Quercus turbinella*	Sonoran scrub oak	Native	Perennial
Fouquieriaceae	*Fouquieria splendens*	ocotillo	Native	Perennial
Juglandaceae	*Juglans major*	Arizona walnut	Native	Perennial
Krameriaceae	*Krameria erecta*	littleleaf ratany	Native	Perennial
Krameriaceae	*Krameria grayi*	white ratany	Native	Perennial
Lamiaceae	*Hedeoma nana*	dwarf false pennyroyal	Native	Perennial
Lamiaceae	*Hyptis albida*	Unknown	Native	Perennial
Lamiaceae	*Marrubium vulgare*	horehound	Non-Native	Perennial
Lamiaceae	*Salvia pinguifolia*	rock sage	Native	Perennial
Liliaceae	*Calochortus* sp.	mariposa lily	Native	Perennial
Malpighiaceae	*Cottsia gracilis*	slender janusia	Native	Perennial
Malvaceae	*Abutilon incanum*	pelotazo	Native	Perennial
Malvaceae	*Abutilon parishii*	Parish's Indian mallow	Native	Perennial
Malvaceae	*Ayenia filiformis*	Trans-Pecos ayenia	Native	Perennial
Malvaceae	*Sphaeralcea ambigua*	desert globemallow	Native	Perennial
Malvaceae	*Sphaeralcea emoryi*	Emory's globemallow	Native	Perennial
Malvaceae	*Sphaeralcea rusbyi*	Rusby's globemallow	Native	Perennial
Nyctaginaceae	*Mirabilis laevis* var. *villosa*	wishbone-bush	Native	Perennial
Oleaceae	*Fraxinus anomala*	singleleaf ash	Native	Perennial
Oleaceae	*Menodora scabra*	rough menodora	Native	Perennial
Orobanchaceae	*Castilleja applegatei*	wavyleaf Indian paintbrush	Native	Perennial
Papaveraceae	*Corydalis* sp.	fumewort	Native	N/A
Plantaginaceae	*Keckiella antirrhinoides*	snapdragon penstemon	Native	Perennial
Plantaginaceae	*Maurandella antirrhiniflora*	roving sailor	Native	Perennial
Plantaginaceae	*Penstemon parryi*	Parry's beardtongue	Native	Perennial
Plantaginaceae	*Penstemon subulatus*	hackberry beardtongue	Native	Perennial
Platanaceae	*Platanus wrightii*	Arizona sycamore	Native	Perennial
Poaceae	*Achnatherum speciosum*	desert needlegrass	Native	Perennial
Poaceae	*Aristida purpurea*	purple threeawn	Native	Perennial
Poaceae	*Aristida ternipes*	spidergrass	Native	Perennial
Poaceae	*Aristida ternipes* var. *gentilis*	spidergrass	Native	Perennial
Poaceae	*Avena fatua*	wild oat	Non-Native	Annual
Poaceae	*Bothriochloa barbinodis*	cane bluestem	Native	Perennial
Poaceae	*Bouteloua curtipendula*	sideoats grama	Native	Perennial
Poaceae	*Bromus diandrus*	ripgut brome	Non-Native	Annual
Poaceae	*Bromus rubens*	red brome	Non-Native	Annual
Poaceae	*Cynodon dactylon*	Bermudagrass	Non-Native	Perennial
Poaceae	*Dasyochloa pulchella*	low woollygrass	Native	Perennial
Poaceae	*Digitaria californica* var. *californica*	Arizona cottontop	Native	Perennial
Poaceae	*Disakisperma dubium*	green sprangletop	Native	Perennial

Table E-1. Plant species observed during mapping at Tonto National Monument, 2008–2010, cont.

Family	Scientific name	Common name	Nativity	Duration
Poaceae	*Elymus glaucus*	blue wildrye	Native	Perennial
Poaceae	*Eragrostis curvula*	weeping lovegrass	Non-Native	Perennial
Poaceae	*Eragrostis lehmanniana*	Lehmann lovegrass	Non-Native	Perennial
Poaceae	*Eragrostis pectinacea*	tufted lovegrass	Native	Annual
Poaceae	*Eragrostis pectinacea* var. *miserrima*	desert lovegrass	Native	Annual
Poaceae	*Heteropogon contortus*	tanglehead	Native	Perennial
Poaceae	*Hilaria mutica*	tobosagrass	Native	Perennial
Poaceae	*Hordeum murinum*	mouse barley	Non-Native	Annual
Poaceae	*Lamarckia aurea*	goldentop grass	Non-Native	Annual
Poaceae	*Muhlenbergia emersleyi*	bullgrass	Native	Perennial
Poaceae	*Muhlenbergia microsperma*	littleseed muhly	Native	Annual
Poaceae	*Muhlenbergia porteri*	bush muhly	Native	Perennial
Poaceae	*Pappostipa speciosa*	desert needlegrass	Native	Perennial
Poaceae	*Poa fendleriana*	muttongrass	Native	Perennial
Polemoniaceae	*Linanthus bigelovii*	Bigelow's linanthus	Native	Annual
Polemoniaceae	*Phlox tenuifolia*	Santa Catalina Mountain phlox	Native	Perennial
Polygonaceae	*Eriogonum fasciculatum*	eastern Mojave buckwheat	Native	Perennial
Polygonaceae	*Eriogonum inflatum*	desert trumpet	Native	Perennial
Polygonaceae	*Eriogonum wrightii*	bastardsage	Native	Perennial
Polygonaceae	*Rumex* sp.	dock	N/A	N/A
Pteridaceae	*Astrolepis cochisensis*	Cochise scaly cloakfern	Native	Perennial
Pteridaceae	*Cheilanthes fendleri*	Fendler's lipfern	Native	Perennial
Pteridaceae	*Pellaea* sp.	cliffbrake	Native	Perennial
Rhamnaceae	*Ceanothus greggii*	desert ceanothus	Native	Perennial
Rhamnaceae	*Rhamnus crocea*	redberry buckthorn	Native	Perennial
Rhamnaceae	*Rhamnus ilicifolia*	hollyleaf redberry	Native	Perennial
Rhamnaceae	*Ziziphus obtusifolia*	lotebush	Native	Perennial
Rosaceae	*Cercocarpus montanus*	alderleaf mountain mahogany	Native	Perennial
Rosaceae	*Cercocarpus montanus* var. *glaber*	birchleaf mountain mahogany	Native	Perennial
Rosaceae	*Rubus arizonensis*	Arizona dewberry	Native	Perennial
Rubiaceae	*Galium stellatum*	starry bedstraw	Native	Perennial
Rutaceae	*Thamnosma texana*	rue of the mountains	Native	Perennial
Santalaceae	*Phoradendron californicum*	mesquite mistletoe	Native	Perennial
Sapindaceae	*Dodonaea viscosa*	Florida hopbush	Native	Perennial
Selaginellaceae	*Selaginella arizonica*	Arizona spikemoss	Native	Perennial
Simmondsiaceae	*Simmondsia chinensis*	jojoba	Native	Perennial
Solanaceae	*Lycium fremontii*	Fremont's desert-thorn	Native	Perennial
Solanaceae	*Lycium pallidum*	pale desert-thorn	Native	Perennial
Solanaceae	*Lycium parishii*	Parish's desert-thorn	Native	Perennial
Solanaceae	*Nicotiana obtusifolia*	desert tobacco	Native	Perennial
Verbenaceae	*Aloysia wrightii*	Wright's beebrush	Native	Perennial
Verbenaceae	*Glandularia bipinnatifida*	Dakota mock vervain	Native	Perennial
Zygophyllaceae	*Larrea tridentata*	creosote bush	Native	Perennial

N/A = unable to be determined

Appendix F. 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, plant species names, and other information.

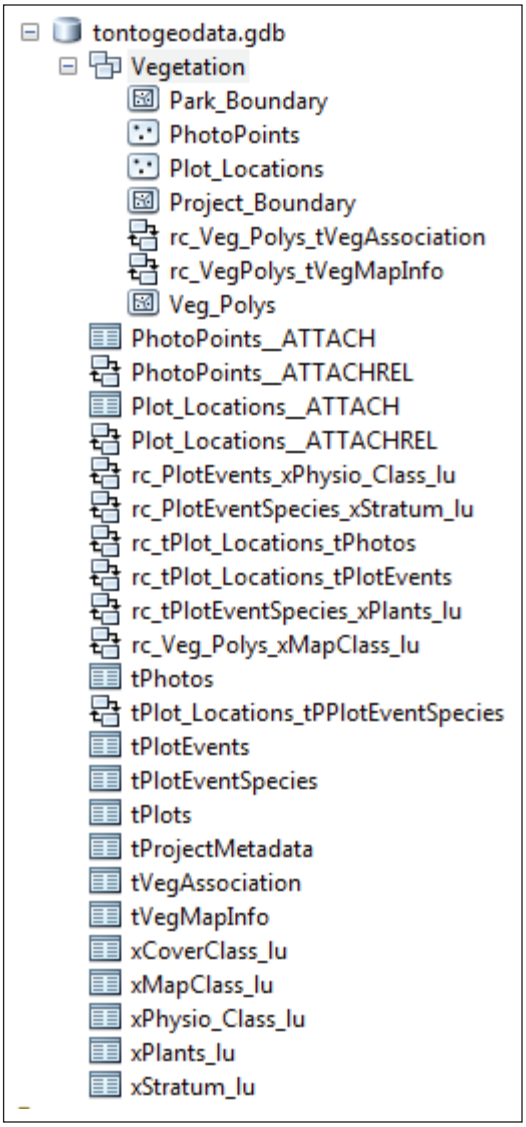


Figure F-1. Database relationships for the final map and related data products.

Feature class and related table descriptions

Veg_Polys: 85 polygon features, each attributed with community association 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.

Plot Locations: 50 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. The user can select any plot 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 plots have that particular species in that particular abundance). This feature alone is a powerful exploratory tool within this GDB. 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 GPS units and subsequently merged and imported into the GDB.

Feature class attachments

File attachments were created for two feature classes in the GBD: the Veg_Polys, Plot_Locations, and VegPoly_PhotoPoints. In ArcMap 10 (or later versions), 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

- tontgeodata.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).
- PhotoPoints – Four photos are taken with every polygon, at each photo point; one for each cardinal direction.

Tables

- tPlotEvents – Plot metadata and veg info
- tPlotEventSpecies – Recorded species within plot
- tPlots – Landscape attribute data
- tProjectMetadata - Metadata
- tVegAssociation – Western veg associations list
- tVegMapInfo - Association data and codes
- xCoverClass_lu – lookup table for cover classes
- 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

Relationship classes

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

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

NPS 358/139825, August 2017

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™